Farmers Socio-Demographic Factors and their Adaptive Response to Climate Change in Mubi Region of Adamawa State, Nigeria

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Abstract

The study examined farmer's socio-demographic factors and their adaptive response to climate change in Mubi Region of Adamawa State, Nigeria. The primary data were obtained through the use of structure questionnaire survey of 927 respondents from 28 communities of the study area; data obtained were analyzed using, descriptive statistics bivariate regression, multiple regression analysis, principal components analysis and canonical correlation analysis. The results ascertained that farmers in the study area are aware of climate change and adopt various adaptation strategies such as planting of early maturing crops, planting of drought and heat tolerant seeds and changing time of land preparation. The result of the ANOVA analysis showed that farming experienced has a significant influence on farmer's adaptive response to climate change ($F=43.547$, $P<0.05$), this shows that to a great extent farmer's adaptive response to climate change is influenced by their farming experience. The canonical loading results shows that education of farmers in the study has positive and significant association with planting drought and heat tolerant seed varieties and planting early maturing crops. However, constraints towards adaptation according to the respondents includes, higher cost of fertilizer and other farm inputs, poor information on early warning system, traditional beliefs and unavailable credit facilities.

Key Word: *Climate Change, farmer's sociodemographic factors, Farmer's adaptive response, farmer's adaptation Strategies and*

Introduction

Farming activities in recent times has been bedeviled by harsh environmental conditions as a result of global climate change. These changes have negatively influenced all farming activities from the tropics to the desert lands. These changes in the weather and climate conditions are orchestrated mostly by anthropogenic activities and in some cases from natural causes. Anthropogenic activities like the incomplete combustion of fossil fuel during the industrial production processes, car, locomotives and generator exhausts and industrial chimneys, mining activities and waste dumps. Others are bush burning, use of harsh and environmentally unfriendly agrochemicals among others. Natural causes could include volcanic eruption, earth quakes, hurricanes, tornadoes, etc.

It is mandatory that farmers must rise up to the challenges of the effects of global climate change on their agricultural productivities. To do these, farmers have adopted some adaptive or preventive measures to combat these harsh environmental conditions to enable them grow their crops and rear their animals for optimum productivity. In doing this, what inform the choices of the adaptive or preventive strategies farmers use? It is believed that the choice of any measure taken or adopted by the farmers is as a result of the extent to the farmer's sociodemographic characteristics; their extent of education, size of workforce, farm size, income, family types, religion, culture, awareness, information available to the farmers etc. that will determine the type of adaptive response to climate change. Sociodemographic factors like age of the farmer, length of time he has engaged in farming activities, level of education, gender, age, source of information and awareness, income, among others negatively or positively affect farmer's choices of adaptive response to climate change. This paper is in response to the fact that how does farmers' sociodemographic characteristics influences farmer's choice of adaptive response to global climate change in order to boast his agricultural productivity.

Despite the issues already raised, most farming activities are impaired by the climate conditions, the soil fertility, the quality of crops or stocks grown and reared, the farmer's maintenance culture and habits, the available input to be used in the farmers, the labor and other factors such as the farmer's income, knowledge of seasonality and ability to forecast weather or climatic conditions among others. All these are fundamental to agricultural productivity in every farming community. Every action taken by the farmer during his production season or harvesting season is informed by the farmer's knowledge based on previous experiences or from other farmers, which has been made known to the farmer. All these are a product of his sociodemographic characteristics or factors which inform his choice of action or decision concerning his farming activities.

Sorhang and Kristiansen (2011) strongly held that farmer's sociodemographic factors play very significant role in the choice of actions they take regarding their farming activities. The socio-demographic characteristics of respondents have significant impact on their level of awareness of climate change as well as their adaptation responses to the impacts of climate change. Studies like those of Deressa *et al.,* (2011) stated that age might often mean better experience, access to information, and knowledge, but also other factors like weaker health, and consequently age and experience might give both positive and negative outcomes. Experience in farming increases the likelihood of uptake of adaptations to climate changes. Sorhang and Kristiansen (2011) stated that those over 69 years old seems to be less adaptive, however, younger people seem to some extent to be more likely to adopt adaptation strategies. Maddison (2006) reported that there is a positive relationship between the education level of the head of household, the implementation of improved technologies, and adaptation to climate changes. Deressa *et al.,* (2011) study showed that higher farm income positively affects the perception of climate change while non-farm income has negative effects.

In a study by Sorhang and Kristiansen (2011), they reported that 5 per cent of the respondents in Hagere Selam mentioned that they perceived reduced income or increased poverty due to climate changes effects on their agricultural productivity. When there is low income or lack of income to take up certain adaptive response, the farmer is the one who is at a loss. Franzel (1999) reported that the impact of income on adaptation found a positive correlation between income and adaptive capacity. Furthermore, farm and nonfarm income, farm size, and livestock ownership, represent wealth were all some sociodemographic characteristics which influences farmer's adaptive response to climate change. According to Kandlinkar and Risbey (2000), with income and resource limitations, farmers fail to meet transaction costs necessary to acquire adaptation measures and at times farmers cannot make beneficial use of the available information they might have due to lack or shortage of income.

In another study by Odewumi, Awoyemi, Iwara *et al.,* (2013) to identify factors influencing farming's perception of climate change, these authors found the length of farming to exert significant influence on farmers' perception of climate variation. They stated that years of farming enable a farmer to understand changes in crop behaviour and the possible reasons for the observed changes. Nhemachena and Hassan (2007) found that farming experience increases the probability of uptake of all adaptation options because experienced farmers have better knowledge and information on changes in climatic conditions, crop and livestock management practices. Sumathi and Annamalai (1993) found that farmers having more years of experience were the highest adopter of technologies, there is positive and significant correlation with the level of adoption. Experience helps an individual to think in a better way and makes a person more mature to take right decision. Maddison (2006) notes that perception of climate change appears to hinge on farmer experience and the availability of free extension advice specifically related to climate change.

Smithers and Smit (2009) observed that adaptations can either be planned or autonomous with the latter being done without awareness of climate change predictions but based on experience and prevailing conditions. In their studies, Deressa *et al.,* (2009) and Akponikpe, Peter & Agbossou *et al.,* (2010) revealed that farmers with higher levels of education are more likely to adapt better to climate changes. In line with this, Dhaka, Chayal and Poonia (2010) reported that the farmers' level of education greatly increases the probability of adaptation to cope with effect of climate change. Yirga (2007) stated that the influence of household size on adaptation methods can be seen from two perspectives. The first assumption is that households with large families may be forced to divert part of the labour force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family. The other assumption is that large family size is normally associated with a higher labour endowment, which would enable a household to accomplish various agricultural tasks. Deressa *et al.,* (2011) reported that households with large families are more likely to adapt to climate changes. Sorhang and Kristiansen (2011) further revealed that larger household size is related to higher adaptive capacity implying that farmers with large family sizes are more likely to adapt to climate adaptation responses.

