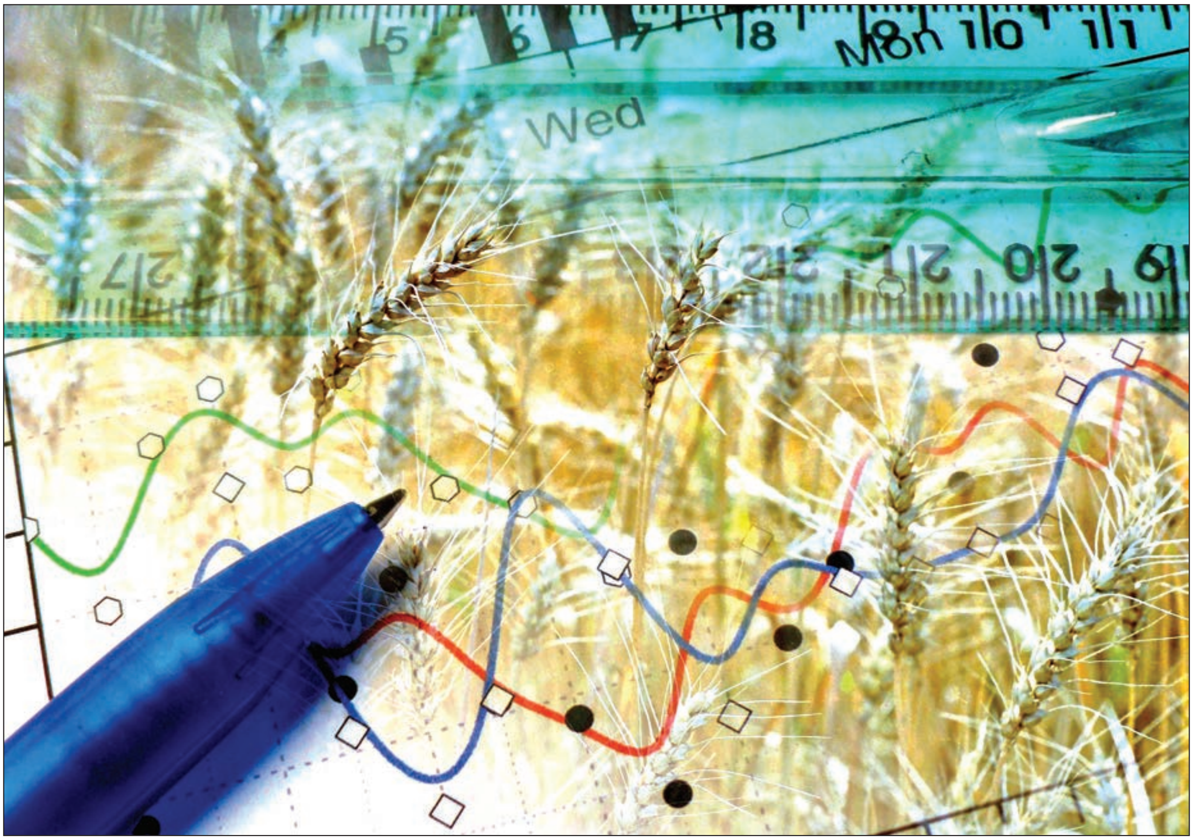

Trends in Agricultural Economics

ISSN 1994-7933

science alert

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OPEN ACCESS Trends in Agricultural Economics

ISSN 1994-7933
DOI: 10.3923/tae.2017.1.11

Research Article
Ordered Probit Analysis of Factors Influencing Farmers' Contributions to Climate Change Adaptation Decisions in Southwest Nigeria

