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Farmers' Perception and Factors Influencing their Response to Climate Change in the North Bank Region of the Gambia.

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Abstract

Crop production is mainly rain-fed in most developing economies especially in Africa. Therefore, any variation in the climate patterns has immediate effects on productivity. It is crucial for farmers in this region to sustainably adapt to climate change if food security, sufficiency and sustained livelihoods are to be achieved. A farmer's choice of an adaptation strategy is influenced by certain socioeconomic factors and the perception of the farmer about the changes in climate. This study investigates farmers' perceptions and the socioeconomic factors that influenced their decisions to respond to climate change in the North Bank Region of The Gambia. Data for the study was collected from 258 farmer household heads and nine Focus Group Discussions. Descriptive statistics and a logit regression model were used to analyze the data obtained from the households. Results from the study revealed that about 97.29% of farmers had experienced changes in climate factors for the past 30 years. Also, analysis from the logit model indicated a combination of socioeconomic factors influenced a farmer's response to climate change. The study concluded that; age, awareness of climate change, marital status, access to extension services and farmland influence farmers in the North Bank Region to adopt response strategies to climate change. It is recommended that the positive and significant socioeconomic factors that influence response in this study such as awareness of climate change, access to extension services, access to credit and size of farmland should be considered and enhanced when implementing programmes and projects on response/adaptation to climate change among farmers in the study region.

Keywords: *Perception, Response, Climate Change, The Gambia, logit Model*

INTRODUCTION

Climate change is a global concern. The situation however, is more serious in Africa due to the vulnerable nature of the continent (IPCC, 2007). According to Morton (2007), majority of the livelihoods in sub Saharan Africa (SSA) are dependent on natural resources, particularly the rural poor, making them more susceptible to climate change. Crop production is mainly rain-fed in most developing economies in the continent, thus, any variation in the climate patterns will have immediate effects on productivity (Nastis *et al*., 2012). The need to sustainably adapt to the adverse effects of climate change is paramount if food security, sufficiency and sustained livelihoods is to be achieved. According to Gbetibouo (2009) climate change perception is a first prerequisite to adaptation, thus it is essential to assess how farmers understand and experience changes to the climate as a stepping stone to sustainable climate change adaptation.

Farmers adopt diverse response measures and strategies to reduce the impact of climate change on their livelihood activity. Tesfay (2014) argues that, farmers use different response strategies that fit with the types of problems caused by climate change, which affect them This is because climate change impacts are unevenly distributed across various geographic areas and regions. Hence, adaptation mechanisms also vary with types and intensity of the impacts. Since SSA is the hardest hit by climate change impacts, adaptation is the priority of most farmers. This is evidenced in countries like Senegal, Ghana, Nepal, Bangladesh, Nigeria, and The Gambia where farmers have been mentioned to perceive and even responded to changes in the climate ((Mertz *et al*., 2009; Maharjan *et al*., 2011; Arbuckle *et al*., 2013; Yaffa, 2013; Kutir *et al*., 2015).

The preference for adaptation strategies depends on a farmer's perception and willingness to adapt. Therefore, adaptation to climate change differs from farmer to farmer. Tesfay (2014) argues that improving sustainable adaptation to current climate variability is not an alternative to preparing for adaptation to longer term changes in climate. It is an adjunct, a useful first and preparatory step that strengthens capacity now to deal with future circumstances (Muleta *et al*., 2011). Therefore, increase use and strengthening farmers' adaptive capacity to climate change is paramount for increasing crop yield and food security (Kutir *et al*., 2015).

Mabe *et al*. (2014) opined that a farmer's decision to adopt an adaptation strategy to cope/mitigate the effect of climate change depends largely on certain socio-economic factors, which need to be known. Factors that influence a farmer's adaptation decisions are very imperative in designing policies to promote effective adaptation, especially in the agricultural sector (Mabe *et al*., 2014). Recent development in literature have indicated that a number of socioeconomic characteristics such as age, gender, educational status, household size among others and farm characteristic such as size of farmland and soil fertility influence a farmer's decision to response to climate change (Di Falco *et al*., 2011; Deressa *et al*., 2009). For instance Abid *et al*.(2015) and Yegbemey *et al*. (2014) established in their different studies that education, farm experience, household size, land area, tenancy status, organizational membership among others influence farmers' adaptation in Punjab province and northern Benin respectively. Knowing the factors that influence farmers' climate change adaptation strategies is very vital in developing intervention actions to enhance farmers' adaptive capacities (Mabe *et al*., 2014).

Even though some studies have been carried out on farmers' perception and adaptation to climate change in developing countries (ATPS, 2013; Abid *et al*., 2015), there is little empirical evidence on farmers' perception and the factors that influence their adaptation to climate change in the Gambia. This study therefore seeks to (1) assess farmers' perception about climate change, (2) identify the factors that influence a farmer's adaptation to climate change and (3) identify the challenges that inhibits farmers in their adaptation to climate change.

MATERIALS AND METHODS

The North Bank Region falls within Sudan-Sahelian zone with 600-900 mm of rainfall per annum. Geographically, most of the rural areas fall within this zone and a small portion of the region is within the Sudan–Guinean, with 900–1200 mm rainfall per annum. The dominant soil types in all the communities in the region were sandy loam and clay soils. The major ethnic groups found in the study area are Mandinka, Wolof, Fullas, Manjago, Serehule and Bambara. According to Yaffa (2013), virtually all residents in the North Bank Region depend directly or indirectly on the agricultural sector. For this reason, poor or failed harvests seriously threaten food security in the area. Fig. 1 below is a map of the North Bank Region with selected communities for the study.