Looking at the works of other researchers, what role can farmer's sociodemographic factors play in the choice of the farmer's adaptive response to climate change? It is on the strength of this argument that this research sought to examine how farmer's sociodemographic factors influence their choices of adaptive response to climate change in Mubi Region of Adamawa state, Nigeria.

Objectives of the Study

1) To examine the various forms of climate change adaptation strategies adopted by farmers in Mubi Region
2) To ascertain the influence of farmers socio-demographic factors on adaptive response to climate change
3) To identify the major constrains to effective adaptation measure

Hypothesis

Farmer socio-demographic factors (gender, marital status, age, education, farming experience and income) are not related to climate change adaptation response strategies adopted by farmers in Mubi region.

Materials and methods (Research methods)

Study Area

Mubi Region lies between latitude $9^{0}30^{1}$, 11^{0} North of the equator and longitudes $13^{0}45^{1}$ East of the Greenwich meridian. The Region is bounded by Borno State to the North; West by Hong and Song Local Government Areas of Adamawa State and to the South and East by the Republic of

Cameroon (See figure 1) it has a land area of 4728.77km^2, with a population of 960,223 projected from 2006-17. The Region has five Local Government Area and 24 Districts, dry season last for a minimum of five (5) months (November to March) while wet seasons spans from April to October. The mean annual rainfall in the Region ranges from 900mm-1050mm (Adebayo, 2004). Generally planting of crops begins earlier in the mountainous area due to orographic factors. Agriculture is the mainstay of about 80% of the inhabitants of the area.

A multistage sampling technique was used in the selection of the registered farmers from the study area. The first stage involved the consideration of the Five Local Government of the study area. While the second stage adopted the simple random selection of 60 percent of the District in each Local Government Area of the study area, the third stage constitute consideration of 5 percent of the registered farmers from each selected District as shown on Table 1, which resulted to 927 respondents for the research. Then two farming settlement were chosen through simple random sampling method from each of the selected District for the study, this yielded 28 settlements. The study used a structure questionnaire, participant observation and interview. The structured questionnaire sought the respondents' opinion, knowledge or suggestion on farmer's sociodemographic factors as predictors of the choices of farmer's adaptive response to climate change in Mubi Region of Adamawa State, Nigeria. The questionnaire is close and open ended response format and was designed in a manner to capture all the variables in the study.

Descriptive and inferential statistical techniques were used to analyze data collected. Data obtained were analysed using simple percentages analysis, bivariate regression, multiple regression analysis, principal components analysis and canonical correlation analysis (COR). Multiple regression analysis is a generalized statistical technique used to analyze the relationship between a single dependent variable and several independent variables. In this technique, non-metric variables (binary or categorical) can only be used by creating dummy variables (Hair, Black, Babin & Andersen, 2010). The results of data analyzed are presented on tables .

Figure 1: Adamawa State Showing Mubi Region

Source: Mubi Region, Geographical synthesis (2004)

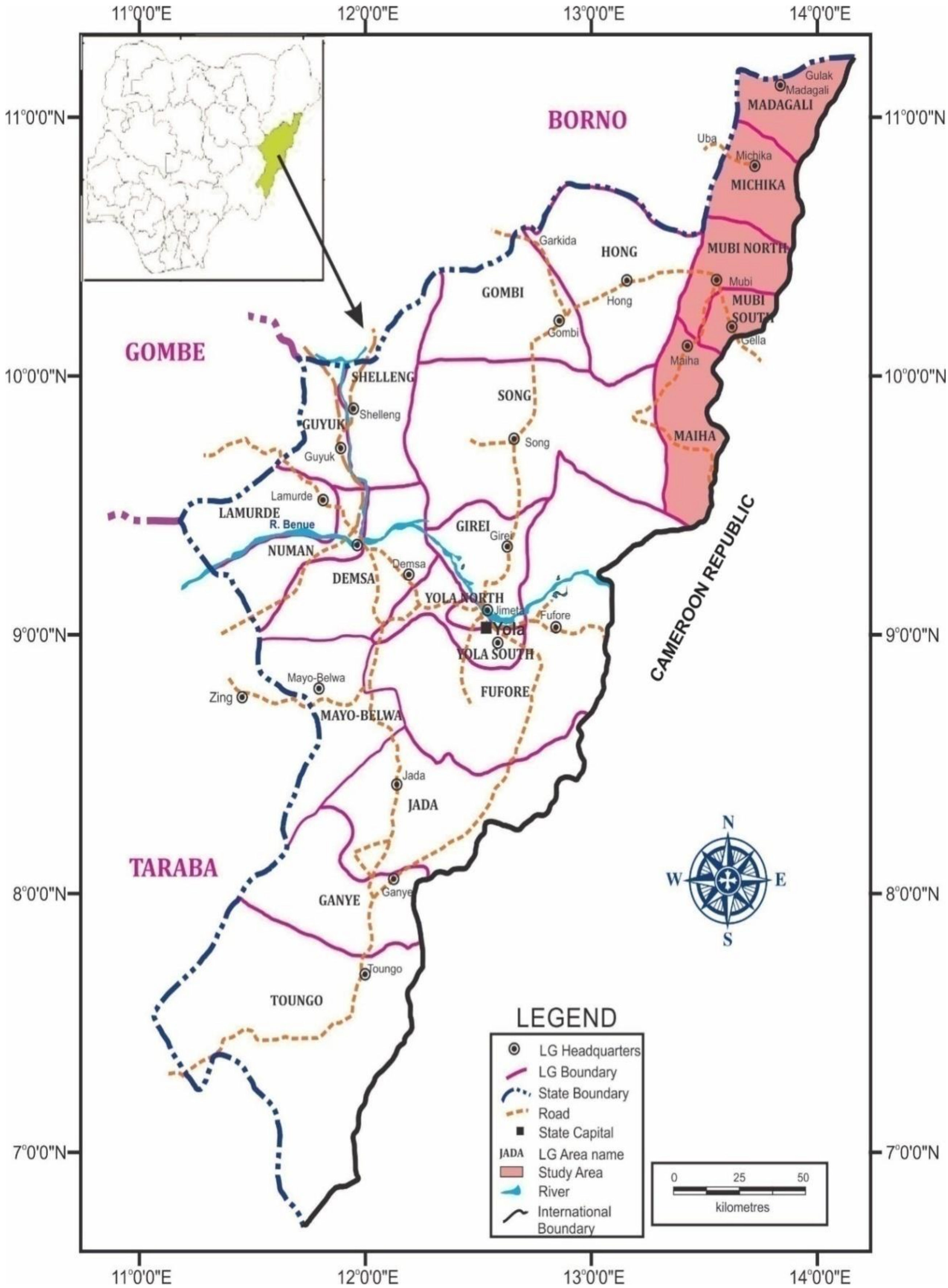

Table 1: Number of farmers in each sample district with their sample size and total number of questionnaire copies administered