Amusa Taofeeq Ade and Simonyan Judith Bosede

Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria

Abstract
Background and Objective: Agricultural activities in the tropic is already experiencing low crop yields and altered animal compositions as a result of devastating effects of climate change. This has necessitated informed decisions by farmers to cope with the challenges of climate change. This study aimed to investigate the factors influencing farmer's contributions to climate change adaptation decisions in Southwest Nigeria using ordered probit model approach. **Materials and Methods:** Three states were purposively selected from Southwest Nigeria which include: Ekiti, Ogun and Oyo States. Data for the study were collected from 348 randomly sampled farm units. Data collected were analyzed using descriptive statistics such as mean and inferential statistical methods such as one way analysis of variance (ANOVA) and ordered probit model. **Results:** The result of the descriptive analysis showed that climate change is having serious effects on agricultural production in Southwest Nigeria as revealed by increased indices of higher temperature and heat, prolonged drought, increased drying up of seedlings, drying up of rivers, lakes and streams and increased cases of flooding among others. The result of the ordered probit model was highly significant ($p \leq 0.0000$). The explanatory power of the factors as reflected by Pseudo R^2 was high (0.734), indicating that the hypothesized variables were actually responsible for about 73% of the variations in level of contributions of farmers to climate change decision making. Out of the nine variables specified in the model, gender, age, education, farming experience, financial contribution and off-farm job significantly ($p \leq 0.01$ and $p \leq 0.05$) influenced farmer's contributions to climate change adaptation decision making. **Conclusion:** Based on the results of the study, it is concluded that climate change is already having serious effects on agricultural production in Southwest Nigeria as shown by indices of climate change indicators. Socio-economic attributes of farmers significantly (at $p \leq 0.01$ and $p \leq 0.05$) influence their roles in decision making as regards climate change adaptation. Hence, the study recommended improved extension visits to the farmers on how to effectively cope with the effects of climate change. There should be improved decision making power of the farmers through improved education, income and access to relevant information on climate change adaptation.

Key words: Climate change, policy, environmental-sensitive, decision making, ordered probit

Received: September 17, 2016 Accepted: November 18, 2016 Published: December 15, 2016

Citation: Amusa Taofeeq Ade and Simonyan Judith Bosede, 2017. Ordered probit analysis of factors influencing farmers' contributions to climate change adaptation decisions in Southwest Nigeria. Trends Agric. Econ., 10: 1-11.

Corresponding Author: Amusa Taofeeq Ade, Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria Tel: +2348036185143

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Tropical agriculture is already experiencing low crop yields and altered animal compositions as a result of extreme weather condition and climate change. Climate change as described by IPCC[1] is a change in the state of the climate that can be identified (using statistical test) in the mean and the variability of climatic properties that persist for an extended period typically decades or longer. NMA[2] identified two dimensions to the issue of climate change. The first being the changes that have already been observed in climate parameters such as temperature, rainfall and extreme weather events and the second being the changes that are to be expected in the future. The devastating future expectations of climate change are in form of further decrease in precipitation, unpredictable rainfall pattern and prolonged drought which have become more noticeable in sub-saharan Africa, Nigeria and in particular South-western part of the country. For instance, Adebayo *et al.*[3] observed that, the seasonal shifting of rain and that of the fruiting period in Oyo State and the gradual disappearance of flood-recession in riverine areas of Ondo State are among the effects of climate change in communities in the Southwest Nigeria. In addressing this global threat, Tubiello and Rosenzweig[4] suggested a wide range of adaptation practices that exist within farming system to help maintain or increase crop and livestock yields under climate change.

Climate change adaptation activities according to Nyong *et al.*[5] are those strategies that enable the individual or the community to cope with or adjust to the impacts of the change in climate. Climate change adaptation as described by IPCC[6] is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or explores beneficial opportunities. In agriculture, climate change adaptation practices help farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socio-economic conditions including climatic variability, extreme weather conditions such as droughts, floods and volatile short term changes in local and large-scale markets[7]. Adaptation practices are activities that farmers at household level put in place to combat the effects of climate change while mitigation efforts entail formulation and implementation of environmental-friendly policies at formal level to reduce the emission of Green House Gases (GHGs) and depletion of protective ozone layer[8].

Adaptation practices for crop production among farmers in Southern Nigeria include planting of early maturing crops, mulching, small scale irrigation, adoption of hardy varieties of crops, tree planting, early planting, fadama and staking to avoid heat burns[3,5]. To cope with climate change in livestock production, Adesina *et al.*[9] identified coping strategies among Nigerian farmers to include the use of emergency fodder in times of droughts, multi-species composition of herds to survive climate extremes, culling of old livestock, de-stocking to reduce population and climatic inducing heat stress, expand rain harvest, shading, supplementary feeding, dip and dose, fence camp and provision of more opportunity for livestock for water among others. Risbey *et al.*[10] affirmed that the responses of farmers to cope with the associated challenges of climate change in food production result from their farming decisions.

Farm decision making according to Ilbery[11] is an on-going process whereby farmers are continually making short and long-term decisions to manage risks emanating from variety of climatic and non-climatic sources. In addition, Smit and Skinner[12] substantiated that, adaptation to climate change is the result of individual farmer's decisions influenced by climatic forces internal to the farm households and external forces that affect the agricultural system at large. Farming decision making is therefore a mental and intelligent process in which farmers use information available about farm resources to select and combine those farm resources they consider best for addressing their farming challenges and achieving farming objectives. Farmers constantly face such challenges as tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases[13] which are mostly as a result of changes in climatic conditions.

