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Vulnerability and Adaptation Strategies to Climate Change among Smallholder Rice Farmers in Ogun State, Nigeria

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ABSTRACT: Climate variability has caused tremendous effects on agricultural production system in Nigeria. These require that smallholder farmer that constitutes the majority of the farming population uses different adaptation strategies to mitigate these climate effect. This study analysed vulnerability and adaptation strategies to climate change among smallholder rice farmers in Ogun State, Nigeria. Multistage sampling procedure was used to select 208 respondents from major rice producing clusters in Ogun State. Interview guide and Focus Group Discussions (FGD) were used to obtain primary data on the features and elements technologies, adaptation strategies to climate change, effects of climate change on rice production and yield of rice crop. Data were analyzed of climate change, farmers' vulnerability to climatic variation change, production using frequency counts, percentages, mean, standard deviation, Logit regression analysis, and Pearson Product Moment Correlation (PPMC). Results showed that 93.8% of the smallholder rice farmers were married with a mean age, household size and farming experience of 46.25 years, 9 persons and 8.36 years respectively. Major climatic variabilities experienced were irregular rainfall pattern ($\bar{x}$ = 2.88), increased temperature ($\bar{x}$ = 2.80) and excessive heat ($\bar{x}$ = 2.76). Adaptation strategies used by smallholder rice farmers were appropriate spacing and sowing density of seeds ($\bar{x}$ = 3.66), altering planting schedule ($\bar{x}$ = 3.19) and construction of drainage canal ($\bar{x}$ = 2.13). Logit regression analysis revealed that age (β = 0.011, $p < 0.05$) and farm experience (β = 0.014, $p < 0.05$) increased the likelihood of high rice yield in the study area. PPMC showed significant ($P<0.05$) relationships between adaptation strategies for ware shortage (r = 0.488), flooding (r = 0.281), collective action (r = 0.295) and rice yield. The study concluded that appropriate spacing, sowing density of seeds and altering planting schedule were the main adaptive strategies that positively influence rice production in the study area. The study therefore recommended that more adaptation strategies should be disseminated to smallholder rice farmers to mitigate the effect of climate change and improve yield.

Keywords: Vulnerability, Climate Change, Adaptation Strategies, Smallholder Rice Farmers.

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INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC, 2007) defined climate change as statistically significant variation on climate that persists for an extended period, typically decades or longer. It includes shifts in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature. Climate change is a change in climate that is attributable directly or indirectly to human activities. It affects the atmospheric conditions of the earth thereby leading to global warming. Climate change has the potential to affect all natural systems thereby becoming a threat to human development and survival socially, politically and economically. Climate change is considered to be one of the most unprecedented threats of our time. Although climate change is not a new phenomenon, its recent usage, especially in the context of development refers to changes in the prevailing climate over time that might be due to natural changes or persistent anthropogenic changes in the composition of the atmosphere or in land use, the perceived impacts on the economy and livelihoods (Adebayo *et al*., 2011).

It has been established that climate variability and change has tremendous impacts on agricultural production and productivity especially in developing countries. The occurrences of extreme climatic events particularly flooding, excessive rise in temperatures, frequent dry spells within growing seasons (Adesina *et al*., 2006; Mark *et al*., 2007; Unmubig and Cramer, 2008) irreversible damages to ecosystems translating, in part, to rapid expansion of the tropical deserts in the drier part of West Africa (Ayoade, 2007) among others, are strong proof of immensely altered climatic patterns. One of the dominant thrusts of agreement and mandates from the various Conventions on climate change particularly the Marrakesh Accords of 2001 and Bueno Aires Programme of Work on Adaptation and Responses Measures (2004) is that developing countries be strengthened to develop and or amplify existent adaptation strategies to reduce their vulnerability to climate change. The emphasis on adaptation is informed by the fact that developing countries are predisposed to suffer greater impacts of climate change due to their fragile economies, exposure to many other stressors and consequently their abysmally low adaptive capacity. These countries also have weak resilience i.e. ability to recover from shocks (such as those that may come from natural disasters) due to deep rooted poverty, degraded environments among other problems (Thornton *et al*., 2006). Therefore, they are vulnerable, as more frequent and severe events that appear inevitable could "tip them over the edge" into more calamitous disasters (Huq and Ayers, 2007).

Nigeria is vulnerable to the impacts of climate change largely because 70% of Nigerians farmers engaged in smallholder rain-fed agriculture (Nigerian Environmental Study/Action Team (NEST), 2011). For Nigeria, agriculture is important because about 42% of the country`s GDP comes from agriculture and related activities. The impact of climate change is very visible in most communities in Nigeria, from the Sahel in the north to rainforest and coastal zone in the south. Drought in the north, for example, has led to poor crop yields, water scarcity and forced migration. In the south, sea level rise increases the risk of flooding, salt- water intrusion and displacement of people and livestock. Erosion associated with heavy rainfall and flooding is now a frequent threat in most zones in Nigeria, especially in the rainforest where mudslides can occur. In the context of climate change, traditional food sources become unpredictable and scarce. Climate change impacts will be differently distributed among regions, generations, age, classes, income groups, occupation and gender, Intergovernmental panel on climate change (IPCC, 2001). Those charged with the responsibility to secure water, food and fuel for cooking, processing and heating face the greatest challenges.

Climate change will likely elicit a significant change in agricultural production both in quantum of products as well as the location or area of production now and in the years ahead. Darwin *et al.* (2005) estimated that the amount of land classified as land class 6 i.e. the primary land class for rice, tropical maize, sugarcane and rubber would decline by between 18.4 and 51 percent during the next century due to global warming, with possible consequences in terms of shift in rainfall belts, traditional areas of production of certain crops and negative consequences to the local people (Follett *et al*., 2001).This is corroborated by the IPCC (2018) which stated that by 2020, yields from rain-fed agriculture could be reduced by up to 50% in some countries.