S/No	L.G.A	Selected District at 60 per cent	No. of registered farmers in each selected district	A sample size of 5 per cent farmers	No. of settlement selected
1	Madagali	Madagali	1440	72	2
		Gulak	1220	61	2
		Mildo	1704	85	2
	Total		**4364**	**218**	**6**
2	Maiha	Maiha	1221	61	2
		Belel	806	40	2
		Sarou	1440	72	2
	Total		**3467**	**173**	**6**
3	Michika	Bazza	2342	117	2
		Vih	906	45	2
		Garta	2494	125	2
		Futu	890	45	2
		Zah	901	45	2
	Total		**7533**	**377**	**10**
4	Mubi North	Bahuli	1206	61	2
		Mayo Bani	986	49	2
	Total		**2192**	**110**	**4**
5	Mubi South	Gella	984	49	2
	Total		**984**	**49**	**2**
Total		**14**	**18,450**	**927**	**28**

Source: Federal Ministry of Agriculture and Rural Development (2018)

In the present study, multiple regression analysis was used to understand the influence of years of farming, age and education on farmers' knowledge of climate change. The test was used to identify the main factors or variables that contribute most to farmers' knowledge of climate change as well as show the level of explanation accounted by the predictor variables. It was also used to examine if farmers' adaptive response strategies to climate change were influenced by socio-demographic factors (gender, farming experience, age, income, and education).

Principal components analysis (PCA) was also used to identify significant factors responsible for climate change; identify principal adaptive measures as well as pick out major constraints of climate change adaptation among farmers in Mubi Region. PCA is a very powerful multivariate statistical technique which is performed to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible the variability present in data set (Jianqin, Jingjing & Xiaojie, 2010). PC provides information on the most meaningful parameters, which describe the whole data set affording data reduction with minimum loss of original information (Vega, Pardo & Barrado, 1998). PCA attempts to transform a large set of inter-correlated indicators into a smaller set of composite indicators, uncorrelated (orthogonal) variables called principal components (PCs), and simplifies the structure of the statistical analysis system (Jianqin *et al.*, 2010). PCA was performed in the present study to reduce the adaptive measures and constraints of climate change adaptation data set as well as to extract a small number of latent factors for analyzing relationships among the elements This was achieved by extracting only components with eigen values >1 after Varimax rotation (Wang, Guo & Jin, 2009; Otitoju & Enete, 2016). Component loadings according to Liu, Lin and Kuo (2003) can be classified as strong (>0.75), moderate (0.75-0.50) and weak (0.50-0.30).

Furthermore, (COR) was performed to understand how socio-demographic factors (notably gender, marital status, age, cropping pattern, education, farming experience and average income) are related to a set of adaptation measures. Through this analysis, significant socio-demographic factors and adaptation factors are identified and their nature of interrelationship explained. Canonical correlation can make use of both metric and non-metric data for either the dependent or independent components (Hair, Black, Babin & Anderson, 2010). The form of canonical analysis according to Malacarne (2014) can be expressed as:

$$\mathbf{X} = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}, \quad \mathbf{Y} = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}.$$

In this model, X and Y are sets of socio-demographic factors and adaptation parameters. The socio-demographic parameters included:

X= socio-demographic parameters:

X_1 = Gender

X_2 = Age of farmers

X_3 = Cropping pattern

X_4= Education

X_5= Farming experience

X_6= Average monthly income

X_7= Marital status

While, the adaptation parameters included:

Y = Adaptation parameters

Y_1 = Altering plants schedule

Y_2 = Planting of tolerant seed variety

Y_3 = Planting early maturing seed

Y_4 = Crop diversification

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Y_{23} = Change of farm land

Canonical correlation is a symmetrical or proportional technique in that the distinction between independent and dependent variables is not considered necessary (Sherry & Henson, 2005; Hair *et al.*, 2010; Iwara *et al.*, 2011). Canonical correlation according to Aweto (1981) and Veldman

(1967) cited in Offiong (2010) is a multivariate statistical approach that examines the way in which two multivariate measures are related and the strength and nature of these relationships. The canonical variates or functions are pairs of maximally correlated linear combinations of predictor and criterion variables. The reason of canonical analysis is basically the formation of pairs of linear arrangement of two sets of variables in such a way as to make the most of the correlation between each pair. This analysis gives a clear picture of the complex interactions between two sets of variables.

Results and Discussion

a) Assessment of adaption strategies employed by farmers in Mubi Region

The farmers in Mubi Region are knowledgeable of climate change, they apply or employ different adaptive measures to mitigate the direct impact on crops and animals and the essence is to achieve good yield. Several adaptive measures are employed by farmers in the area, but the principal measures usually employed are shown in Table 2. The PCA result has helped to condense the several factors into few and significant ones. As shown in the result that of the 23 variables considered in the present study, 5 were extracted and they explained 49.0 per cent of the variation in the set of data used to measure farmers' adaptive measures. PC_1 explained 12.3 per cent of total variance in the data set and signified use of cover crops. PC_2 explained 10.5 per cent of the total variance in the variable set and signified planting of tolerant seed variety. PC_3 represented minimum tillage and was accountable for 10.1 per cent of the total variance. PC_4 signified planting early maturing crops and it was responsible for 8.1per cent of the variance in the data set, while PC_5 denoted changes in the time of land preparation and it was responsible for 8.0 per cent of the variance in the data set.

The result in Table 2 therefore recognizes use of cover crops, planting of tolerant seed variety, minimum tillage, planting early maturing crops and changes in the time of land preparation as main adaptive measures employed by farmers in the area to sustain their farming business in the midst of changing and harsh climate phenomena. In the area, the planting of cover crops mostly legumes (cowpea, soya beans, groundnuts; lima beans) are used to conserve the soil and maintain soil moisture. The planting of these crops help to reduce the rate of soil water loss (evaporation) mostly during periods of increased dry spells. As a result of the ability of these crops to withstand harsh climate condition, they grow very well in Mubi Region. Apart from the atmospheric nitrogen fixation process of these leguminous plants to the soil, they also help in soil erosion control. In line with these assertions, Kaye and Quemada (2017) stated that cover crops have long been publicized for their ability to fix atmospheric nitrogen, improve soil health, reduce erosion, and leaching. See table 2. The result on table 2 further showed that cover crop effects on greenhouse gas fluxes typically mitigate warming by ~100 to 150gCO_2 e/m^2/year, which is higher than mitigation from transitioning to no-till. They also help in soil carbon sequestration and reduced fertilizer use.