Climatic and agricultural challenges have placed many farmers in the position of making critical decisions about farming, financial security and well-being that has long term consequences. Farmers are known to make decisions on cropping patterns based on local predictions of climate and decisions on planting dates based on complex cultural models of weather[5]. In making adaptation decisions about climate change, Olorunfemi[14] pointed out that timely and useful information is necessary about the possible consequences of climate change, people's perceptions of those consequences, available adaptation options and the benefits of slowing the rate of climate change. Downing and Watt[15] stated that successful anticipatory adaptation decision requires the best available information concerning the nature of future climate risks.

The relevant questions that agitate the minds are, what are the effects of climate change on agricultural production in

Southwest Nigeria, are there differences in the intensity of the effects of climate change on agriculture across the local agro-ecological zones in Southwest Nigeria? What are the factors that influence farmer's contributions to decision making as regards climate change adaptation activities? This paper therefore provided answers to these pertinent questions. Although, there are numerous empirical studies on socio-economic factors influencing decision making in labour choice[16,17] marketing of farm products[18], farm input use[19] and farm enterprise choice[20]. In another study, Damisa and Yohanna[21] investigated role of rural women in farm management decision making process. It is imperative to state that none of these available studies captured socio-economic factors influencing farmer's contributions to decision making in respect to climate change adaptation practices. Hence, this study was carried out to investigate factors influencing farmers' contributions to climate change adaptation decisions in Southwest Nigeria in order to fill the existing information gap in knowledge.

The findings of this study will be found useful by ministries of environment and agriculture especially in the review and formulation of environmental related policies that will empower and moderate the contributions of men and women to climate change adaptation decision making at farm households level. This is because with the information that was made available by this study, government agencies will be more informed and focussed in formulating agricultural and environmental-sensitive policies to combat the effects of climate change through adaptation at farm households' level. Researchers with keen interest in climate change adaptation and farm decision making will be properly guided to be more focused based on the information that was provided. The objective of the study was to empirically investigate effects of climate change on agricultural production and factors influencing farmers' contributions to climate change adaptation decisions in Southwest Nigeria.

MATERIALS AND METHODS

Area of study: The study was carried out in Southwest Nigeria. Southwest is made up of six states which include: Ekiti, Lagos, Ogun, Ondo, Osun and Oyo States. National Population Commission[22] reported that the region has a total population of 27,581,632 people comprising 14,049,234 males and 13,532,398 females. Southwest Nigeria falls within latitudes 6°N, 4°S and longitudes 4°W, 6°E, covering about 114,271 km^2. Adepoju *et al.*[23] stated that the average annual rainfall of Southwest Nigeria ranges between 1,200-1,500 mm with a mean monthly temperature range of 18-24°C during the rainy season and 30-35°C during the dry season. Southwest Nigeria is predominantly agrarian due to its naturally endowed rich alluvial soil. Notable food crops cultivated in the area include: Cassava, maize, yam, cocoyam, cowpea, vegetables and cash crops such as cocoa, kola nut, rubber, citrus, coffee, cashew, mango and oil palm. Livestock such as goat, pig, sheep and poultry are predominantly reared in Southwestern Nigeria.

Sampling and data collection: Multi-stage random sampling technique was used for selecting 360 farm units for the study. Three states were purposively selected in Southwest Nigeria to ensure that the three local ecological zones in the area were covered. The three states selected were Ekiti State from derived savanna, Oyo State from guinea savanna and Ogun State from rainforest belt. From each of the three states, two agricultural zones were randomly sampled. These were zones I and II from Ekiti State, Ibadan/Ibarapa and Ogbomosho zones from Oyo State while Ijebu Ode and Abeokuta zones were selected from Ogun State. From each of the selected six agricultural zones, two local government areas (LGAs) were randomly selected making 12 LGAs. Random sampling technique was used to select two farming communities from each of the sampled 12 LGAs making 24 farming communities for the study. From each of the selected farming communities, random sampling technique was also used to select 15 farm units giving a total of 360 farm units. Data for this study were obtained from primary source through the use of structured questionnaire. Data were collected with the assistance of five trained research assistants. Out of the 360 copies of questionnaire administered, 348 copies were considered good enough for use representing 96.7%.

Estimation procedure: The data collected were analyzed with descriptive statistics (mean) using 4-point rating scale and cut-off point value of 2.50 to establish the intensity of the effects of climate change on food production in the area. The intensity of the effects of climate change indicators among the three agro-ecological zones (Derived Savanna, Guinea Savanna and Rainforest) in Southwest Nigeria were compared using one-way analysis of variance (ANOVA) while *post-hoc* Scheffe test of multiple comparison was used to determine the direction of the significance for indicators that were significant at $p \leq 0.05$. Ordered probit model was employed in estimating the socio-economic factors influencing farmers' contributions to climate change adaptation decisions among farm households in Southwest.