The International Food Policy Research Institute (IFPRI) (2009) predicted that crop model indicates that by 2050 in sub-Saharan Africa, in which Nigeria is inclusive, average rice, wheat, and maize yield will decline by up to 14 percent, 22 percent, and 5 percent, respectively, as a result of climate change. Omotayo *et al*. (2007) highlighted some serious bottlenecks against expanded production and distribution of Ofada rice which need to be combated. These include transportation difficulties, price instability, pest attacks, and insufficient rains, among others. A well-articulated stakeholder solution to ease these problems is imperative. According to Daramola (2005), yield of rice per hectare is low because of sundry challenges such as production system (which may include problem of climate change), aging farming population, and low competitiveness of local rice with imported rice. From the above scenario, it is therefore pertinent to analyse vulnerability and adaptation Strategies to climate change among smallholder rice farmers. In order to ascertain the sustainability of the process, because climate change cannot be separated from sustainable development, as sustainable development may be the most effective way to frame the mitigation question and a crucial dimension of climate change adaptation and impacts (Swart *et al*., 2003). The broad objective of the study is the analysis of climate change adaptation strategies among smallholder rice farmers in Ogun state, Nigeria.

Specific Objectives

The specific objectives of the study are to describe the features and elements of climate change experienced by smallholder rice farmers; assess smallholder rice farmers' vulnerability (exposure and sensitivity) to climatic change; examine smallholder rice farmers' adaptation strategies to climate change and assess the yield of rice crop among smallholder farmers in the study area.

Hypotheses of the Study

The hypotheses of this study are stated in a null form as follows:

H_{O1}: Socio-economic characteristics of smallholder rice farmers have no significant effect on rice yield

H_{O2}: There is no significant relationship between smallholder rice farmer adaptation strategies (that is, water shortage, flooding and collective action) to climate change and yield of rice crop.

MATERIAL AND METHODS

The study was conducted between November 2016 and May 2017 in Ogun state. It falls between longitudes 2^0 40'E-6^0 40'E and latitudes 4^0 40'N-9^0 15'N (Onakomaiya *et al*., 1992). Rainfall ranges from 900mm in the Northern, up to 16000mm along the coast. The annual average temperature throughout the year ranges from 21^0C -32^0C.

Ogun State is one of the state noted for rice production in South west Nigeria, in fact, the name tagged "Ofada" of the local rice is associated to one of the communities that produce rice in the state. The population of the study comprises all rice farmers in rural areas where rice is produced in Ogun State, Nigeria.

A multistage sampling technique was used to select sample for the study. A total of 208 smallholder rice farmers were selected for this study. To achieve this selection, the following steps were taken: Out of twenty (20) Local Government Areas (LGAs) in Ogun State, six (6) of them namely, Obafemi Owode, Ewekoro, Yewa North, Ogun Waterside, Ijebu North and Ijebu North East LGAs were purposively selected because these LGAs are the major rice producing LGAs in the state (The National Farmers Database Survey, 2015 Omotayo *et al*., 2007).

From each of the six (6) selected rice producing LGAs, purposive sampling technique was used to select *Lukofo, Onidundun* and *Aiyewere* clusters in Obafemi Owode LGA, *Ifo* and *Owowo* clusters in Ewekoro LGA, *Eggua* cluster in Yewa North. Also, *Ode-Omi* cluster was selected from Ogun Waterside, *Ago Iwoye* and *Aparaki* clusters in Ijebu North LGA while *Imewuro* cluster was selected in Ijebu North East LGA. This selection was based on the fact that, these clusters were major rice producing clusters from these locations.

Using Watson (2001) sampling technique at confidence level of 98% with an estimated 30% variance in population (that is degree of variability), a total of 208 smallholder rice farmers were selected as follows: 45 smallholder rice farmers from *Lukofo, Onidundun* and *Aiyewere* clusters in Obafemi Owode LGAs, 24 from *Ifo* and *Owowo* clusters in Ewekoro LGA, 41 from *Eggua* cluster in Yewa North. Also, 44 smallholder rice farmers were selected from *Ode-Omi* cluster in Ogun Waterside LGA, 32 from *Ago Iwoye* and *Aparaki* clusters in Ijebu North LGA while 22 farmers were selected from *Imewuro* cluster in Ijebu North East LGA.

Primary data for the study were obtained using a structure interview guide. Furthermore, Focus Group Discussion (FGD) session was conducted with the groups of about 5 and 10 smallholder rice farmers to obtain information on some of the objectives of the study Data obtained from the study was subjected to descriptive and inferential statistics using Statistical Package for Social Science (SPSS) version 15.0. Descriptive statistics such as frequency distribution, percentages, means and standard deviation was used for data obtained. Moreover, hypothesis 1 was measured using Logistic regression analysis, and PPMC was used for hypothesis 2

Logistic Regression Analysis

This was used for hypothesis 1 (Socio-economic characteristics of rice farmers have no significant effect on their rice production (i.e. yield) to determine the effect of the farmers' socio-economic characteristics on their yield, yield of rice crop, which constitute the dependent variable was dichotomized into two (High yield of rice crop = 1 and low yield of rice crop = 0). The selected socio-economic variables, which made up the independent variables such as actual age in years, years spent in school, marital status, farm experience (years), farm size, income, quantity of fertilizer used and sources of seeds used. The dependent variable and independent variable were thus cross-tabulated against each other using Logistic regression analysis. The Logistic regression analysis was found appropriate because it helps to establish the extent to which the independent variables influenced the yield of rice crop.