Another adaptive measure employed by 89.9 per cent of farmers in the area is the planting of tolerant seed variety. Through the assistance of agricultural extension officers and research institutes in Nigeria, farmers in the area have access to treated or improved variety crops that are able to resist pests, insects and droughts. The planting of these crop varieties enable farmers in the area to adapt and manage successfully the threats and unpredictability of climate change.

Through this measure, they are able to make food available to households. In a related study carried out in the Adamawa State, Williams *et al.*, (2015) reported that a significant per centage of farmers in the area plant crops that are resistant to pest and drought. This adaptive measure according to the authors enables farmers in the area to be able to cope with the unpredictable impact of climate change as well as to facilitate and enhance food production for their respective households. In another study carried out in Tanzania, Westengen and Brysting (2014) stated that crop adaptation of switching to more drought-tolerant crop species or varieties is an important adaptation strategy within a diverse portfolio of livelihood responses to climatic stress.

Farmers in the area know the importance of minimum tillage and it is practiced to reduce the impacts of climate change. Smith, Martino, Cai *et al.*, (2008) stated that tillage of the soil facilitates microbial decay of soil organic matter which results in the release of CO_2 to the atmosphere. Therefore, minimizing tillage favours sequestration of carbon in the soil. In the last decades, advancements in weed control methods and farm machinery now allow many crops to be grown with minimum tillage (Smith *et al.*, 2008). In another study, Mangalassery, Sjogersten, Sparkes *et al.*, (2014) stated that soil tillage practices have an immense influence on the physical properties of soil and the greenhouse gas (GHG) balance. The study showed that zero tillage could play a significant role in minimising emissions of GHGs from soils and contributing to efforts to militate against climate change. In all, farmers in the area practice minimum tillage to basically conserve soil nutrient and protect the soil and other crops from extreme weather events (see PCA result on table 3).

Planting of early maturing crops is also employed by well over 86 per cent of the farmers to adapt to the changing climate phenomena. This is consistent with the findings of Williams *et al.*, (2015) in Adamawa State where a larger per centage of the farmers enage in planting of early maturing crops. Nevertheless, the planting of early maturing crops as identified in the present study enables farmers to harvest crops before the onset of extreme weather conditions. It also enables farmers to be able to meet up with household food demands as well as generate household income from the sales of farm produce. Early maturing crops also enable farmers to produce food throughout the year or season as crops can be planted twice a year (one for the raining season and the other for dry season). The crops so planted are able to tolerate existing weather conditions. Through with these measures, farmers are able to deal with the unpredictable impact of climate change and boost food production.

Table 2: PCA result showing adaption strategies employed by farmers[a]

Variables	Principal components				
	PC_1	PC_2	PC_3	PC_4	PC_5
Mulching cover crops	<u>0.707</u>	0.031	0.114	-0.030	-0.018
Groundwater harvesting	0.685	-0.064	0.218	0.023	0.075
Water storage in ponds	0.634	-0.115	0.181	0.039	0.258
Use of wetlands	0.630	0.170	0.219	-0.106	0.019
Irrigation scheme	0.500	0.335	0.252	-0.136	0.002
Altering plants schedule	0.445	0.279	0.163	0.238	-0.101
Tolerant seed variety	0.278	<u>0.764</u>	0.036	0.229	0.034
Planting early maturing seed	0.027	0.649	0.017	0.168	0.105
Intensive use of fertilizer	-0.135	0.638	-0.028	0.193	0.302
Crop diversification	0.149	0.595	0.038	0.201	0.196
Minimum tillage	0.191	-0.087	<u>0.788</u>	0.262	0.072
Change crops to livestock	0.148	-0.047	0.682	0.105	0.030
Zero minimum tillage	0.233	-0.017	0.630	0.112	0.120
Forestation	0.271	0.149	0.600	-0.134	-0.002
Multiple cropping	0.071	0.396	0.521	-0.206	0.099
Planting maturing crops	-0.166	0.284	0.191	<u>0.792</u>	0.048
Change of farmland	0.232	0.162	-0.045	0.678	0.108
Use of pesticides and herbicides	-0.147	0.240	0.077	0.656	0.190
Changing time of land preparation	0.164	-0.096	0.104	0.084	<u>0.712</u>
Mixed cropping	-0.070	0.271	0.016	0.177	0.610
Changing planting dates	0.392	0.147	0.044	0.227	0.493
Prayers to God/gods	-0.122	0.262	-0.048	-0.003	0.455
Movement of new land	0.144	0.163	0.267	-0.021	0.450
Eigenvalues	2.84	2.41	2.33	1.86	1.84
per cent variance	12.33	10.5	10.14	8.09	7.99
Cumulative exp.	12.33	22.83	32.97	41.06	49.04

[a]the underlined with coefficients ±≥0.7 are considered significant
Source: Researcher's fieldwork, 2018

The last but significant adaptive measure employed by 85.6 per cent of the farmers in the area is the ability to change the time of land preparation for certain crops. Due to the unpredictable nature of climate, farmers in the area have also altered the timing for the planting of certain crops. Crops like groundnut and vegetables among several others are now planted in the early rains due to their dependence on moisture. This approach enables the farmers to mitigate the impacts of extreme weather events like increase in temperature and sporadic rainstorms. In line with the assertion made above, Singh, Prasad and Reddy (2013) stated that changing planting date is necessary to avoid the detrimental effects of high temperatures.

According to Olesen, Trnka, Kersebaum *et al.*, (2011), a shift in planting dates (e.g., earlier planting of spring crops to avoid hot and dry periods during summer) is one of the expected adaptation responses to climate change in the cooler zones of Europe, while for wheat in Northwest India, sowing date would need to be advanced by six days per degree rise in temperature (Kalra, Chakraborty, Sharma *et al.*, 2008). Also, study carried out by Kuchirak (2008) stated that earlier planting of maize and wheat and improved yields have been achieved in the US by avoiding temperature stress during seed filling. In all, the results in Table 2 simply indicate that use of cover crops, planting of tolerant seed variety, minimum tillage, planting early maturing crops and changes in the time of land preparation the main adaptive measures employed by farmers in Mubi Region to cope with the unpredictable nature of climate.

b) Influence of farmers' socio-demographic factors on adaptive response to climate change

The analysis was carried out using stepwise multiple regression analysis. Data on socio-demographic attributes were gathered from the responses of gender, farming experience, age, farm size, income, and education, while data for adaptive response was obtained/gathered using responses obtained for the questionnaire. This item is chosen among others because it has the highest mean value of 4.14. The respective data were duly recoded to make them suitable for the application of parametric statistics. The result of stepwise multiple regression analysis is shown in Tables 3 to 5. The summary result in Table 3 showed that among the four predictor variables entered into the model, only farming experience was retained and it explained 10.4 per cent of the variation in farmers' adaptive response to climate change. It therefore suggests that the adaptive measures employed by farmers in the area are substantially determined and controlled by farming experience.