One-way analysis of variance (ANOVA): Analysis of variance (ANOVA) is an extremely important method in exploratory and confirmatory data analysis. It was employed in this study to compare the mean ratings of the intensity of effects of climate change across the three agro-ecological zones in Southwestern Nigeria. When using ANOVA, the observed differences between group means depends on the spread (variance) of the responses within groups. Widely different averages can more likely arise if individual farmers response to the extent of climate change adaptation within groups vary greatly. It is therefore necessary to take into account the variance within group when assessing difference between groups. Thus, if the variance between groups exceeds what is expected in terms of variance within groups, the null hypothesis will b rejected.

Variance between groups:

Let S^2_B represent the sample variance between groups[24]:

$$S^2_B = \frac{SS_B}{df_B} \tag{1}$$

This represent the Mean Square Between (MSB) which is the variability of the group means around the grand mean.

The SS_B (sum of square between) is:

$$SS_B = \sum_{i=1}^{k} n_i (X_i - X)^2 \tag{2}$$

where, n is the size of the group i, the X_i is the mean of the group i and X is group mean.

The degree of freedom (df) is represented as:

$$df_B = k - 1 \tag{3}$$

where, k is the number of groups of farmers, that is across the agro-ecological zones. Therefore,

$$df_B = 3\text{-}1 = 2 \tag{4}$$

Variance within groups:

Variance within (SW^2) quantifies the spread of values within groups. In ANOVA, the variance within is also called the Mean Square Within (MSW) and is calculated:

$$SW^2 = \frac{SS_w}{df_w} \tag{5}$$

Where the Sum of Squares within (SS_w) is:

$$SS_w = \sum_{i=1}^{k} (n_i - 1) S^2_i \tag{6}$$

and the degree of freedom within is:

$$df_w = N\text{-}k \tag{7}$$

An alternative formula for the variance within is:

$$S^2_w = \frac{(df_i)(S^2_1) + (df_2)(S^2_2) + ... + (df_k)(S^2_k)}{df_1 + df_2 + .. + df_k} \tag{8}$$

where, s^2_i is the variance in group i and df_i is the degrees in the group (df_i = n_i-1). This alternative formula shows the variance within as a weighted average of group variances with weights determined by group degrees of freedom. The ratio of the variance between (S_B) and the variance within (S_w) is the ANOVA F- statistic:

$$F_{stat} = \frac{S^2_B}{S^2_W} \tag{9}$$

Under the null hypothesis, this test statistic has an F sampling distribution with df_1 and df_2 degrees of freedom. The p-value for the test is represented as the area under Fdf_1, df_2 to the right tail of the F_{stat}. Therefore, the null hypothesis was upheld when the F-calculated (F-cal) value was less than the F-critical (F-tab) value of 3.00 at $p \leq 0.05$ level of significance. On the other hand, when the F-calculated (F-cal) value was greater than the F-critical (F-tab) value of 3.00 at $p \leq 0.05$ level of significance, the null hypothesis of no significant different on the intensity of effects of climate change across the three local agro-ecological zones was rejected.

Ordered probit model: Ordered probit model is widely used approach to estimate models of ordered types. The ordered probit model is built around a latent regression in the same manner as the binomial probit model[25]. Let:

$$Y_i^* = X^i \beta_i + \varepsilon \tag{10}$$

The latent variable (farmer's contributions) in this study exhibits itself in ordinal categories which was coded as 0, 1, 2,⋯, j. The response of category j is thus observed when the underlying continuous response falls in the j-th interval as:

$$Y^* = 0 \text{ if } Y^* \leq \delta 0$$
$$Y^* = 1 \text{ if } \delta 0 < Y^* \leq \delta 1$$
$$Y^* = 2 \text{ if } \delta 1 < Y^* \leq \delta 2 \quad (11)$$

where, Y* (i = 0, 1, 2) are the unobservable threshold parameters that were estimated together with other parameters in the model. Green[25] noted that when an intercept coefficient is included in the model, Y_o^* is normalized to a zero value and hence only j-1 additional parameters are estimated with Xs. Like the models for binary data, the probabilities for each of the observed ordinal response, that is, farmer's level of contributions to decision making in this study had 3 responses which could be low, moderate and high with ordinal values of 0, 1, 2 was given as:

$$\text{prob } (Y = 0) = P(Y^* \leq 0) = P\ (\beta'X + \varepsilon i \leq 0) = ø\ (-\beta'X) \quad (12)$$