The following equation shows the logit regression model for this study:

$Z = \ln P/1\text{-}p = bo + b_i x_i + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + b_7 x_7 + b_8 x_8 + b_9 x_9$

Z = Probability of yield of rice production (1= high yield, 0 = low yield)

bs = coefficient of explanatory variable which increase or decrease z

x_1 = Age (years)

x_2 = Educational level (No of years spent in formal school)

x_3 = Marital status (Single = 1; married = 2; separated =3; widowed =4)

x_4 = Farm experience (total number of years spent in rice farming activities)

x_5 = Farm size (hectares)

x_6 = distance from rice farm to other locations

x_7 = Income

x_8 = Quantity of fertilizer used

x_9 = Sources of seeds used

Pearson's Product Moment Correlation Coefficient (PPMC)

PPMC was used for hypothesis 2. It is most familiar measure of dependence between two variables measured on ratio/interval scale. It indicates the strength of a linear relationship between two variables (adaptation strategies and yield of rice), The Pearson correlation is +1 in the case of a perfect direct (increasing) linear relationship (correlation), -1 in the case of a perfect decreasing (inverse) linear relationship. The closer the coefficient is to either -1 or +1, the stronger the correlation between the variables. If the variable is independent, Pearson's correlation coefficient is 0.

Rice Farmers Adaptation Strategies to Climate Change

This was measured on a 4-point rating scale as; Always= 4, occasionally = 3, Seldom = 2, Never = 1.

Effect of Climate Change on Rice Production

a. Yield: This was measured at ratio scale as;

Total rice farm size cultivated (hectares)

i. 2016_—
ii. 2015 —
iii. 2014 —
iv. 2013 —

v. 2012 —

Total yield from rice production (tons/hectare):

i. 2016 —

ii. 2015 —

iii 2014 —

iv 2013 —

vi. 2012 —

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Smallholder Rice Farmers

Results in Table 1 revealed that the mean age of the smallholder rice farmers was 46.25 years. About 40.4% of the respondents fell between the age bracket of 41 and 50 years, this constitutes the modal age group while 28.8% were within the ages of 31 and 40 years. This implies that majority of the respondents were still economically active, productive and expected to be well efficient in rice production. This finding corroborate Oladoja *et al*. (2006) and Omotayo *et al*. (2007) that most Nigerian farmers are still very active and they are within the ages of 41 and 50 years. Also, the mean household size of the respondents was 9.34. This implies that rice farmers had a relatively large household size. The reason adduced for this may be attributed to the fact that rice production is labour intensive and family labour is part of the labour components on rice farm, which is also relatively cheaper, affordable and easily accessible. Therefore, large household size by the smallholder rice farmers will be of advantage to them.

The marital status of the rice farmers shows that majority (93.8%) of the smallholder rice farmers were married while few 5.8% were single. This shows that married smallholder rice farmers are mainly involved in rice farming in the study area. This might be due to the fact that most of them rely on rice farming to cater and feed their household. This high percentage of the involvement of married smallholder farmers in rice production agrees with the position of Ekong (2003) who noted that most rural people are married in most Nigerian communities. The mean and standard deviation of years spent in school by the smallholder rice farmers were 8.36 years and 3.48 respectively. By implication, the smallholder rice farmers had primary and secondary School education, which is equivalent to literacy level. Also, the mean cultivated land by smallholder rice farmers was 5.23 hectares while 47.5% cultivated less than 4 hectares of land for rice production. This has implications for the goal of self-sufficiency and sustainable rice production without importation of rice in Nigeria, because the respondents are small scale rice farmers, therefore they need to be encouraged to engage in large scale rice production to meet the goals of self- sufficiency and sustainable rice production. This also is in consonance with the findings of Omotayo *et al*. (2007) that average farm size across the three States in Southwest Nigeria was 3.95 hectares.

The mean year of experience of smallholder rice farmers was 20.9 years with standard deviation of 8.46. Many (50.9%) of the respondents had 11 to 20 years' experience in rice production while 25.0% had 21 to 30 years of rice production experience. This implies that small scale rice production, fully mechanized would enhance self-sufficiency and sustainable rice production. This will enable smallholder rice farmers to identify whether or not the problem encountered in the course of rice production is due to climate change or not, and what to do to ameliorate the effect of climate change on rice production. Also, finding in Table 1 revealed that the mean monthly income of the respondents was ₦84, 025.51. Majority (95.6%) had income between ₦100, 000 and N200, 000. This implies that the income status of smallholder rice farmers is as a result of improved processing techniques through milling and bagging which is acceptable to the consumers and indirectly attract more income. Another reason that may be adduced for high income status is the proximity of the study area to Lagos State which is the commercial nerve centre of the country and this may engender better pricing for the "*Ofada*" rice (the local rice).

Table 1: Socioeconomic Characteristics of Smallholder Rice Farmers (n = 208)

Variables	Frequency	Percentages	Mean	S.D
Age (Years)				
<30	7	3.4	46.25	9.408
31- 40	60	28.8		
41- 50	84	40.4		
51 and above	57	27.4		
Household size				
<3	11	5.3	9.34	3.22
4-6	47	22.6		
7-9	29	13.9		
10 and above	121	58.2		
Marital Status				
Single	12	5.8		
Married	195	93.8		
Widowed	1	0.5		
Years spent in school				
<6	138	66.4	8.36	3.48
7-12	51	24.6		
13 and above	19	9.2		
Farm size (Hectares)				
<4	99	47.5	5.23	3.44
5-8	82	39.5		
9 and above	27	12.0		
Years of farm experience				
< 10	31	15.0	20.29	8.462
11-20	106	50.9		
21-30	52	25.0		
31 and above	19	9.2		
Monthly income (N)				
<100,000	1	0.5	84,025.51	
100,000-200,000	199	95.6		
Above 200,000	8	3.9		

Source: Field Survey, 2016, SD= Standard Deviation

Production Characteristics of Smallholder Rice Farmers

Table 2 shows the production characteristics of the smallholder rice farmers. Finding indicates that many (51.0%) of the smallholder rice farmers combined the use of used manual and mechanized methods of land preparation while 43.3% used only manual method and 5.8% used only mechanized method. It was deduced from the findings that the smallholder rice farmers did not rely on manual method of land preparation alone because of extent of land to be cultivated, cultural practices involved in rice production, and timeliness of operation. Also, the mean bag of fertilizer used by the smallholder farmers was 12.8 bags while most (67.3%) of the respondents utilized 6 to 10 bags of fertilizers. The number of bags of fertilizer used is as a result of the extent of farm size cultivated. This is in line with the recommended fertilizer application of 100 to 170kg/ha of nitrogen (Okeleye *et al*., 2006).