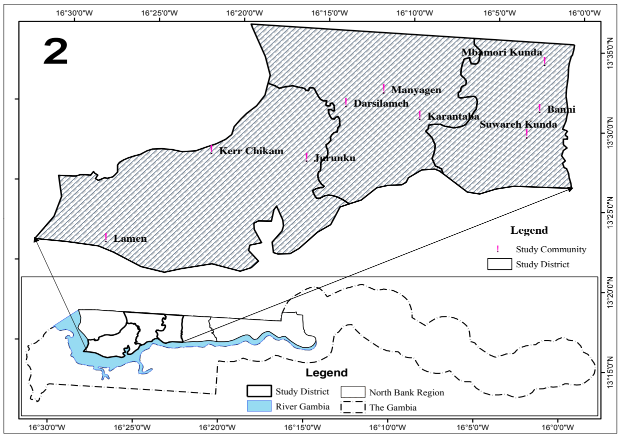

Figure1: Map of Study Area

A descriptive design was adopted in conducting the study. Burns and Grove, (2003) opined that descriptive research "is designed to depict a picture of a situation as it naturally happens". A multistage cluster sampling technique was used to select the respondents for the study. The North Bank Region was purposely selected in the first stage because it is the region most affected by drought, unpredictable rainfall and high temperatures in the country (Kutir *et al*. 2015). Simple random sampling technique was used to select three districts from the six districts in the region and three communities from each district. In the last stage, simple random sampling was used to select households from each community. In each selected household the head was interviewed for the study, but in the absence of the household head any adult member (more than 18 years old) was interviewed. In all, 258 household heads were interviewed for the entire study. This number was obtained using Krejcie and Morgan (1970) sample size computation formula.

Table 1: Sample for the Study

Region	Sampled District	Sampled Communities	Sampled households
North Bank Region	Lower Badibbu	Mbamori Kunda	9
		Banni	39
		Suwareh Kunda	46
	Jokadu	Munyagen	50
		Karantaba	11
		Darsilameh	45
	Upper Niumi	Lamen	37
		Jurunku	11
		Kerr Chikam	10
Total	**3 districts**	**9 communities**	**258**

A face-to-face interview was conducted with the aid of a questionnaire to sampled household heads. This was done by asking the interviewee questions and the responses recorded. The logic of this method was to enable easy access to information since majority of the respondents could not read or write. A total of nine Focus Group Discussions (FGD) was also conducted for the entire study, one in each community. Each FGD constituted nine members since the smallest number of household heads for the selected communities was nine.

Descriptive statistics (mean, minimum values, maximum values and percentages) were used in analyzing the data. In addition, a binary logistics (logit) regression model was employed to determine socio-economic and farm characteristic that affect farmers' response to climate change. According to Treiman (2009) logit and probit regression analyses are most widely used to estimate the probability of a binary response based on one or more predictor (or independent) variables. The two procedures yield generally similar outputs and the choice is largely a matter of preference and professional conventions. In this study, the logit model was adopted. The logistic regression model has been used in many applications due to its mathematical convenience (Greene, 2003). The binary logit is expressed in the Equation below:

Equation 1: Binary Logit Regression Formula

$$\Pr\left(y=1/x^{'}\right)=\frac{\exp(x^{'}\beta)}{1+\exp(x^{'}\beta)}=A(x^{'}\beta) \quad ..(1)$$

Where $\Pr\left(y=1/x^{'}\right)$ denotes the probability of a farmer responding to climate change, the dependent variable takes a value of 1 given an independent variable $x^{'}$. The explanatory power of the independent variable is explained by its coefficient. The dependent variable is the probability of a household responding to climate variability by adapting to variations in climate. This dependent variable takes two discrete values which are: 1= a farmer adopts at least one or more response strategies to climate change or 0=no response to climate change.

In the view of Mudombi (2011), the model predicts the maximum likelihood of a household being an adapter versus being a non-adapter. The coefficient β in the model depicts a relationship of how variations in the independent variables affect the predicted log of odds of a farmer adapting versus farmer not adapting. This relationship between the dependent and the independent variable can be depicted using the antilog of the β (exp β) which is the odds ratio. The formula of the odds ratio is presented below.

$$\frac{p_i}{1-p_i}=\frac{1+e^{\wedge(x^{'}\beta)}}{1+e^{-\wedge(x^{'}\beta)}}=e^{\wedge(x^{'}\beta)} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where P_i= is the probability of response to climate change $\Pr\left(y=1/x^{'}\right)$ and $(\Pr(y=0/x^{'}))$ is the probability of not responding to climate change measured as a dummy variable (1 = response to climate change, 0= no response to climate change). Therefore, farmers that adapted one or more strategies to climate change were given the score of 1 indicating that they responded to climate change whiles farmers who did not adapt any strategy were given the score of 0 indicating they didn't respond to climate change.

Equation (2) denotes the odds ratio of response to climate change. An odds ratio that is greater than 1 implies that a unit change in each independent variable leads to a decrease/ increase in the odds of a farmer's responding to climate change (Mudombi, 2011). Ten independent variables were hypothesized to influence a farmer's response to climate change based on literature review. These 10 independent variables are the $x^{'}$ in equation (1) and (2)

X_1 = Gender of respondents

X_2 = Age of respondents

X_3 = Climate change awareness of respondents

X_{10} =Size of farm land

Thus, the logit regression model uses a number of independent variables to envisage the odds of a farmer's response to climate change in the North Bank Region of the Gambia. Descriptive statistics of variables hypothesized to influence response decisions of farmers to climate change are illustrated in Table 2.

RESULTS AND DISCUSSION

Farmers' Perceptions about Climatic Factors

Perceptions of the respondents about changes in climate factors (Table 3) revealed that 97.29% of them had experienced changes in climate factors for the past three (3) years with 80.63% of the respondents perceiving changes in both rainfall and temperature. However, 2.33% of the respondents did not perceive any changes in the climate factors. Farmers attributed the changes in climate factors (rainfall and temperature) to continuous deforestation and bushfires in the study area. These findings are in line with those of a previous study by Ndambiri *et al*. (2013) in Kenya.