Result of ANOVA in Table 3 showed that farming experience has a significant influence on farmers' adaptive response to climate change ($F = 43.547$, $p<0.05$). These shows that to a greater extent farmers' adaptive response to climate change is influenced by their farming experience. This is expected as the experience gained over time and observed crop behaviour over time determines the kind of adaptive measure to employ in order to enhance crop production. From the experience gained in past years and the yield recorded, farmers will be able to prepare for the seasons ahead as well as know the exact adaptive measure to put in place to mitigate the impacts of climate change. The observation of climate conditions (early or late rains and early cessation) among others are some of the climate changes that farmers consider in responding to climate change. For instance, if they observe early cessation of rains over time, they will plant or sow crops with early maturity or that are able to resist changing climate condition.

Furthermore, the result in Table 6 showed that farming experience exercised significant influence on farmers' adaptive response to climate change ($t = 6.599$, $p<0.05$). It also shows that farming experience is able to make about 21.9 per cent of the farmers in Mubi Region employ adaptive measures to enable them mitigate the impacts of climate change and sustain their livelihood. As already argued above, farming experience increases the likelihood of farmers to take up or adopt adaptation options based on the experiences gained over time and also based on the record of crop yields over time. The behaviour of crops (in terms of growth) and yields recorded as well as cost involved in crop management will enable farmers know the suitable adaptive measures or options that need to be put in place to improve the conditions experienced in the past farming season.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.322	0.104	0.103	0.25140

Table 4: ANOVA of the influence of farming experience on adaptive response

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	2.752	1	2.752	43.547*	0.000
Residual	52.962	838	0.063		
Total	55.714	839			

*Significant at 5 per cent alpha level

Table 5: Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.726	0.032		22.733*	0.000
Farming experience	0.219	0.033	0.222	6.599*	0.000

*Significant at 5 per cent alpha level

This can only be feasible through farming experience. This result agrees with the submission of Elum, Modise and Marr (2017) that the extent at which a system will adapt is dependent on its vulnerability to climate change which is in turn influenced by its level of exposure and sensitivity to climate change impacts. For instance, frequent happening of extreme weather events such as flood hazards can lead to great farming losses thereby increasing farmers' risk awareness and need to adapt measures to reduce the risk.

The result also corroborates the findings of Limantol, Keith, Azabre *et al.*, (2016) when they reported that farmers in Ghana who are aware of climatic changes and have experienced the impacts are adapting strategies to enable them cope with the effects but require support. The result obtained also agrees with the findings of Fadina and Barjolle (2018), when they found that climate change adaptation strategies was influenced by farming experience, educational level, farm size and gender. The study argued that that only the most experienced and well educated are able to employ adaptation strategies to climate change. A study carried out in the mountainous region of Nepal by Poudel, Funakawa and Shinjo (2017) found that majority of the household based on their experience and knowledge of climate change have changed farming practices to include changes in sowing/planting time and the introduction of new cash crops such as black cardamom and coffee which are more resilient to water stress and have higher market value as well as changes in water conservation methods.

The result on Tables 3 to 4 therefore identifies farming experience as a socio-demographic attribute that significantly influence farmers' adaptive response to climate change. These factors are able to make significant proportion of farmers in Mubi Region employ appropriate adaptive measures. This will enable them cope with unpredictable impact of climate change and increase food production. Farmers who are more experienced are more likely to employ different adaptation strategies to climate change.

c) farmers' socio-demographic factors and climate change adaptation

In this part of the analysis, canonical correlation analysis (COR) was performed to understand how socio-demographic factors (notably gender, marital status, age, cropping pattern, education, farming experience and average income) are related to a set of adaptation measures and to give answer to the research hypothesis. The analysis used a combination of PCA and COR. PCA was used to reduce the sets of socio-demographic and adaptation factors, and the regression scores generated using the model was further used for COR. The results obtained are shown in Tables 6 to 9. The information in Table 6 provides test of significance. The result showed that the test is significant ($p<0.05$). It therefore suggests that the canonical correlation test for the sets of variables is significant. Hence, the two extracted canonical roots or variates are significant at 5 per cent confidence level. The significance of the canonical correlation is argued in the literature not to determine the number of canonical variates or functions to retain for the purpose of making inference (Sherry & Henson, 2005; Iwara, Ogundele, Ibor *et al.*, 2011). The reason is because significance test does not reveal the amount of variance shared by the two sets of variables. On this note, the use of redundancy coefficient and canonical loadings was suggested as they reveal the amount of variance shared by the two sets of variables (Sherry & Henson, 2005; Iwara *et al.*, 2011). It therefore means that though the canonical correlation is significant but the number of canonical roots or functions to retain in order to understand the nature of interrelationship between socio-demographic factors and adaptation measures to climate change was determined considering the values of canonical loading.

In addition, Table 7 gives information on the ratio of the eigenvalues which provides relative measure or variance on the importance of the two canonical correlations (otherwise known as canonical roots). As usual, the first canonical variate/correlation is more important than the second canonical variate because it explains a higher variance in the data set, followed by the second canonical variate and so on. The result further shows that the first canonical variate explains 5.3 per cent (0.230 x 0.230) of the variance in the dependent canonical variable. In the same way, the second canonical variate explains 1.3 per cent (0.130 x 0.130) of the variance in the second dependent canonical variable.

More so, the significance of the test in Table 8 indicates that the two canonical correlations are significant ($p<0.05$), which implies that the two pairs of canonical variates may be used to examine the association between socio-demographic factors and adaptation measures. The canonical loadings in Table 9 using the threshold of ≥ 0.6 on the first and second canonical variates or roots are used to make inference of the intrinsic relationship between socio-demographic factors and adaptation measures. An examination of the canonical loadings for socio-demographic factors on the first canonical function showed that only education (0.821) showed high correlations, while on adaptation measures, using the first canonical function, planting of tolerant seed variety (0.688) and planting early maturing crops (0.640) exhibited high correlation on the first canonical function. This therefore implies that on the first canonical function, education has positive association with planting of tolerant seed variety and planting early maturing crops.

The second canonical was not extracted because the variables for adaption were less than the threshold of ≥ 0.6. The result of the canonical loading therefore shows that education of farmers in the area has positive and significant association with the planting of tolerant seed variety and planting early maturing crops. This is expected as education plays a vital role in farmers' response to adaptive measures. Farmers who are highly educated and well informed of climate change and adaptation measures are more likely to respond and employ a suitable measure to mitigate the impacts of climate change on agricultural production. Particularly, educated farmers are more likely to plant tolerant seed varieties than uneducated farmers who may not be properly informed on the relevance of getting tolerant seed varieties and possibly where to access them. Also, farmers that are well aware of the changes associated with climate change in terms of changes in the onset and cessation of the rains are more likely to plant early maturing crops that are able to cope with the observed changes in climate conditions.