Also, results from Table 2 revealed that majority (70.5%) of the smallholder rice farmers cleared their farm of weed once, 20.2% of the smallholder rice farmers cleared the farm of weed twice, while 3.4% engaged in this practice more than twice. This implies that most of the smallholder rice farmers cleared their farms of weed one or two times in the course of cultivation of rice. As regard source of seeds, results show that 52.3% of respondents sourced their seeds from previous harvest. 59.5% of the smallholder rice farmers planted above 41kg of seed per hectare with a mean of 45.38kg. This implies the smallholder rice farmers planted approximately 1bag per hectare. Furthermore, majority (92.8%) of the smallholder rice farmers produced improved "*Ofada*" rice variety. This support the finding of Omofonwan and Kadri (2007) that improved varieties of rice seeds is common and available to the farmers. In relation to market form, result indicated that 62.1% of the smallholder rice farmers sell milled rice; however manual threshing is done by the smallholder rice farmers before taken them for milling (as indicated in Plate 1). This implies that rice values addition is practiced to a greater extent amidst the farmers.

Table 2: Production Characteristics of Smallholder Rice Farmers (n = 208)

Variables	Frequency	Percentages	Mean	S.D
Methods of Land Preparation				
Manual	90	43.3		
Mechanized	12	5.8		
Manual and mechanized	106	51.0		
Quantity of Fertilizer Used (bag)				
<5	62	29.8	12.8	6.8981
6 -10	140	67.3		
11&above	6	2.9		
Weeding Rice Farm/Season				
Once	159	70.5		
Twice	42	20.2		
More than twice	7	3.4		
Sources of seeds				
Agro services	59	28.4		
Previous harvest	109	52.3		
Fellow farmers	38	18.3		
Open market	2	1.0		
Quantity of Seed Used/Hectare (kg)				
<40	83	40.1	45.38kg	12.33
41 and above	125	59.5		
Rice Varieties				
ITA 150	15	7.2		
Ofada	193	92.8		
Rice Type				
Asian Rice	3	1.4		
Africa Rice	200	96.2		
Nerica	5	2.4		
Market Form				
Milled form	129	62.1		
Paddy form	79	38.0		

Source: Field Survey, 2016, SD=Standard Deviation

Plate 1: Manual Rice Threshing by the Smallholder Rice Farmers

Climatic Elements Experienced by the Smallholder Rice Farmer

Findings in Table 3 depicted the climatic elements experienced by smallholder rice farmers. Results indicated that the main climatic elements experienced by smallholder rice farmers were: irregular pattern of rainfall ($\bar{x}$ =2.88), increased temperature ($\bar{x}$=2.80). This implies that there is evidence of climate change in the study areas, which is indicative of the reduction in yield, and income. This corroborates the findings of (Somado, 2008; Arimi and Jenyo-Oni 2014; Mahdu, 2019) that farmers also face problem of extreme weather events such as floods, droughts and low soil fertility, which are responsible for low rate of rice production. These challenges called for adaptation strategies to climate change or variability in order to maintain optimum level of rice yield.

Smallholder Rice Farmers` Vulnerability (Exposure) to Climate Change

The smallholder rice farmers' vulnerability (exposure) to climate change is presented in Table 4. Findings revealed that the major climate change hazards to which smallholder rice farmers were exposed include: atmospheric temperature ($\bar{x}$=3.13), excessive heat ($\bar{x}$=2.76), high soil temperature ($\bar{x}$=2.63), sunshine intensity ($\bar{x}$=2.38) and long duration of sunshine ($\bar{x}$=2.30). By implication, it then means that in terms of degree of exposure to climatic elements, smallholder rice farmers are faced with climatic hazards of hash atmospheric temperature, excessive heat, high soil temperature, and extreme weather events such as floods, droughts and low soil fertility which are responsible for low rate of rice production. The most critical aspect of climate change to rice production is increase in temperatures. This has the most damaging effects on rice quality as advanced by **(**Ezeibe and Eze, 2012; Arimi, 2014). Also, temperature changes greatly influence the growth pattern, duration and productivity of rice crops. This has the most damaging effects on rice quality. Temperature changes greatly influence the growth pattern, duration and productivity of rice crops (Nguyen, 2004).

Smallholder Rice Farmers `Vulnerability (Sensitivity) to Climate Change

The smallholder rice farmers' vulnerability (sensitivity) to climate change, that is, the degree to which climate related hazards affects rice production, is presented in Table 5.