The perception of farmers about changes in the rainfall pattern for the past 3 years showed that 91.6% of the farmers perceived a decreased in the amount of rainfall, late onset and early cessation of the rain. However, 8.3% of them perceived an increase in the amount and late onset of the rainy season. During the FGD, farmers added that the rainfall pattern had been changing with continuous decreasing and early cessation for the past 3 years with each succeeding year having a slightly lower amount of rainfall than the previous years.

Meteorological data also revealed late onset, early cessation and decrease in amount of rainfall for the past three years (2012, 2013, and 2014) with a worsening situation (Fig. 2).

This confirms the perception of farmers on the changes in the rainfall pattern. These changes have serious implications for crop production, food security and sufficiency as agriculture in the study area is mainly rain-fed. The impact of these changes in rainfall pattern is far from being abstract as sampled farmers indicated low crop yields and sometimes no crop yields as a result of the worsening rainfall pattern.

Table 2: Explanatory Variables for the Model

Variable	mean	Standard Deviation	Minimum	Maximum	Expected sign on R
Gender Dummy(male=1female=0)	0.60	0.49	0	1	+
Age	51.11	15.17	20	85	+/-
Formal Educational status Dummy(educate=1 not educated 0)	0.17	0.38	0	1	+
Marital Status Dummy(yes=1 no=0)	0.89	0.31	0	1	+
Household size	32.14	15.47	3	75	+
Member of farmer organization Dummy(yes=1 no=0)	0.35	0.48	0	1	+
Access to credit Dummy(yes=1 no=0)	0.14	0.35	0	1	+
Awareness about climate change Dummy(yes=1 no=0)	0.85	0.36	0	1	+
Access to extension Dummy(yes=1 no=0)	0.49	0.50	0	1	+
Size of farmland(hectares)	4.43	3.31	0.5	20	+

Table 3: Farmers Perception about Changes in Climate Factors

Perception	Frequency	Percent
Climate has not changed	6	2.33
Climate has changed	251	97.29
Total	**258**	**100**
Perceived factors of change		
Change in Rainfall only	34	13.44
Change in Temperature only	15	5.93
Change in both Rainfall and Temperature	204	80.63
Total	**253**	**100**

The perception of farmers about changes in the rainfall pattern for the past 3 years showed that 91.6% of the farmers perceived a decreased in the amount of rainfall, late onset and early cessation of the rain. However, 8.3% of them perceived an increase in the amount and late onset of the rainy season. During the FGD, farmers added that the rainfall pattern had been changing with continuous decreasing and early cessation for the past 3 years with each succeeding year having a slightly lower amount of rainfall than the previous years. Meteorological data also revealed late onset, early cessation and decrease in amount of rainfall for the past three years (2012, 2013, and 2014) with a worsening situation (Fig. 2). This confirms the perception of farmers on the changes in the rainfall pattern. These changes have serious implications for crop production, food security and sufficiency as agriculture in the study area is mainly rain-fed. The impact of these changes in rainfall pattern is far from being abstract as sampled farmers indicated low crop yields and sometimes no crop yields as a result of the worsening rainfall pattern.

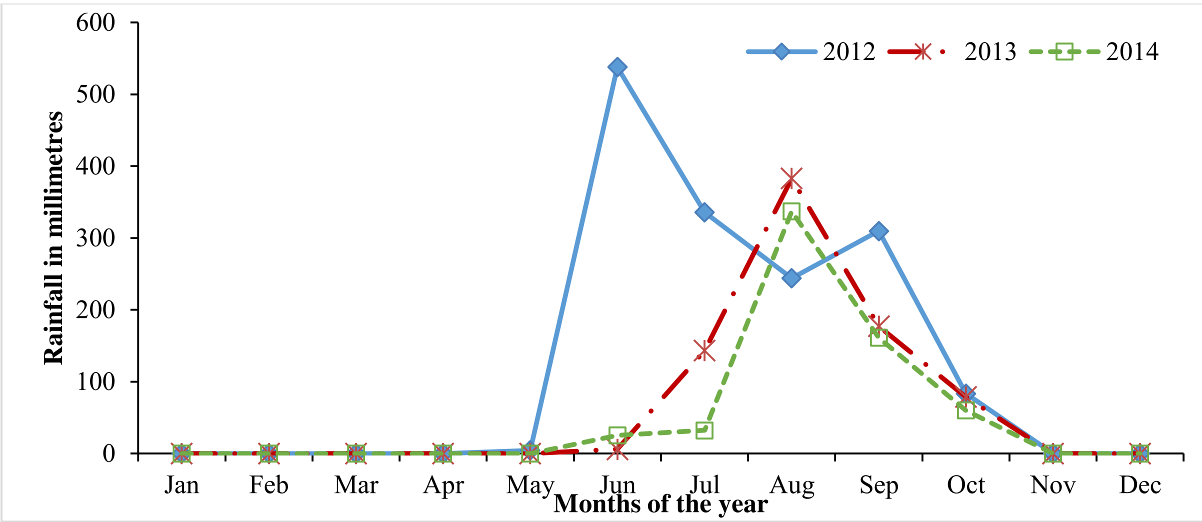

Figure 2: Rainfall Pattern in the North Bank Region for the past 3 years
Source: Meteorological Department of The Gambia, 2015

However, a three (3) decade backward analysis of meteorological data revealed that there was no agreement in meteorological data and farmer perceptions about the rainfall pattern in the study area for the past 30 years. Most of the farmers indicated during the FGD that rainfall was continuously decreasing over the past 30 years. Fig. 3 shows the trend of the rainfall with time and the trend in the rainfall over the past 30 years in the region indicates an erratic but slightly increasing pattern. This is confirmed by the low but positive coefficient of determination (R^2 = 0.104). In addition, farmers' perception about late onset and early cessation of the rainfall for the past 30 years was not in accordance with the meteorological data as indicated in Table 4. The meteorological data revealed that there has not been any significant shifts in the onset and cessation of the raining season in the region for the past 30 years. It was only in the year 1991 where there was a delay in the onset to July instead of May/June or even earlier while the cessation of the rainfall for the past 30 years were mostly in October or even later. The contradiction between the farmers' perception and the observed rainfall pattern over the past 30 years can be explained in two perspectives.