Similar result was reported by Fadina and Barjolle (2018) when they found that farming experience, educational level, farm size and gender have a significant impact on climate change adaptation strategies. The study further identified education of farmers to exert the most influence on farmers' climate change adaptation strategies. Fadina and Barjolle (2018) further stated that literate farmers are able to search for information and make choices based on their preference and level of information gathered. Similarly, the study of Maddison (2006) and Obayelu, Adepoju and Idowu (2014) also reported a positive relationship between the education level farmers and adaptation to climate change measures. Obayelu *et al.*, (2014) argued that farmers with higher levels of education are more likely to adapt better to climate change. They found education to positively relate to both diversifications to non-farm activities and adjustment of planting period relative to soil and water conservation adaptation techniques. In another study carried out in Sri Lanka, Menike and Arachchi (2016) found the size of the household, income, education, accessibility to climate information through television and radio, being a member in farmers' group, location of the land, crop variety, access to formal loans and distance to input markets as factors that significantly affect farmers' adaptation.

The result obtained in Tables 6,7,8 and 9 simply suggests that increasing farmers' education will increase their likelihood of climate change adaptation.

Table 6: Multivariate statistics and F Approximations: test of significance

Statistics	Value appox.	F-value	d.f.	p-Values
Wilks' Lambda	0.931	6.06	10	0.001
Pillai's Trace	0.070	6.04	10	0.001
Hotelling-Lawley Trace	0.073	6.09	10	0.001
Roy's Greatest Root	0.056	9.32	5	0.001

Table 7: Eigenvalues and canonical correlations

Root no.	Eigenvalue	Pct.	Cum. Pct	Canon. Corr	Sq. Cor
1	0.056	0.764	0.774	0.230	0.053
2	0.017	0.237	1.000	0.130	0.017

Table 8: Dimension reduction analysis

Root no.	Wilks lambda	F-tests	d.f. error	d.f.	p-Value
1	0.931	6.06	10	1666	0.001
2	0.983	3.61	6	834	0.006

Table 9: Result of canonical correlation analysis[a]

Variables	Canonical loadings/structure		Canonical cross-loadings	
	1	2	1	2
Socio-demographic variables				
Education	<u>0.821</u>	0.572	0.189	0.075
Marital status	0.572	0.821	0.312	0.107
Adaptation measures				
Use of cover crops	-0.498	0.578	-0.114	0.075
Planting of tolerant seed variety	<u>0.688</u>	0.159	0.135	0.021
Minimum tillage	-0.332	-0.387	-0.076	-0.051
Planting early maturing crops	<u>0.640</u>	0.539	0.124	0.070
Changes in time of land preparation	-0.070	-0.447	0.106	0.058

[a]Variables underlined with canonical loadings ≥ ±0.60 are considered significant

d) Constraints faced by farmers in climate change adaptation

This section gives answer to the fifth research objective which is to determine the major constraints to effective adaptation towards climate change in Mubi region. It also gives answer to the fifth research question which is to identify significant constraints/dimension to effective adaptation towards climate change in Mubi region. In order to give adequate answers to this research question, PCA was performed to reduce the 18 variables and identify principal constraints farmers faced in climate change adaptation in the study area. As shown in Table 10, the PCA result has condensed the 18 variables into 4 principal factors and the four factors explained 44.0 per cent of the variation in the data set. PC_1 explained 12.0 per cent of total variance in the data set and signified cost of fertilizers and other farm inputs. PC_2 explained 11.7 per cent of the total variance in the data set and signified poor information on early warning system. PC_3 represented traditional beliefs and was accountable for 10.5 per cent of the total variance, while PC_4 signified unavailable credit facilities and was responsible for 9.7 per cent of the variance in the data set.

The result in Table 10 therefore recognizes cost of fertilizers and other farm inputs, poor information on early warning system, traditional beliefs and unavailable credit facilities as the chief constraints faced by farmers in climate change adaptation. These four major constraints play significant role in farmers' inability to employ climate change adaptation measure. Cost of fertilizers and other farm inputs are identified by the present study to be the first and strongest problem faced by farmers in climate change adaptation. Similar result was reported by Williams *et al.,* (2015) when high cost of fertilizer and other farm inputs was identified as one of the common constraints to climate change adaptation in Michika, Adamawa State. The implication however is that framers in the area are unable to cope with changing climate phenomenon as a result of the high cost of fertilizers and their inability to acquire other farm inputs (such as improved seeds and herbicides etc.) which are necessary to cope with the menace or threat of climate change.

The absence of these farm inputs increases farmers' likelihood of not adopting suitable adaptation measures. This is expected as farmers' ability to deal with climate change phenomena depends on the availability of these farm inputs. For instance, the increase in temperature results in plant diseases and outburst of pest which if not properly managed can seriously affect plant yield. Farmers can however manage such outburst with the availability of pesticides and other chemicals that are able to kill these pests.

In a related study, Zizinga, Kangalawe, Ainslie *et al.,* (2017) stated that farmers that were able to use farm inputs like improved seeds, fertilizers and herbicides were more likely to take up soil conservation practices as compared to their counterparts. They further argued that farm inputs increased the probability of adopting soil conservation practices and other adaptation measures. The second paramount constraint is poor information on early warning system. In a similar study, Williams *et al.,* (2015) identified lack of access to weather information as a constraint to climate change adaptation. Also, Ozor, Madukwe, Enete *et al.,* (2010) stated that poor information on climate change and farmers' poor access to weather forecast gadgets is a major barrier to climate change adaptation among farming households in Southern Nigeria. In the area, farmers are not properly informed on time on incoming weather event to enable them prepare early.