Table 3: Climatic Elements Experienced by the Smallholder Rice Farmer (n=208)

S/N	Climate Elements	Regularly	Occasionally	Not Experience	Mean	S.D
1	Irregular pattern of rainfall	183(88.0)	25(12.0)	-	2.88	0.32
2	Increased temperature	181(87.0)	12(5.8)	15(7.2)	2.80	0.55
3	Decreased temperature	126(60.6)	55(26.4)	27(13.0)	2.47	0.71
4	Flooding	41(19.7)	150(72.1)	17(8.2)	2.12	0.52
5	Drought	51(24.5)	127(61.1)	30(14.4)	2.10	0.62
6	Windstorm	16(7.7)	175(84.1)	17(8.2)	2.60	1.42)
7	Outbreak of weevils	14(6.7)	60(28.8)	134(64.4)	1.42	0.61
8	Land degradation as a result of erosion	14(6.7)	145(69.7)	49(23.6)	1.83	0.53
9	Attacks by birds increased in a flooded rice field	144(69.2)	50(24.0)	14(6.7)	2.62	0.61
10	Damage of rice plant increases as a result of prevalent of birds on rice field during flooding	118(56.7)	89(42.8)	1(0.5)	2.56	0.50
11	Climate change increases attack by birds on rice plants at milk stage, until harvest causing severe yield loss	126(60.6)	73(35.1)	9(4.3)	2.93	0.25
12	Prolong drought creates right conditions for grass cutter or rats attack on rice plants.	76(36.5)	130(62.5)	2(1.0)	2.36	0.50
13	Intense Flooding creates right conditions for grass cutter or rat attacks on rice plants	124(59.6)	69(33.2)	15(7.2)	2.52	0.63

Source: Field survey, 2016, S.D= Standard Deviation

Table 4: Smallholder Rice Farmers` Vulnerability (Exposure) to Climate Change (n = 208)

Climatic Stimulus	Increase	Decrease	Irregular	No change	Mean	S.D	Rank
Atmospheric Temperature	107(51.4)	16(7.7)	80(38.5)	5(2.4)	3.13	0.953	1st
Heat	78(37.5)	6(2.9)	108(51.9)	16(7.7)	2.76	1.026	2nd
Soil Temperature	68(32.7)	29(13.9)	86(41.3)	25(12.0)	2.63	1.048	3rd
Sunshine Intensity	74(35.6)	5(2.4)	54(26.0)	75(36.1)	2.36	1.314	4th
Sunshine Duration	74(35.6)	10(4.8)	49(23.6)	74(36.1)	2.38	1.302	5th
Erosion	9(4.3)	35(16.8)	157(75.5)	7(3.4)	2.20	0.534	6th
Rainfall Intensity	38(18.5)	19(9.1)	67(32.2)	84(40..4)	2.03	1.097	7th
Rainfall Duration	38(18.5)	16(7.7)	68(41.3)	86(41.3)	2.00	1.039	8th
Dry Season	51(24.5)	3(1.4)	48(23.1)	106(51.0)	1.94	1.19	9th
Drought	38(18.3)	8(3.8)	74(35.6)	88(42.3)	1.92	1.05	10th
Flood Occurrence	20(9.6)	19(9.1)	88(42.3)	81(88.9)	1.85	0.88	11th
Strong Wind	12(5.2)	25(12.0)	87(41.8)	84(40.4)	1.75	0.75	12th

Source: Field Survey, 2016; S.D= Standard Deviation

Table 5: Smallholder Rice Farmers Vulnerability (Sensitivity) to Climate Change (n= 208)

Climate Related hazards	Regularly Effects	Occasionally Effects	Never Effects	Mean	S.D
Strong Wind	61(29.3)	146(70.2)	1(0.5)	2.00	1.79
Soil fertility	7(3.4)	40(19.2)	161(77.4)	1.36	0.57
Drought	97(46.6)	51(16.8)	76(36.5)	1.84	0.87
Flooding	49(23.6)	51(24.5)	108(51.9)	1.84	0.83
Increase Temperature	41(19.7)	44(21.2)	124(59.2)	1.79	0.32
Excessive Heat	14(6.7)	72(34.6)	122(58.7)	1.63	0.64
Wind Storm	38(18.3)	69(33.2)	101(48.6)	1.42	0.50
Land loss	7(3.4)	40(19.2)	161(77.4)	1.36	0.57
Water Overflow	16(7.7)	75(36.1)	117(56.3)	1.32	0.66
Disease Outbreak	39(18.8)	41(19.7)	128(61.5)	1.24	0.43

Source: Field Survey, 2016; S.D = Standard Deviation

Findings revealed that the major climate related hazards that affected rice production were; strong wind ($\bar{x}$=2.00), drought ($\bar{x}$=1.84), flooding ($\bar{x}$=1.84), increase temperature ($\bar{x}$=1.79) and excessive heat ($\bar{x}$=1.63). This implies that rice production in Ogun Sate is mainly affected by strong wind and lack of rainfall and excessive heat which may affect the health of the smallholder rice farmers, thus their productivity, this directly leads to low rice yield. It was observed that most of the poor and remote farming communities are especially vulnerable to climate change as they tend to be unable (or less able) to access relevant information on possible changes in climate, or warnings of unpredictable weather events. Such communities have tended to rely on traditional indicators of climate and weather patterns such as the appearance of migratory birds or the flowering of certain trees. As both weather patterns and the traditional indicators become unreliable, farmers are highly vulnerable to production losses which might result from unpredictable weather events. The finding is corroborated by Ugwoke and Achike (2012) that extreme weather events such as thunderstorms, heavy wind, and floods devastate farmlands and can lead to rice crop failure.

Level and Time of Occurrence of Climate Related Hazards

Level and time of occurrence of climate related hazards are presented in Tables 6 and 7 respectively. Findings indicate that based on the mean values ($\bar{x}$=2.08) only flood was observed to be high, while other variables were seen to be moderate or low, which have bearing on rice production system with attendance loss or increase of income, yield, rice production infrastructure and livelihood of rice farmers or could make it possible to respond to adaptation strategies. From Table 7, it was discovered that some factors associated with rainfall like strong wind, wind storm, occurred at the peak of the rainfall, while 29.8% of the smallholder rice farmers observed that flood occurred at the peak of rainfall. Increase temperature, disease outbreak equally also occurred at the peak of rainfall. Land loss was observed throughout wet season. In terms of the mean value, drought ($\bar{x}$= 3.19), wind storm ($\bar{x}$=2.59), strong wind ($\bar{x}$=2.37), Excessive Heat ($\bar{x}$=2.20), and increase in temperature ($\bar{x}$=2.08) were the most frequently observed climatic hazards in the study areas. The inference that could be drawn was that many of the hazards are climatic related, health related, seasonal, and occurred at the peak of dry season, thus they may have effect on rice production chain. According to Ramirez (2010) that unforeseen changes associated with global warming in temperature carbon dioxide and rainfall are expected to impact on rice production. This implies that natural disasters such as flooding due to heavy rainfall could be a threat to rice production, as paddies may be washed away or plants lodge into heavy floods (Nwalieji and Uzuegbunam, 2012).