Firstly, according to African Technology Policy Studies (ATPS, 2013) most farmers know precise days or weeks within a critical crop growth period when a crop's demand for water is peak; hence if it does not rain adequately in those critical growth period, farmers might perceive it as decrease in rainfall amount. In addition, majority of the farmers relate crops harvest to the rainy season, as such if other climatic and environmental factors result in a low harvest they tend to perceive the season as bad season of low rains since rainfall is a crucial factor to their crop production.

Secondly, it can be difficult for farmers to remember accurately past weather events, which are not of historical relevance to them as well as their inability to distinguish between climate and weather patterns. This is evidence in Fig. 2 and 3 in which farmers could accurately remember the rainfall pattern for the past 3 years that collaborated with the meteorological data, but could not perceive adequately the changes in rainfall for the past 30 years. According to Moyo *et al*. (2012) farmers inability to vividly remember long time climate event makes it challenging when investigating climate change as farmers may need to use personal experience, which could be unreliable. In principle, farmers choose to learn from experience instead of statistical descriptions, which may lead to flawed interpretation (Moyo *et al*., 2012). Also, Moyo *et al*., (2012) reported that farmers may be observing rainfall decline, which could be attributed to temperature increases. Osbahr *et al*. (2011) noted that temperature increase results in increased evapotranspiration rates, which eventually lead to faster soil water depletion. The findings of this study are in line with the finding of ATPS (2013b) in which meteorological data on rainfall contrast farmers' perceptions in Ethiopia. Moyo *et al*. (2012); Mulenga and Wineman (2014); Dhanya and Ramachandran (2015) also indicated farmers' perceptions of rainfall different from that of meteorological data over the past 10-30 years in their various studies in Zimbabwe, Africa, Zambia and India respectively

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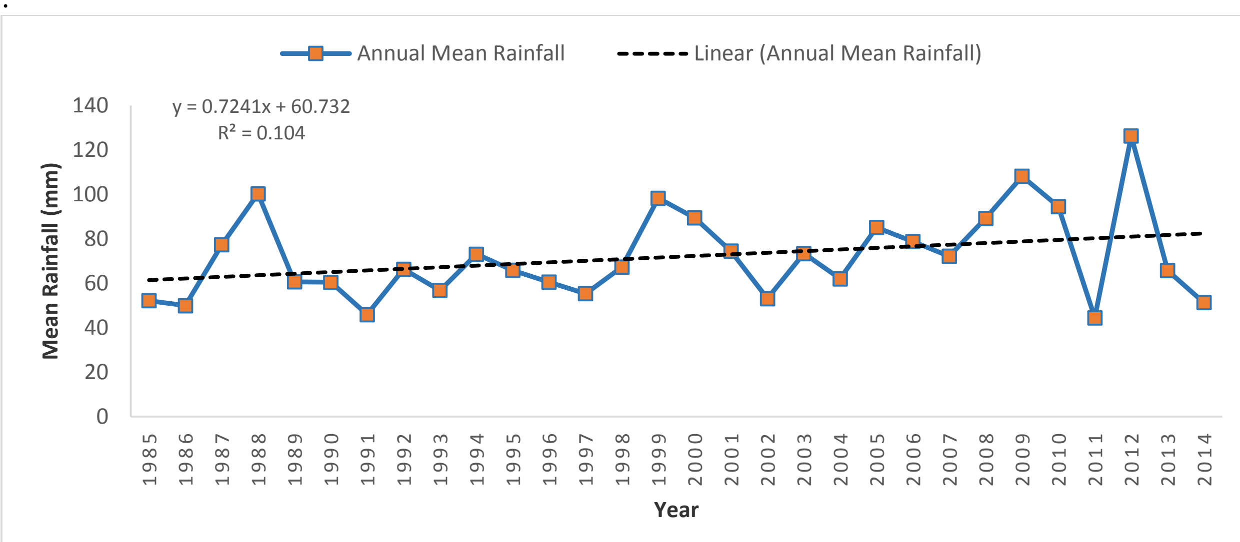

Figure 3: Erratic Trend of Rainfall in the North Bank for the past 30 years

Source: Meteorological Department of The Gambia, 2015

Table 4: Onset and Cessation of Rainy Season in the North Bank Region for the Past 30 Years

Year	Month of Onset Rainy season	Cessation Month of Rainy Season	Year	Onset of Rainy season	Cessation Month of Rainy Season
1985	June	October	2000	June	October
1986	June	October	2001	June	November
1987	June	October	2002	January	December
1988	may	October	2003	June	October
1989	June	October	2004	June	October
1990	June	October	2005	February	October
1991	July	October	2006	June	October
1992	February	October	2007	June	October
1993	June	October	2008	February	October
1994	June	October	2009	may	October
1995	may	December	2010	June	October
1996	June	October	2011	may	October
1997	June	October	2012	may	October
1998	June	October	2013	June	October
1999	may	October	2014	June	October

Source: Meteorological Department of The Gambia, 2015

On changes in temperature for the past 3 years, 77.7% of the respondents perceived an increased in temperature over the past 3 years while 22.3% indicated a decrease in temperature. These findings are in line with the findings of Oruonye (2014) and Adebayo *et al*. (2012) in which farmers perceived an increase in temperature in Taraba and Adamawa state, Nigeria. Farmers also added during the FGD that yearly temperature had been increasing for the past 30 years with each succeeding year having a slightly higher temperature than the previous years due to continuous deforestation and bush fires. They also indicated a reduction in the maturing period of crops and reduced grain production of crops as the effects of increased temperature on their crop production. Fig. 4 shows meteorological data on maximum temperature for the North Bank Region for the past 3 years. It shows an increase in temperature over the past 3 years that goes to confirm the observations made by farmers.