$$\text{prob } (Y = 1) = ø\ (\delta 1-\beta'X)-ø\ (-\beta'X) \quad (13)$$

$$\text{prob } (Y = 2) = 1- ø\ (\delta 1-\beta'X) \quad (14)$$

where, 0<Y1*<Y2*<...<Y*j-1..... n is the cumulative normal distribution function such that the sum total of the above probabilities is equal to one. The specification of the ordered probit model in this study is as follows. Let Yi denote the level of contributions: low contribution (0 = Yi), moderate contribution (1 = Yi) or high contribution to decision making (2 = Yi) in climate change adaptation activities. The marginal effects of the regressors X on the probabilities are not equal to the coefficients. The marginal probabilities could therefore be calculated from the probit model as:

$$\frac{\text{dprob}[Y_j]}{dx_j} = [\varnothing(\delta_{j-1} - \beta' X_j) - \varnothing(\delta_j - \beta' X_j)]\beta \quad (15)$$

where, ø is the normal density function, j the threshold parameter and Xj the j the explanatory variable. The farmer's contributions to climate change adaptation decision making is specified as follows:

$$Y^{*(\text{contr.})} = b_0+b_1\ {}^{op}X_1{}^{op}+b_2\ {}^{op}X_2{}^{op}+b_3\ {}^{op}X_3{}^{op}+b_4\ {}^{op}X_4{}^{op}+b_5\ {}^{op}X_5{}^{op}+b_6\ {}^{op}X_6{}^{op}+b_7{}^{op}X_7{}^{op}+b_8\ {}^{op}X_8{}^{op}+b_9\ {}^{op}X_9{}^{op}+ui^{op} \quad (16)$$

Where:

$Y^{*\ (\text{contr.})}$ = 1 (low contribution), 2 (moderate contribution) or 3 (high contribution)

X_1 = Gender of the farmer, dummy (1 if male, 0 otherwise)

X_2 = Ages of farmer (years), continuous (in number)

X_3 = Years Of education (In years), continuous (in number)

X_4 = Years of farming experience, continuous (in number)

X_5 = Financial contributions to farm business, dummy (1 if contributing; 0 otherwise)

X_6 = Number of hours spent of farm per day, continuous (in number)

X_7 = Having off farm jobs; dummy (1 if yes, 0 otherwise),

X_8 = Access to communication facilities; dummy (1 if having access; 0 otherwise)

X_9 = Membership of farmers cooperatives; dummy (1 if member, 0 otherwise)

RESULTS AND DISCUSSION

Effects of climate change on agricultural production in Southwest Nigeria: The result in Table 1 presented the indices of intensity of the effects of climate change on agricultural production in Southwest Nigeria. From the result, 14 out of the 23 identified indicators of climate change had mean values that ranged from 2.51-3.58 which are greater than the cut-off point value of 2.50 on 4-point rating scale. This showed that the 14 identified indicators of climate change are perceived by farmers as having serious effects on agricultural production in Southwest Nigeria. Some of the identified indicators and their respective mean values include: higher temperature and heat (3.58), prolonged drought (3.51), increased drying up of seedlings after germination (3.14), poor quality of storage farm produce as a result of heat (3.10), drying up of rivers, lakes and streams (2.88), increased post harvest spoilage of harvested crops (2.87), increased cases of flooding (2.83), increased soil erosion resulting from unusual heavy rains (2.73), decreased rainfall amount (2.71), heat stress on crop and livestock (2.62), stunted growth of crops (2.58), unusual heavy rainfall (2.55), reduction in crop yield (2.53) and deceased soil moisture (2.51).

The findings agreed with that of Ozor and Nnaji[26] which showed that effects of climate change on agricultural production as perceived by farmers in Enugu state include: Soil erosion, post harvest losses due to climate variability, decrease in yields of crops and animals, flooding, heat from high temperature, drought and decrease in soil moisture. The findings of this study also corroborated the report of Olagunju[27] that drought and desertification impact directly or indirectly on all aspects of human life and the environment including the ecological, health, geo-chemical, hydrological and socio-economic facets; including agricultural production. Musa[28] attributed the drying up of Chad basin in Nigeria to the effect of drought and desertification. Findings of Ishaya and Abaje[29] equally revealed that the threat of climate change is

Table 1: Mean ratings of farmers and analysis of variance (ANOVA) of the intensity of effects of climate change on agricultural production in Southwest Nigeria (N = 348)