Table 6: Sensitivity (Level of Occurrence) to Climate Related Hazards (n = 208)

Climatic Related Hazards	High Occurrence	Moderate Occurrence	Low Occurrence	Do not Occur	Mean	S.D
Flood	43(20.7)	28(13.5)	35(16.8)	102(49.0)	2.08	0.859
Increased Temperature	69 (33.2)	29(13.9)	77(37.0)	33(15.9)	1.95	0.915
Soil Fertility	29(13.9)	105(50.5)	42(20.2)	32(15.4)	1.93	0.683
Land loss	23(11.1)	84(40.4)	34(16.7)	67(32.2)	1.92	0.683
Excessive Heat	22(15.4)	30(14.4)	44(4.2)	102(49.0)	1.89	0.843
Strong Wind	13(6.3)	104(50.0)	59(28.4)	22(15.4)	1.74	0.585
Wind Storm	2(1.0)	107(51.4)	39(18.8)	60(28.8)	1.76	0.490
Drought	48(23.9)	24(11.5)	111(53.4)	25(12.0)	1.66	0.869
Water Overflow	22(10.6)	10(4.8)	91(43.8)	85(40.9)	1.44	0.271
Disease Outbreak	1(0.5)	4(1.9)	100(48.1)	103(49.5)	1.06	0.271

Source: Field Survey, 2016; S.D = Standard Deviation

Table 7: Sensitivity; Time of Occurrence of Climate Related Hazards (n = 208)

Climate Outcome	ARY	TDS	PDS	TWS	DPR	DNO	Mean	S.D
Drought	2(1.0)	21(10.1)	44(21.2)	5(2.4)	3(1.4)	133(63.9)	3.19	0.76
Windstorm	41(19.7)	22(10.6)	3(1.4)	6(2.9)	81(38.9)	55(26.4)	2.59	1.805
Strong wind	18(8.7)	38(18.3)	9(4.3)	6(2.9)	82(39.4)	55(26.4)	2.37	1.589
Excessive Heat	5(2.4)	37(17.8)	27(13.0)	54(26.0)		85(40.9)	2.20	1.397
Increase Temperature	4(1.9)	29(13.9)	30(14.4)	3(1.4)	87(41.8)	55(26.4)	2.08	1.328
Disease Outbreak	10(4.8)	-	3(1.4)	18(8.7)	85(40.9	92(44.2)	1.55	1.160
Land loss	6(2.9)	-	-	66(31.7)	-	133(63.9)	1.36	1.089
Water Overflow	1(0.5)	3(1.4)	-	5(2.4)	44(21.2)	155(74.5)	1.26	0.655
Soil infertility	2(1.0)	6(2.9)	-	3(1.4)	72(34.)	125(60.1)	1.21	0.47
Flood	-	-	3(1.4)	5(2.4)	62(29.8)	138(83.3)	1.16	0.47

Source: Field Survey, 2016; S.D == Standard Deviation ARY = All-round the year, TDS= Throughout Dry Season, PDS= Peak of Dry Season, TWS= Throughout Wet Season, DPR = During Peak of Rainfall, DNO = Do not occur

Adaptation Strategies used by Smallholder Rice Farmers

Findings in Table 8 present the adaptation strategies used by smallholder rice farmers. The major adaptation strategies used for tackling the problem of water shortage or drought is: applying appropriate spacing and density of seeds ($\bar{x}$= 3.66), planting at the onset of rainfall ($\bar{x}$= 3.20), altering planting schedule ($\bar{x}$= 3.19), application of good cultural practices ($\bar{x}$= 2.81) and adjusting the cropping pattern ($\bar{x}$= 2.82). Furthermore, the construction of drainage canal to prevent crops from being submerged by flood water ($\bar{x}$= 2.13), was the major adaptation strategy used by smallholder rice farmers for the management of flooding. These results imply that integrated approach was employed by smallholder rice farmers as adaptation strategies to combat the effects of climate change on rice production. This corroborates the finding of Herath and Krishnal Thirumarpan (2016) all rice farmers used at least one or more adaptation strategy for paddy farming. It is contrary to the view that farmers in the tropics are yet to key into adaptation strategies to ameliorate the effects of climate change (IPCC, 2018).

Total Rice Farm Cultivated in Hectares

The result of the total rice farm cultivated in hectares from year 2012 to 2016 is presented in Table 9. Findings show that majority (90.4%) of the smallholder rice farmers cultivated rice farm less than 3 hectares with a mean farm size of 2.60 ha in year 2012. In the same vein, majority (85.7%) of the smallholder rice farmers equally cultivated less than 3 hectares of farmland in the year 2013, with mean farm size of 2. 99ha while in year 2014 about 62.0 percent of the smallholder rice farmers cultivated about 3 to 4 hectares of farm land for rice production. Furthermore, in year 2016, many (62.4%) of the smallholder rice farmers cultivated between 4 and 6 hectares of farm land. This implies that there is a constant and progressive increase in the total farm size cultivated by the smallholder rice farmers, although they are still regarded as smallholder rice farmers which is in line with the classification of Federal Ministry of Agriculture and Rural Development (FMARD, 2010) that the size of small scale farm is less than 5 hectares in Nigeria. However, this finding can be attributed to various government policies put in place by the federal government to encourage rice production. The result supports the findings by (Nwalieji, 1999; Nwalieji and Uzuegbunam, 2012) that smallholder rice farmers in Africa (Nigeria inclusive) cultivated more than two hectares of land for rice produced under upland, swamp and/or irrigated lowland conditions. In a Focus Group Discussion (FGD) at *Imewuro* in Ijebu North East the smallholder rice farmers reiterated that.