Meteorological trends in both minimum and maximum temperatures for the past 30 years illustrate an increase in maximum temperature and a decrease in minimum temperatures, which is in agreement with farmers' perceptions recorded as showed in Fig. 5 and 6. Temperature is the only variable that farmers perceived which had a clear indication in the meteorological record. The R^2 (0.281) from Fig. 5 indicates the association in the trend of maximum temperature over the years is weak, while the gradient (0.0312x) confirms an increasing trend in maximum temperatures though marginal over the past 30 years. However, the trend in minimum temperatures has being decreasing slightly over the past 30 years as indicated by the negative gradient value (-0.0706x) with R^2 (0.2423) indicating a weak relationship between changes in minimum temperature over the past years

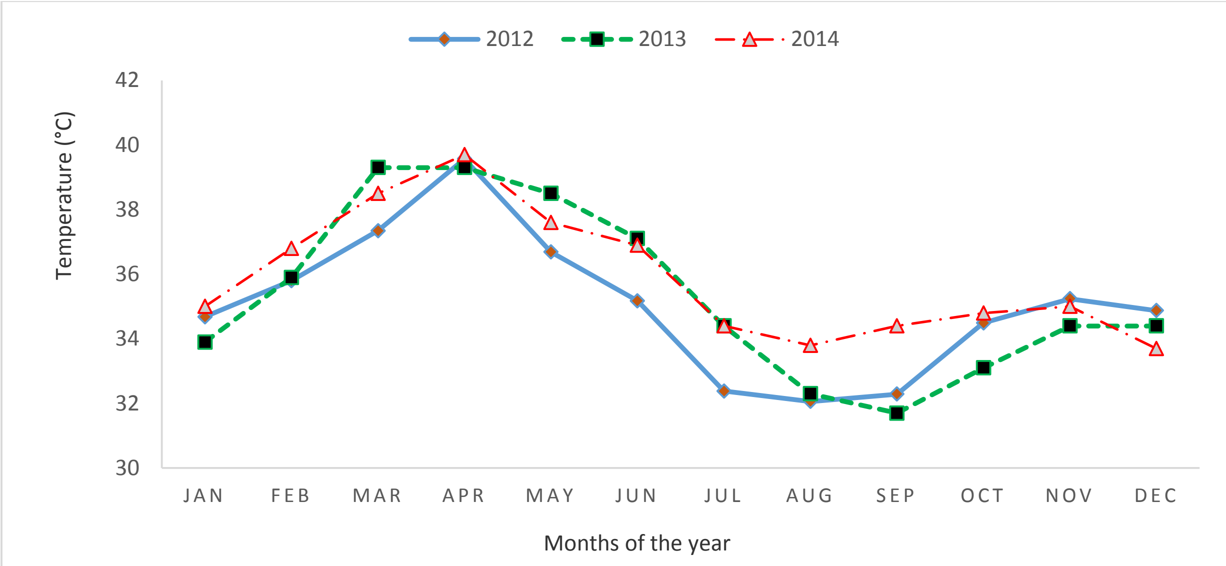

Figure 4: Changes in Temperature in the North Bank Region for the past 3 years
Source: Meteorological Department of The Gambia 2015

Meteorological trends in both minimum and maximum temperatures for the past 30 years illustrate an increase in maximum temperature and a decrease in minimum temperatures, which is in agreement with farmers' perceptions recorded as showed in Fig. 5 and 6. Temperature is the only variable that farmers perceived which had a clear indication in the meteorological record. The R^2 (0.281) from Fig. 5 indicates the association in the trend of maximum temperature over the years is weak, while the gradient (0.0312x) confirms an increasing trend in maximum temperatures though marginal over the past 30 years. However, the trend in minimum temperatures has being decreasing slightly over the past 30 years as indicated by the negative gradient value (-0.0706x) with R^2 (0.2423) indicating a weak relationship between changes in minimum temperature over the past years.

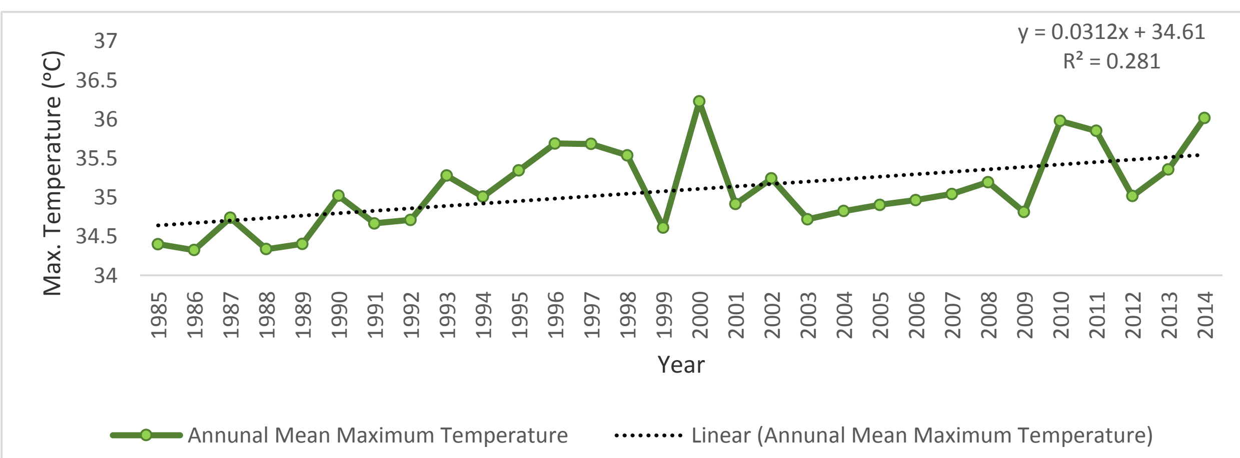

Figure 5: Annual Mean Maximum Temperature of the North Bank Region for the past 30 years
Source: Meteorological Department of The Gambia 2015