Effects of climate change	$\bar{x}$	SD	Rmk	Total sum of square	Mean square	F-ratio	p-value (Significant)	Rmk	*Post Hoc* test
Decreased rainfall amount	2.71	0.99	S	164.99	0.48	1.94	0.15	NS*	-
Unusual heavy rainfall	2.55	0.83	S	321.80	0.93	5.52	0.00	S*	Ogun (RF)/Ekiti (DS)
Higher temperature and heat	3.58	0.65	S	322.25	0.93	3.42	0.03	S*	Ogun (RF)/Ekiti (DS)
Heavy winds	2.22	0.82	NS	230.49	0.08	1.82	0.16	NS*	-
Increased cases of flooding	2.83	0.95	S	323.33	0.99	6.18	0.03	S*	Ogun (RF)/Ekiti (DS)
Prolonged drought	3.51	0.68	S	159.48	0.46	0.62	0.54	NS*	-
Increased desertification	2.37	0.84	NS	186.60	0.54	1.85	0.15	NS*	-
Increase in pest and disease problems	2.09	1.08	NS	211.57	0.61	1.25	0.28	NS*	-
Extinction of some crop species	1.79	1.17	NS	204.20	0.59	0.72	0.48	NS*	-
Deceased soil moisture	2.51	0.86	S	198.71	0.58	1.21	0.26	NS*	-
Premature ripening of fruits	1.61	1.14	NS	191.09	0.55	0.78	0.46	NS*	-
Reduction in crop yield	2.53	0.89	S	165.26	0.47	0.08	0.92	NS*	-
Poor quality of storage farm produce as a result of heat	3.10	0.61	S	321.43	0.93	4.87	0.01	S*	Ogun (RF)/Ekiti (DS)
Stunted growth of crops	2.58	0.94	S	243.66	0.71	0.11	0.29	NS*	-
Drying up of rivers, lakes and streams	2.88	0.94	S	307.67	1.89	3.14	0.01	S*	Ekiti (DS)/Oyo (GS)
Increased drying up of seedlings after germination	3.14	0.60	S	220.76	0.64	0.49	0.61	NS*	-
Heat stress on crop and livestock	2.62	0.86	S	251.26	0.73	2.06	0.14	NS*	-
Intense weed growth	2.39	0.99	NS	277.79	0.81	4.03	0.01	S*	Oyo (GS)/Ogun (RF)
Increased soil erosion resulting from unusual heavy rains	2.73	0.83	S	235.93	0.69	2.47	0.12	NS*	-
Storage losses in roots and tubers	2.47	0.91	NS	289.07	0.83	3.28	0.03	S*	Ogun (RF)/Ekiti (DS)
Increased salinity and pollution due to climate variability	1.79	1.17	NS	320.86	0.94	0.13	0.13	NS*	-
Decrease in fish population due to water level, currents or speed	2.10	0.95	NS	314.01	0.91	0.39	0.38	NS*	-
Increased post harvest spoilage of harvested crops	2.87	0.79	S	275.38	0.80	3.34	0.02	S*	Ogun (RF)/Ekiti (DS)

Rmk: Remark, S: Serious, NS: Not serious, S*: Significant at $p \leq 0.05$, NS*: Not significant, RF: Rainforest, GS: Guinea Savanna, DS: Derived Savanna, *Post Hoc* (Scheffe) Test shows the direction of significance among the three local agro ecological zones

Table 2: Parameter estimates and marginal effects of ordered probit model analysis of factors influencing farmers' contribution to climate change adaptation decisions among farm households in Southwest Nigeria

	Parameter estimates		Marginal effects (dy/dx)	
Variables	Coefficient	Z-ratios	dy/dx	Z-ratios
Gender	0.0216 (0.0066)	3.27***	0.0867 (0.0266)	3.26***
Age	0.0398 (0.0174)	2.29**	0.0536 (0.0234)	2.29**
Education	0.0528 (0.0165)	3.21***	0.0690 (0.0214)	3.21***
Experience	0.0449 (0.0087)	5.16***	0.0938 (0.0182)	5.15***
Fin. Contri.	0.1126 (0.0294)	3.82***	0.1045 (0.0273)	3.82***
Hrs/day	0.1377 (0.0982)	1.40	0.0923 (0.0659)	1.40
Off farm jobs	-0.0149 (0.0067)	-2.22**	-0.0210 (0.0095)	-2.21**
Access to comm.	0.0573 (0.0494)	1.16	0.0383 (0.0330)	1.16
Member of coop.	-0.0014 (0.0032)	-0.43	-0.0014 (0.0033)	-0.42

***Denotes $p \leq 0.01$, **Denotes $0.01 > p \leq 0.05$, Figures in parenthesis are standard errors, No. of obs = 348, LR χ^2 (9) = 57.85, Prob> χ^2 = 0.0000, Pseudo R^2 = 0.734, log likelihood = -887.849

more on health, food supply, biodiversity lost and fuel wood availability and that; it is the poor, who depend heavily on the natural resources that are mostly affected by incidence of climate change.