Yield of Rice Production

The result of the total yield from rice crop in tonnes from year 2012 to 2016 is presented in Table 10. Results show from Table10 that majority (87.5%) of the smallholder rice farmers produced less than 10 tons of rice per hectare, with an average yield of 9.48 tons, in year 2012, majority (81.6%), in year 2013, of the smallholder rice farmers produced less than 10 ton of rice per hectare with average yield of 9.96 tons while in year 2014, majority (70.0%) of the smallholder rice farmers produced less than 10tons of rice per hectare, with average yield of 9.03 tons. Also, the mean production of rice in year 2016, by the smallholder rice farmers was 13.39 tons. According to OGADEP (1998), as cited by Agbamu and Fabusoro (2001), rice output level in Ogun State was 10.6 metric tons in 1992, 5.86 metric tons in 1994 and 6.02 metric tons in 1997, respectively. This result implies that the average yield of rice production fluctuates between year 2012 to 2014, but increase marginally from 2015 to 2016. This outcome might be attributed to the challenges of climate change. The marginal increase witness by the rice farmers from year 2015 to 2016 might be because of various policies and programmes, government initiated to encourage rice farmers to enhance yield of rice and add value to rice products. Personal interview with the smallholder rice farmers at *Lukofo* village in Obafemi Owode show that: *Rice farmers in the Owode area use garawa which is the unit of measurement for selling among rice farmers in this area (Plate 4).*

Table 8: Adaptation Strategies used by smallholder rice Farmers (n = 208)

S/N	Adaptation Strategies	Always	Occasionally	Seldom	Never	Mean	S.D
	Water Shortage/Drought						
1	Using of water pump	33(15.9)	54(25.0)	28(13.5)	93(44.7)	2.15	1.15
2	Using of drought resistant seeds	44(21.2)	8(3.8)	7(3.4)	149(71.6)	1.71	1.24
3	Adjustment in cropping patterns	120(87.7)	5(2.4)	8(3.0)	75(3.61)	2.82	1.42
4	Apply good practices in rice production to increase	126(60.6)	4(1.9)	2(1.0)	76(36.5)	2.87	1.43
5	Appropriate spacing and density of seeds	76(36.6)	97(46.6)	31(14.9)	4(1.9)	3.66	0.61
6	Water retention techniques	24(10.5)	16(7.7)	65(31.3)	103(49.5)	1.77	0.96
7	Altering planting schedules	115(58.3)	4(1.9)	95(36.1)	14(6.8)	3.19	0.98
8	Planting at the onset of rain	123(59.1)	2(1.0)	74(35.6)	9(4.3)	3.20	1.01
9	Digging drainage channels	56(26.9)	33(15.9)	79(38.0)	40(19.3)	2.60	1.05
10	Use of hand Irrigation	77(34.0)	16(7.7)	82(39.4)	33(15.9)	2.69	1.15
11	Drought-tolerant, disease and/pest-resistant varieties	55(26.4)	23(11.1)	85(46.9)	42(20.2)	2.44	1.09
	Flooding						
12	Construction of drainage canal to prevent crops from being submerged by flood water	28(13.5)	27(13.0)	100(48.1)	53(25.5)	2.13	0.91
13	No action is taken to control flood	62(29.8)	32(15.4)	107(51.4)	58(22.9)	1.95	0.75
14	Irrigation system operators regulate the flow of water	7(3.4)	36(17.3)	107(51.4)	58(22.9)	1.95	0.75

Source: Field survey, 2016

Table 9: Total Rice Farm Cultivated in Hectares (n = 208)

Variables	Frequency	Percentage	Mean (S.D)
2016 (Hectare)			
< 3	53	25.5	4.41(1.43)
4-6	129	62.4	
7&above	26	12.5	
2015 Farm Size			
<3	61	29.3	4.13(1.39)
4-6	144	57.7	
7&above	3	1.4	
2014 Farm Size			
<3	129	62.0	3.07(1.45)
4-6	55	26.5	
7&above	24	11.5	
2013 Farm Size			
< 3	178	85.7	2.99(1.16)
4-6	30	14.4	
7&above	-	-	
2012 Farm Size			
<3	188	90.4	2.60(0.99)
4-6	20	9.6	
7 &above	-	-	

Source: Field Survey, 2016, S.D = Standard Deviation

Plate 2: Unit of Rice Measurement among Smallholder Rice Farmers

Table 10: Yield of Rice Production

Variables	Frequency	Percentage	Mean(S.D)
2016-Rice Yield (ton/Ha)			
<10	82	39.5	13.39(10.11)
11-20	116	55.8	
21 &above	10	4.7	
2015-Rice Yield(ton/Ha)			
<10	116	55.7	11.45(4.09)
11-20	89	42.9	
21 &above	3	1.5	
2014-Rice Yield(ton/Ha)			
<10	152	70.0	9.03(4.96)
11-20	54	26.0	
21 &above	2	1.0	
2013-Rice Yield(ton/Ha)			
<10	170	81.6	9.96(3.77)
11-20	37	17.6	
21 &above	1	0.5	
2012-Rice Yield (ton/Ha)			
<10	182	87.5	8.97(9.48)*
11-20	25	12.0	
21 &above	1	0.5	

Source: Field Survey, 2016

Hypotheses

Effect of Smallholder rice farmer socioeconomic characteristics on rice yield

The factors that influenced the smallholder rice farmers' yield in the study area were examined using the binary logistic regression model. As indicated in Table 11, the likelihood estimates of the Logitic model indicated that the Chi-square statistic of 151.45 was highly significant ($p < 0.00$), suggesting that the model has a strong explanatory power. The pseudo coefficient of multiple determinations (R^2) shows that 69 percent of the variation in smallholder rice farmer yield in the study area was collectively explained by the independent variables. The age of the smallholder rice farmers and their sources of information had a positive significant coefficient at $p < 0.05$, on their rice yield. This suggests that the age of smallholder rice farmers may positively influences the decision to adopt certain technologies and this will indirectly affect their yield.