Table 10: PCA result showing Constraints faced by farmers in climate change adaptation

Variables	Principal components			
	PC_1	PC_2	PC_3	PC_4
Cost of fertilizers and other farm inputs	<u>0.770</u>	0.291	0.165	0.048
Lack of storage facilities	0.617	-0.058	0.218	0.327
Absence of government policy on adaptation	0.614	0.112	-0.126	-0.042
Lack of financial resources	0.576	0.059	0.074	0.387
Lack of access to weather information	0.471	0.439	0.258	-0.088
Poor information on early warning system	0.020	<u>0.721</u>	0.031	0.142
Limited income to farmers	0.001	0.590	-0.076	0.331
Government irresponsiveness to climate risk magt	0.118	0.555	0.348	-0.022
High cost of lands	0.314	0.509	0.101	0.149
Inadequate knowledge to cope with adaptation	0.212	0.347	0.107	-0.016
Traditional beliefs	-0.029	0.030	<u>0.723</u>	0.072
Communal system of land ownership	0.122	0.038	0.625	0.200
High cost of farm labour	0.097	0.382	0.551	0.087
Limited access to improve crop variety	0.401	0.144	0.401	0.284
Unavailable credit facilities	0.098	0.101	0.113	<u>0.730</u>
Poor farming service delivery	0.042	0.400	0.006	0.533
Unavailability of farm labour	0.083	0.018	0.279	0.500
Limited available farmlands	0.199	0.198	0.333	0.355
Eigenvalues	2.16	2.10	1.89	1.75
per cent variance	12.0	11.65	10.52	9.71
Cumulative exp.	12.0	23.65	34.17	43.88

[a]the underlined with coefficients ±≥0.7 are considered significant

Source: Researcher's fieldwork, 2018

The absence of early warning system makes farmers in vulnerable to short-term and long-term climate phenomena. The absence of early warning makes farmers to carry out wrong measures which can be detrimental to their farming business. The inability of the farmers in the area to liaise with relevant authority in the state through their farmer's cooperation and other relevant bodies could be responsible for the poor early warning information. Having information on day-to-day weather conditions enables farmers to put in place adequate management practice to enable them cope with extreme weather conditions. The absence puts farmers at risk and thereby making them vulnerable to climate change impacts. The assertions made above agree with those of Otitoju and Enete (2016) when they stated that the absence of weather forecasts or early warning system will without doubt make farmers unaware of the weather situations and therefore become vulnerable to the impact of climate change. UNDP (2018) stated that the use of *climate information and early warning systems* help farmers respond to both short-term/rapid onset climatic hazards (e.g. floods and storms), as well as long-term/slow onset hazards (e.g. drought and long-term climate change).

The third constraint is traditional beliefs. Similar result was reported by Satishkumar, Tevari and Singh (2013) and Otitoju and Enete (2016) where traditional/religious belief was identified as one of the constraints of climate change adaptation. Traditional belief can affect farmers' desire to employ climate change adaptation measure. In the area, some of the farmers see the use of fertilizer and herbicide as taboos and as such do not make use of them. Others do not have faith in climate change warning system, but believe that the outbreak of any weather event is God's will and making. Such belief makes farmers vulnerable to climate change impacts. In addition, the fourth constraint is unavailable credit facilities. In a similar study, Zizinga *et al.*, (2017) identified financial constraints as a problem of climate change adaptation among farmers in south-western Uganda. For sure, the unavailability of credit facilities hinders farmers' ability to acquire farm inputs required to fully prepare against climate change phenomena. Farmers need money to buy fertilizer, improved seed varieties, herbicides, pesticide and pay laborers among others. The absence of credit facilities serves as constrains to the acquisition of these farm facilities. This is because farmers would not have the financial strength to meet up with farming demands. In all, the results in Table 7, 8 and 9 simply indicate that cost of fertilizers and other farm inputs, poor information on early warning system, traditional beliefs and unavailable credit facilities as main constraints of climate change adaptation faced by farmers in Mubi Region. Similar results have been reported by Ozor *et al.*, (2010), Satishkumar *et al.*, (2013), Otitoju and Enete (2016), Zizinga *et al.*, (2017) and UNDP (2018). For instance, the study of Otitoju and Enete (2016) employed PCA and identified about ten major constraints as follows: public, institutional and labor constraint; land, neighborhood norms and religious beliefs constraint; high cost of inputs, technological and information constraint; farm distance, access to climate information, off-farm job and credit constraint; and poor agricultural programs and service delivery constraint.

Conclusion

It is established from the study that the respondents are aware of climate change and the farmers are able to developed adaptation strategies in a way that enable them cope with the erratic impact of climate change on food production. Factors such as labor size, family income, farmer's level of education among others were identified as sociodemographic factors influencing farmer's adaptive response to climate change. The adaptive response strategies adopted by these farmers include, planting tolerant seeds varieties, minimum tillage, planting early maturing crops, and changing time of land preparation. These strategies are seen as the best by the farmers. The major constrains towards adaptation in the study area includes, high cost of fertilizer, poor information on early warning system, traditional beliefs and unavailable credit facilities.

Recommendation

Based on the finding of the study the following recommendations were suggested.

- Provision of improve crop varieties to the farmers

- Micro credit/revolving grants should be made available to the farmers
- Establishment of rural service center to provide technical advice and information on viable agriculture water management
- The development of supplementary irrigation system i.e farming practice that would supply water to crops during growing, especially during short period of drought
- Government should improve knowledge and skills of extension service personnel about climate change and adaptive management strategies. Also increasing extension farmers ratio and making extension services more accessible to farmers, might be the key components of a successful adaptation.

REFERENCES

Akponikpe, P. B. I., Peter J. & Agbossou, E. K. (2010). Farmers' perception of climate change and adaptation strategies in Sub-Saharan West-Africa. 2nd International Conference: Climate, Sustainability and Development in Semi-arid Regions August 16 - 20, 2010, Fortaleza - Ceará, Brazil.

Deressa, T.T., Hassan, R. M. & Ringler, C. (2011). Perception and adaptation to climate change by farmers in the Nile Basin of Ethiopia. *Journal of Agricultural Science*, 149, 23-31.

Dhaka, B.L., Chayal, K. & Poonia, M. K. (2010). Analysis of farmers' perception and adaptation strategies to climate change. *Libyan Agriculture Research Center Journal International*, 1(6), 388-390.

Elum, Z. A., Modise, M. M. & Marr, A. (2017). Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. *Climate Risk Management*, 16, 246 – 257.

Fadina, A. M. R. & Barjolle, D. (2018). Farmers' adaptation strategies to climate change and their implications in the Zou Department of South Benin. *Environments*, 5, 15.

Franzel, S. (1999). Socioeconomic factors affecting the adoption potential of improved tree fallows in Africa. *Agroforestry Systems*, 47(1 - 3), 305–321.

Hair, J. F., Black, W. C., Babin, B. J. & Anderson, R. E. (2010). Multivariate data analysis (7th ed). Pearson Prentice Hall. Available at: http://dlx.b-ok.org/genesis/321000/16a10f0a8fec68bcd698c331985b302c/_as/[Hair_J.F.,_Black_W.C.,_Babin_B.J.,_Anderson_R.E.](b-ok.org).pdf (Accessed 28/9/18).

Iwara, A. I., Ogundele, F. O., Ibor, U. W. & Deekor, T. N. (2012). Multivariate analysis of soil-vegetation interrelationships in a south-southern secondary forest of Nigeria. *International Journal of Biology*, 3(3), 73 – 82.