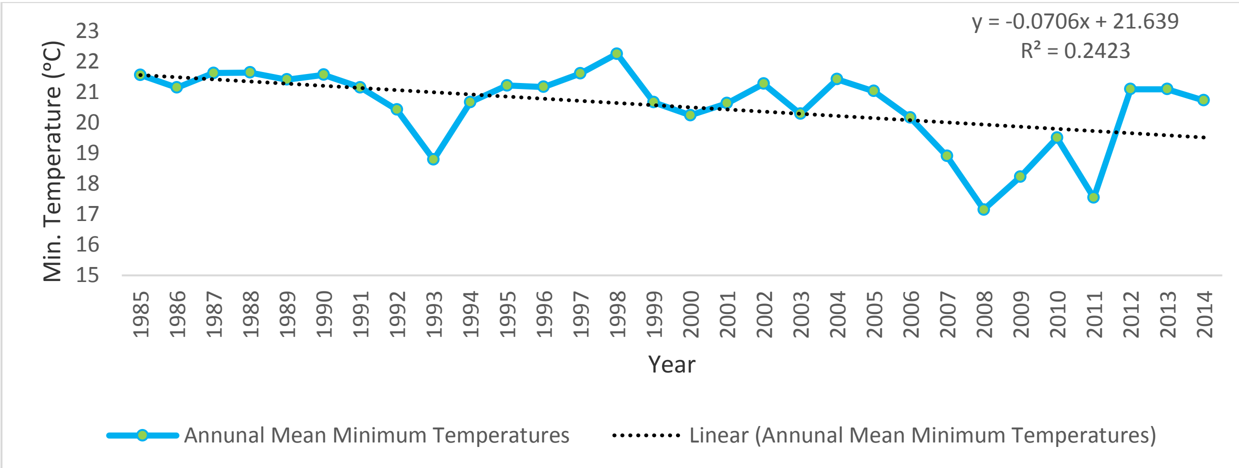

Figure 6: Annual Mean Minimum Temperature of the North Bank Region for the past 30 years
Source: Meteorological Department of The Gambia 2015

Factors Influencing Farmers' Response to Climate Change

Findings from the field survey revealed that an overwhelming majority of 93.41% of the farmers responded to the climate change by adopting one or more response strategies to reduce their vulnerability to climate change and increase crop yields. According to Kutir *et al*. (2015), farmers in the study area practiced one or more of the following response strategies: crop diversification, used different planting dates, used drought resistant crops, used chemical fertilizers, prayer/ritual offerings, implemented soil and water conservation methods, changed land/farm size, early maturing crop varieties, migrated to different locations and crop rotation as response measures to climate change. Table 5 therefore, presents the factors that influence farmers' adoption of an adaptation measure to climate change in the North Bank Region of the Gambia and their significant levels (*P*-values). The significant factors are age, awareness of climate change, access to extension services, access to credit, marital status and size of farmland.

Table 5: Results of Binary Logit Regression on Factors Influencing Farmers' Response to Climate Change.

Log likelihood = -107.12555		Pseudo R2 = 0.2530			
Number of obs. = 258					
		LR chi2(10) = 72.57			
		Prob > chi2 < 0.001			
Response	**Odds Ratio**	**Std. Err.**	**z**	**P>z**	**[95% Conf. Interval]**
Gender	0.76	0.33	-0.62	0.535	0.32 - 1.80
Age	0.98	0.01	-1.65	0.099**	0.96 - 1.00
Educational status	1.11	0.55	0.21	0.834	0.42 - 2.93
Household size	0.98	0.02	-1.04	0.300	0.93 - 1.02
Membership of farmer organization	0.54	0.54	-1.50	0.134	0.25 - 1.21
Access to credit	2.96	1.89	1.70	0.090**	0.85 - 10.37
Access to extension service	4.71	1.85	3.95	<0.001***	2.18 - 10.18

Size of farm land	1.14	0.08	1.86	0.063**	0.99 - 1.31
Awareness of climate change	9.89	3.83	5.92	<0.001***	4.63 - 21.13
Marital status	5.36	2.96	3.05	0.002***	1.82 - 15.82
Cons	0.33	0.28	-1.31	0.189	0.06 - 1.74

Note: * and ** means significant at 1% and 10% level, respectively**

The likelihood ratio chi-square of 72.57 with a p-value of < 0.001 indicates that the model as a whole fits better than the null model (i.e. a model that has no predictors). This implies that the significant factors explain farmers' response to climate change.

The results from the binary logistics regression model indicated that awareness of climate change, marital status and access to extension services were significant at 1% while size of farm land, age and access to credit were significant at 10%. However, gender, formal educational status, member of farmer organization and household size were found not to be significant in influencing a farmer's response to climate change. The odds ratio indicates the effects of a unit change in the independent variable on farmers' response to climate change. Therefore, the odds ratio of awareness of climate change is 9.9, which means that if the climate change awareness level of farmers is increased by 1, the likelihood that farmers will respond is 9.9 times higher. This findings is similar to that of Maddison (2006) who reported that farmers' awareness of changes in climate influence their adaptation decision making in Africa.

Also the odds ratio of access to extension services revealed that the odds of a farmer who has access to extension services is 4.71 times likely to respond to climate change than a farmer without access to extension service. The strong correlation between access to extension and response to climate change in this study is similar to the finding of Fosu-Mensah *et al*. (2012). Nhemachena and Hassan (2007) also revealed that access to extension services was one of the important determinants of farm-level adaptation.