The result further showed that climate change indicators such as: Storage losses in roots and tubers (2.47), intense weed growth (2.39), increased desertification (2.37), heavy winds (2.22), decrease in fish population (2.10), increase in pest and disease problems (2.09), extinction of some crop species (1.79), increased salinity and pollution due to climate variability (1.79) and premature ripening of fruits (1.61) had their mean values less than the cut-off point value of 2.50 on 4-point rating scale. This finding showed that the identified indicators are not serious effects of climate change on agricultural production in Southwest Nigeria. This disagreed with the findings of Ozor and Nnaji[26] who found out that intense weed growth, incidence of pests and diseases and premature ripening had significant effects on agricultural production in Enugu State Southeast Nigeria. The difference in location of the present study carried out in Southwest Nigeria and that of Ozor and Nnaji[26] carried out in Southeast Nigeria may be responsible for the variation in the findings.

The result of analysis of variance (ANOVA) presented in Table 1 showed that the p-values (significant) of 15 out of 23 climate change indicators ranged from 0.12-0.92 which were all greater than 0.05 level of significance. This indicated that, there are no significant differences in the mean ratings of farmers from Ekiti (derived savanna), Ogun (rainforest) and Oyo (guinea savanna) on the intensity of the effects of the 15 climate change indicators on agricultural production in the area. On the other hand, the p-values of the remaining 8 indicators ranged from 0.00-0.03 which were less than 0.05 level of significance. This showed that there are differences in the mean ratings of farmers from the three agro-ecological zones in Southwest Nigeria. The direction of the significance was shown by the result of the *Post-hoc* test as indicated against each of the significant indicators.

Factors influencing farmer's contributions to climate change adaptation decisions in Southwest Nigeria: The result in Table 2 presented ordered probit model analysis used to estimate the determinants of farmer's contributions to climate change adaptation decisions in Southwest Nigeria. The three categories of level of contributions: Low, moderate and high formed the dependent variable as ordered 0, 1 and 2 respectively. Out of the 9 explanatory variables specified in the model, 6 significantly influenced farmer's contribution to decision making in climate change adaptation practices.

The chi square statistics is highly significant ($p \leq 0.0000$). The explanatory power of the factors as reflected by Pseudo R^2 was high (0.734), indicating that the hypothesized variables are actually responsible for about 73% of the variations in level of contributions of farmers to decision making on climate change adaptation activities. In terms of consistency with a priori expectations on the relationship between the dependent and the explanatory variables, the model seems to have behaved well. The parameter estimates of the ordered probit model only provided the direction of the effect of the explanatory variables on the dependent variable (levels of contributions) but did not present the actual magnitude of change or probabilities in the coefficients. Thus, the marginal effects of the ordered probit model result measure the expected change in probability of a particular level of contribution to decision making. This is with respect to a unit change in an independent variable as presented in Table 2.

The gender of farmers (male 1 and female 0) was significant ($p \leq 0.01$) and positively related to farmer's level of contributions to adaptation decision making. The positive and significant implication of gender to contributions to decision making suggests that male farmers are more likely to make higher contribution to decision making in climate change adaptation practices than their female counterparts. The result of the marginal effects indicated that an increase in the number of male farmers in a farm household increase in the probability of males making higher contribution to adaptation decision by 0.0867 (8.67%). In other words, gender is a significant factor determining farmers' level of contribution to climate change adaptation decision making. The findings of this study on influence of gender on adaptation decision seems to correspond with the findings of Ogada *et al.*[30] who found that male household heads have a positive relationship in adoption of manure and fertilizer and intensity of their use in Kenya. In addition, De Acedo Lizarraga *et al.*[31] investigated factors that affect decision making with specific interest on gender and age and found that gender in favour of male positively and influence household decision making.

The coefficient of age of the farmers was positive and significantly ($p \leq 0.05$) related to their level of contributions to decision making in climate change adaptation practices. In other words, an elderly farmer is likely to make higher contributions to decision making in climate change adaptation measures than younger ones. The result of the marginal effects indicate that a one-unit increase in age of the farmers will likely lead to 0.0536 (5.36%) increase in the probability of making higher contribution to adaptation decision making. This finding corroborated the report of the study conducted by ACCCA[32] on improving decision-making capacity of small holder farmers in response to climate risk adaptation in three drought-prone districts of Tigray, Northern Ethiopia where it was found that age of the farmers have impacts on adoption and adaptation decisions. The result however disagreed with the findings of Alam[33] who found that age of farmers is not an important factor in adaptation to water scarcity in drought-prone environments of Rajshahi district, Bangladesh.