Jianqin, M., Jingjing, G. & Xiaojie, L. (2010). Water quality evaluation model based on principal component analysis and information entropy: Application in Jinshui River. *Journal of Resouces and Ecology*, 1 (3), 249-252.

Kalra, N., Chakraborty, D., Sharma, A., Rai, H.K. & Jolly, M. (2008). Effect of increasing temperature on yield of some winter crops in Northwest India. *Curr. Sci.*, 94, 82–88.

Kaye, J. P. & Quemada, M. (2017). Using cover crops to mitigate and adapt to climate change. A review. *Agron. Sustain. Dev.* 37, 4.

Kuchirak, C.J. (2008). Contribution of planting date trends to increased maize yields in the Central United States. *Agron. J.*, 100, 328–336.

Limantol, A. M., Keith, B. E., Azabre, B. A. & Lennartz, B. (2016). Farmers' perception and adaptation practice to climate variability and change: a case study of the Vea catchment in

Ghana. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4917512/pdf/40064_2016_Article_2433.pdf (Accessed: 20/11/18).

Liu, C., Lin, K. & Kuo, Y. (2003). Application of factor analysis in the assessment of groundwater quality in a blackfoot disease area in Taiwan. *Science of the Total Environment*, 313 (1-3), 77–89.

Maddison, D. (2006). The perception of and adaptation to climate change in Africa.CEEPA, Discussion Paper No. 10, Centre for Environmental Economics and Policy in Africa. Available at:http://www.ceepa.co.za/docs/CDPNo10.pdf

Maddison, D. (2006). The perception of/and adaptation to climate change in Africa. CEEPA Discussion, Paper No. 10. Center for Environmental Economics and Policy in Africa, University of Pretoria South Africa.

Malacarne, R. L. (2014). Canonical correlation analysis. *The Mathematical Journal*, 16, 1–22.

Mangalassery, S., Sjogersten, S., Sparkes, D. L., Sturrock, C. J. & Craigon, J. (2014). To what extent can zero tillage lead to a reduction in greenhouse gas emissions from temperate soils? *Scientific Reports*, 4: 4586.

Menike, L.M.C.S. & Arachchi, K.A.G.P. (2016). Adaptation to climate change by smallholder farmers in rural communities: Evidence from Sri Lanka. *Procedia Food Science* 6, 288 – 292.

Nhemachena, C. & Hassan, R. (2007). Micro-level analysis of farmers‟ adaptation to climate change in Southern Africa. *IFPRI Discussion Paper No. 00714. International Food Policy Research Institute, Washington, D.C*

Obayelu, O. A., Adepoju, A. O. & Idowu, T. (2014). Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria. *Journal of Agriculture and Environment for International Development*, 108 (1), 3-16.

Odewumi, S. G., Awoyemi, O. K, Iwara, A. I. & Ogundele, F. O. (2013). Farmer's perception on the effect of climate change and variation on urban agriculture in Ibadan Metropolis, South-western Nigeria. *Journal of Geography and Regional Planning*, 6(6), 209 -217.

Offiong, M. O., Udofia, S. I., Owoh, P. W. & Ekpenyong, G. O. (2010). Effects of fertilizer on the early growth of Tetrapleura tetraptera (DEL). *Nigerian Journal of Agriculture, Food and Environment*, 6(1&2), 53-59.

Olesen, J. E., Trnka, M., Kersebaum, K.C., Skjelvag, A. O. & Seguin, B. (2011). Impacts and adaptation of European crop production systems to climate change. *Eur. J. Agron*, 34, 96–112.

Pashupalak, (2009). Climate change characterization of Orissa. *Paper presented at the national seminar on "Climate change issues and Mitigation priorities" 184 held at Bhubneshwar on 28th Feb. 2009, organized by Satyasai Charitable and Education Trust.*

Poudel, S., Funakawa, S. & Shinjo, H. (2017). Household perceptions about the impacts of climatechange on food security in the mountainous regionof Nepal. *Sustainability*, 9, 641.

Satishkumar, N., Tevari, P. & Singh, A. (2013). A study on constraints faced by farmers in adapting to climate change in rainfed agriculture. *J. Hum Ecol*, 44(1), 23-28.

Sherry, A. & Henson, R. K. (2005). Conducting and interpreting canonical correlation analysis in personality research: A user-friendly primer. *Journal of Personality Assessment*, 84(1), 37–48.

Singh, R. P., Prasad, P.V.V. & Reddy, K.R. (2013). Impacts of changing climate and climate variability on seed productionand seed industry. *Adv. Agron.*118, 49–110.

Smith, P., Martino, D., Cai, Z., Gwary, D. & Janzen, H. H. (2008). Greenhouse gas mitigation in agriculture. *Philosophical Transactions of the Royal Society B* 363, 789-813.

Smithers, J. & Smit, B. (2009). Human adaptation to climatic variability and change. *Adaptation to Climate Change, London: Earthscan*, 15-33.

Sorhang, A. & Kristiansen, S. (2011). *Climate change impacts and adaptations among Ethiopian farmer's*. M.Sc. Thesis, Faculty of Economic and Social Sciences for Development Studies, University of Adger, Ethiopia.

Tubiello, F. N., Soussana, J. & Howden, S. M. (2007). Crop and pasture response to climate change. *PNAS*, 104 (50), 19686–19690.

UNDP (2018) Strengthening Climate Information and early warning system for climate resilient development. Available at: https://adaptation-undp.org/stregthening-climate-information-and-early-warning-system-climate-resilient-development (Accessed 22/11/18

Vega, M., Pardo R., Barrado, E. & Deban, L. (1998). Assessment of seasonal and polluting effects on the quality of river water by exploratory data analysis. *Water Research*, 32 (12), 3581-3592.

Wang, Y., Guo, Q. & Jin, M. (2009). Effects of light intensity on growth and photosynthetic characteristics of Chrysanthemum morifolium. *Zhongguo Zhongyao Zazh*, 34, 1633-1635.

Williams, J. J., Adebayo, A. A. & Abam, A. I. (2015). Farmers perception of climate change in Michika local government area of Adamawa State. *Civil and Environmental Research*, 7(5), 13 – 20.

Williams, J. J., Dunnamah, A, Y. & Kwale, J. M. (2015). An assessment of impact and adaptation strategies to climate change by local indigenous farmers of Michika local government area of Adamawa State, Nigeria.*European Scientific Journal*, 11 (26), 130 – 144.

Zizinga, A., Kangalawe, R. Y. M., Ainslie, A., Tenywa, M. M. & Majaliwa, J. (2017). Analysis of farmer's choices for climate change adaptation practices in south-western Uganda, 1980–2009. *Climate*, 5, 89.