The findings also revealed that, marital status have a positive association with response to climate change. Thus, the odds of a married farmer ever responding to climate change is 5.36 times greater than for unmarried farmers. This finding substantiates that of Mudombi-Rusinamhodzi, *et al*. (2012) in which marital status was most significant to a farmer adaptation to climate variability.

According to recent development in literature, there is no consensus as to the effect of age on a farmer response to climate change (Galvin *et al*., 2001). Some studies have indicated a positive significant of age on adaptation (Gbetibouo and Hassan, 2005) whiles others have found that age has a negative influence in adaptation to climate change (Seo *et al*., 2005; Mandleni, 2011; Fosu-Mensah *et al*., 2012). The results from this study revealed that age negatively influence response to climate change. Thus the expected odds of a farmer to respond to climate change slightly decline with increasing age by 0.980 times. This finding substantiates that of previous studies conducted by Teklewold *et al*. (2006) and Prantilla and Laureto (2013) in which age negatively influence farmer's adaptation to climate change.

Results from the model revealed that farm size was yet another positive determinant of a farmer's response to climate change. The odds of a farmer response to climate change is 1.14 times greater with increasing in farm size. This finding also agrees with the findings of Shiferaw (2014) in which farm size was noted to have positively influenced adaptation. Abid *et al*.

(2015) also found land size/area to be significant to adaptation strategies to climate change in Punjab province, Pakistan.

Likewise, the results revealed that the odds of a farmer with access to credit to respond to climate change is 2.96 higher than a farmer without access to credit. This finding again, is in line with that of Gbetibouo (2009); Deressa *et al*. (2009); Fosu-Mensah *et al*. (2010); Van *et al*. (2015).

In this study membership of farmer organization and educational status of a farmer had no significant influence on the farmers' ability to response to climate change. This findings contradicts with the finding of Van *et al*. (2015); Maddison (2006); Dhakal *et al*. (2013) in which educational status was significant with adaptation to climate change.

The results of this study are also in line with the findings of Mudombi-Rusinamhodzi, *et al*. (2012); Okonya *et al*. (2013) in which household size were not significant to a farmer's adaptation to climate variability. This may be so because, subsistence households are poor, larger family size may increase the dependency ratio and reduce the per capita income and hence, do not contribute meaningfully to raising the resources and adaptive capacity of the family. However, ATPS (2011) found household size to be significant to adaptation to climate change in Malawi.

The results also indicated that gender was not significant in influencing response to climate change. Mudombi-Rusinamhodzi, *et al*. (2012) and Mandleni (2011) also found gender not to be significant to adaptation in their various studies.

Post Model Estimations

From Table 6 the performance of the model in terms of prediction indicated overall rate of correct classification of 80.23%, with 92.31% sensitivity and 42.86% specificity (Table 6).

Table 6: Summary Statistics and Classification Table

Classified	D	~D	Total
+	180	36	216
-	15	27	42
Total	**195**	**63**	**258**

Classified + if predicted Pr (D) >= 0.5
True D defined as RESPONSE = 0

Sensitivity	Pr(+ D)	92.31%
Specificity	Pr(-~D)	42.86%
Positive predictive value	Pr(D +)	83.33%
N False + rate for true ~D	Pr(+~D)	57.14%
False - rate for true D	Pr(- D)	7.69%
False + rate for classified +	Pr(~D +)	16.67%
False - rate for classified -	Pr(D -)	35.71%
Negative predictive value	Pr(~D -)	64.29%
Correctly classified		**80.23%**

The Homsmer-Lemeshow test is an important parameter tests that assumes that there is no difference between the observed and the predicted outcome. Hence, Homsmer-Lemeshow test of the model (Prob > chi2 = 0.2573) failed to reject the null hypothesis which states that "There is not much difference between the expected and observed values" indicating that the model fits the data. The test suggests that the model is a good fit and that the observed and expected cell frequencies are generally in good agreement. In addition, the Receiver Operating Characteristics (ROC) curve showed that for the model to make 100 % correct predictions, it would make about 30 % wrong predictions. The area under the curve is 0.8658 as showed in Fig. 6 below which indicates an excellent predictive power in separating the farmers who responded to climate change and those who didn't respond with optimum cutoff probability of about (0.80) 80 % as shown in Fig. 7 below