Education of the farmers was positively and significantly ($p \leq 0.01$) related to their level of contributions to decision making in climate change adaptation practices. This conforms with a priori expectation. The coefficient of marginal effects (0.0690) suggests that a unit increase in years of education of the farmers will result to 6.9% increase in their contribution to decision making in climate change adaptation practices. The findings of this study agreed with that of Abid *et al.*[34] who found that education, farm experience, household size, land area, tenancy status, ownership of a tube well, access to market information, information on weather forecasting and agricultural extension services all influence farmer's choices of adaptation measures. Sebatta *et al.*[35] also found that education had a positive and significant ($p \leq 0.01$) effect on smallholder farmer's decision making. This suggests that education empowers a farmer to make informed decisions and identify farm-related opportunities where they exist for profit maximization.

The coefficient of farming experience was positive and significantly ($p \leq 0.01$) related to farmer's contributions to decision making in climate change adaptation measures. This is expected because, experienced farmers in a farm household are likely to make the bulk of the decisions to adapt to climate change and as their experiences increase the likelihood of making higher contributions to decision making process also increase. The result of the marginal effects shows that a unit increase in years of farming experience of the farmer would result to 0.0938 (9.4%) increase in the contribution to adaptation decision making process. This finding supported the report of Meijer *et al.*[36] that uptake of agricultural technologies is a complex process influenced by both extrinsic and intrinsic variables such as knowledge (experience) and perception of farmers in adoption of innovation. In addition, the result of the study of Alam[33] showed that farmers with more experience of farming, better schooling, more secure tenure rights, better access to electricity and institutional facilities and awareness of climatic effects are more likely to adopt alternative adaptation strategies.

Financial contribution was positive and important in explaining the level of farmer's contributions to decision making in climate change adaptation activities. The positive and significant ($p \leq 0.01$) effect indicate that as the financial contributions of a farmer to climate change adaptation activities in a farm household increase, there is likelihood for a corresponding increase in the farmer's contribution to decision making in adaptation practices. A unit increase in financial involvement as shown in the marginal effects would yield 0.1045 (10.5%) increase in probability of making contributions to climate change adaptation decision making process. The findings agreed with the result of Enete and Amusa[37] that household socio-economic factors that encouraged high women contributions to farm decision making were their financial contributions to household farming activities, number of years of formal education, farming experience, number of hours spent in the farm and farm size. Also in affirmation, Hassan and Nhemachena[38] reported that access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take. Although, the findings of this study contradicted that of Abid *et al.*[34] where access to credit was not a determinant to adaptation strategies to climate change.

The coefficient of off-farm job was negative and significantly ($p \leq 0.05$) related to the probability of making contributions to climate change adaptation decisions. The significant and negative relationship implies that farmers with off-farm jobs are likely to make lower contributions to adaptation decision in their farming households. A unit increase in number of farmers with off-farm occupation as shown in the marginal effects would result to -0.0210 (-2.10%) decrease in the probability of making contributions to climate change adaptation decision making process. The findings of this study agreed with the result of the study of Otitoju[39] who found that off-farm employment is negatively related to efficiency of food crop farmers in climate change adaptation as increase in non-farm jobs result in increase in reallocation of time away from farm-related activities. However, the result contradicted that of Yohannes *et al.*[40] who found that the decision for adoption of fertilizer is positively influenced by economic factors by off-farm income from off-farm jobs.

CONCLUSION

Climate change is having serious effects on agricultural production in Southwest Nigeria as shown by incidence of higher temperature and heat, prolonged drought, increased drying up of seedlings after germination, drying up of rivers and lakes, increased post harvest spoilage of harvested crops and increased cases of flooding among others. Socio-economic attributes of the farmers such as gender, age, education, farming experience and financial contribution significantly influenced their contributions to decision making in climate change adaptation activities in their farm households. The study recommended improved education, income and extension services to the farmers on climate change copping strategies.

SIGNIFICANCE STATEMENTS

The findings of the study provide relevant information in formulating environmental sensitive policies relating to climate change adaptation decision making at farm households level. In addition, the findings will equip agricultural policy makers and extension agents in addressing the major barriers facing farmers in making informed adaptation decisions to climate change.

ACKNOWLEDGMENTS

The authors sincerely appreciate the genuine efforts of Agricultural Extension Agents who were used as key informants for quality data collection for the study. The cooperation of environmental economics experts in the Department of Agricultural Economics for objective validation of the research instrument is highly appreciated.

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