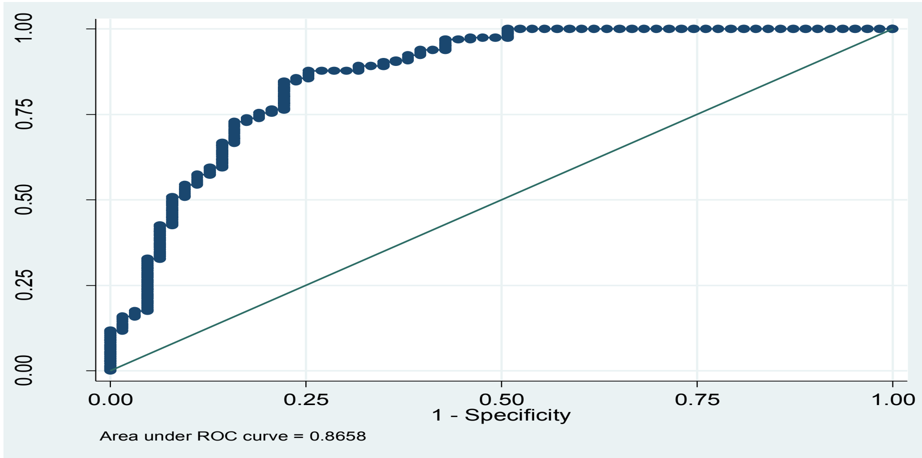

Figure: 6 Receiver Operating Characteristics (ROC) Curve

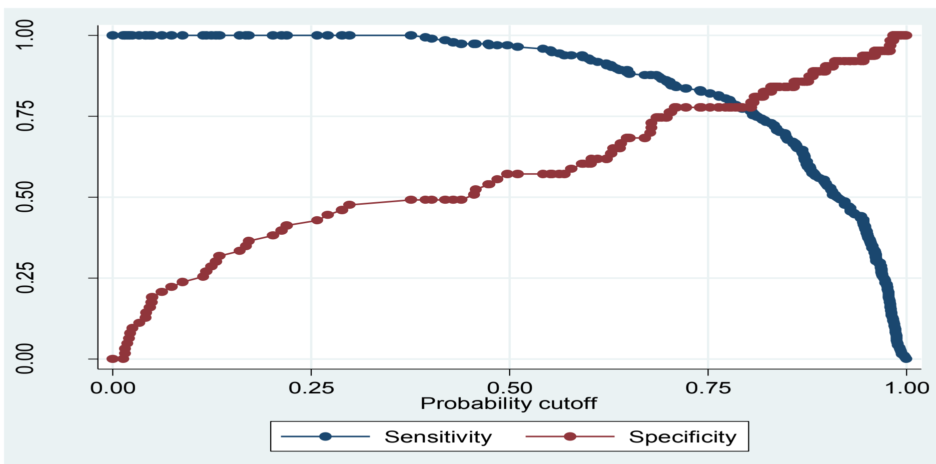

Figure 7: Probability Cutoff Graph

Challenges to the Adoption of Climate Change Adaptation Strategies

The challenges farmers faced in responding to climate change in the study area are presented in Table 7 below. Inadequate access to credit was ranked first in inhibiting all farmers in their response to climate change. This was followed by inadequate access to water and irrigation facilities and inadequate access to efficient inputs ranked 2nd and 3rd respectively. The least challenge was salt intrusion which was ranked 8th in the challenges inhibiting their adaption to climate change. It should be noted that some farmers were not affected by some challenges hence they didn't rank them. These findings are in consonant with that of Idrisa *et al*. (2012) who reported that inadequate financial resources (credit), inadequate access to extension services, poor access to technologies necessary for adaptation and inadequate weather information were the challenges inhibiting farmers' adaptation to climate change in Borno state, Nigeria.

Table 7: Constraints Inhibiting Farmers' in their Response to Climate Change.

Constraints	High	Medium	Low	Total no of respondents	Rank
Inadequate access to credit	254	4	0	258	1st
Inadequate access to water and irrigation facilities	226	28	2	256	2nd
Inadequate access to efficient inputs	246	5	1	252	3rd
Inadequate access to information and poor skills	107	50	17	174	4th
Labor constraints	63	45	20	128	5th
Inadequate access to market	10	76	20	106	6th
Inadequate access to land	35	16	38	89	7th
Salt Intrusion	0	0	56	56	8th

Table 8 presents the possible solutions to these challenges inhibiting farmers' response to climate change. About 84.50% of the farmers specified that government support in the form of farm inputs and credit would help solve their challenges and increase their crop yields. Also, 10.47% of the respondents pointed out that apart from government, other stakeholder could help supply farm inputs and credit as well as stabilize the market for agricultural good as they lack ready market and hence, sometimes they are forced to sell their produce at cheaper prices due to the perishable nature of their produce. Some of the respondents representing 2.33% indicated that awareness on climate change and adaptation measures together with provision of farm inputs will help farmers increase their crop productions. Also, good cooperative unions to buy farm produce and provide credit and farm inputs was recommended by 1.55% of the respondents while preservative means to preserve perishable agricultural goods and agroforestry was recommended by 0.39% and 0.78% of the respondents respectively.

Table 8: Farmers' Proposed Solutions to their Challenges

Solutions to Challenges	Frequency	Percent
Government support in a form of farm inputs and credit	218	84.50
Government and other stakeholders should help stabilize the market for agricultural goods, provide inputs and information	27	10.47
Preservative means to preserve perishable agricultural goods	1	0.39
Create climate change and adaptation measures awareness among farmers and provide farm inputs	6	2.33
Good cooperative unions to buy farm produce and provide credit and farm inputs	4	1.55
Agroforestry	2	0.78
Total	**258**	**100**

CONCLUSIONS

Farmers through personal observations and experiences have adequate knowledge on the changes in climate factors specifically rainfall and temperature for the past 3 years. It can be concluded that farmers' perception of changes in temperature for the past 30 years are in line with the meteorological data, but there is a clear contrast between their perception of changes in rainfall pattern over a 30 year period and the meteorological data and this has repercussions for crop production.

Finding from the empirical models revealed that a combination of factors influences a farmer's response to climate change. Thus, age of farmer, awareness of climate change, marital status, access to extension service, access to credit and farm size influence farmers in the North Bank Region to adopt response strategies to climate change.

Farmers in the North Bank Region are faced with diverse challenges that inhibit their ability to increase their crop productions. These challenges include, but are not limited to inadequate credit, inadequate access to efficient inputs, inadequate access to information and poor skills, labor constraints and inadequate access to market. These challenges have adversely affected the ability of farmers to response to climate change thus, causing some poor farmers not to respond to climate change.

RECOMMENDATIONS

It is recommended that farmers form farmer groups/organization to enable them have easy access to extension services and awareness programmes, as well as enable them have easy access to credit and other farm inputs since NGOs prefer to work with farmers in organized groups. This would help increase crop production, sustain farmers' livelihoods and ensure food security in the country.

Also, the positive and significant socioeconomic factors that influenced response in this study such as awareness of climate change, farm size, and access to extension should be considered and enhanced when implementing programmes and projects on response to climate change among farmers.

There is the need to educate and facilitate the broadcasting of seasonal climate forecast information to help increase farmers' knowledge and shape their perceptions by Government and other private organization**.**

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