Also, **y**ounger farmers are more likely to take risk and likely to be flexible than older farmers and thus have a more likelihood to use adaptation strategies, moreover, they are likely to incur lower switching costs in implementing new farming practices since they have limited experience and learning and therefore, adjustment costs involved in taking available new technologies may be lower for them (Marenya and Barrett, 2007). This study therefore found out that farmers who are young would better use adaptation strategies than old farmers. Rogers and Shoemaker (1971) argued that younger and educated farmers are more inclined to adopt new practices. This raises an important extension policy issue. Extension systems must differentiate their clientele based on critical characteristics such as age. Furthermore, years of experience of the smallholder rice farmers will enable them to be conversant with the challenges of climate change and various conservation strategies or practices to counteract the challenges, therefore this will increase the level of yield.

Table 11: Logitic regression showing relationship between rice yield and respondents socioeconomic characteristics

Variables	Coefficient	Standard Error	P>|z|	Marginal effect
Age	0.011**	0.005	0.045	0.2.03
Household size	0.006	0.022	0.798	0.256
Marital status	0.910	0.210	0.667	0.932
Years spent in school	0.010	0.013	0.417	0.814
Farm size	0.003	0.014	0.821	0.227
Farm experience	0.014***	0.005	0.011	2.594
Quantity of fertilizer	0.005	0.001	0.571	0.569
Cost of fertilizer	0.006	0.001	0.872	0.161
Quantity of seed/Ha	-0.010***	0.003	0.001	-3.991
Adaptation strategies	-0.001	0.005	-2.48	0.805
Effect of climate change	0.857***	0.177	0.001	4.835
Climate element experienced				
Sources of information	0.011	0.022	0.635	-0.477
Adaptation technologies available	0.021**	0.011	0.059	1.915
	-0.006	0.004	0.094	-1.689
Constant	2.042	0.899	0.025	
Number	208			
$LRChi^2$	151.45			
$Prob>Chi^2$	0.001			
Log-Likelihood	24.247			
Pseudo R-Square	0.69			

Note: *= (P<0.01) Significant at 1 percent, **= (p<0.05) Significant at 5 percent**
Source: Field survey, 2016

Thus, source of information is a veritable avenue or means for the smallholder rice farmers to be attuned to challenges of climate change, whether or not to use adaptation strategies and this will have a far reaching impact on the level of rice yield.

Test of significant relationship between adaptation strategies to climate change and rice yield

The results of the hypothesis 'there is no significant relationship between adaptation strategies to climate change and rice yield' Findings in Table 13 indicate that there is a significant relationship (P < 0.05) between adaptation strategies to climate change that is, water shortage strategies (0.488**), flooding strategies (0.281**) and collective action strategies (0.295**) and rice yield. This implies that adaptation strategies used by smallholder rice farmers had a positive influence on the yield level of rice production. This is in line with the views of Smit and Skinner (2002) and Mulwa *et al.,* (2015) that farmers tend to implement multiple strategies that serve multiple purposes and are strongly interrelated with one another.

Table 12: Test of significant relationship between adaptation strategies to climate change and rice yield

Variables	Correlation (r) value	P-Value	Decision
Water shortage	0.488**	0.001	Significant
Flooding	0.281**	0.001	Significant
Collective action	0.295**	0.001	Significant

Source: Field survey, 2016; **Correlation is significant at 0.01 level

CONCLUSION

Drawing from the findings of the study, the smallholder rice famers indicated main climatic elements experienced are increased in temperature and irregular pattern of rainfall with attendant evidence and consequence of climate change for rice production. However, the smallholder rice farmers are exposed and affected by the following climate related hazards; atmospheric temperature, excessive heat, high soil temperature, sunshine intensity and long duration of sunshine. Strong wind, drought, flooding, increase temperature and excessive heat. Moreover, flood was observed to being high, in addition, some factors associated with rainfall like strong wind, wind storm, flood, increase temperature, disease outbreak occurred at the peak of the rainfall, but, land loss was observed throughout wet seasons.

These results imply that integrated approach (in terms of water shortage/drought, flood and collective adaptation strategies) was employed by rice farmers as adaptation strategies to combat the effects of climate change on rice production. But, more could still be done as regards using other adaptation strategies like relay of information about climate related events, using of water pump as a means of providing year round irrigation for upland rice field, using of drought resistant seeds/varieties and action should be taken to control flood.

Total farmland cultivated by smallholder rice farmers range between 2 – 6 hectares of farmland, moreover, the average yield of rice production fluctuates between year 2012 to 2014, but increase marginally from 2015 to 2016. The hypothesis one revealed that age of the smallholder rice farmers and their sources of information had a positive significant coefficient on their rice yield level. Lastly, hypothesis four showed that the major items of adaptation strategies use to combat water shortage/drought, flooding and collective action use as adaptation strategies have a positive relationship on rice yield.

RECOMMENDATION

The need to use robust adaptation strategies for rice production is recommended to mitigate the effect of climate change and improve rice yield. In order to sustain the production of our local rice, effort should be intensified by ensuring that the necessary adaptation technologies such as mechanized machinery and equipment are available and affordable to the farmers. Agricultural extension services should be more effective and channeled towards smallholder rice farmers, so that they can have access to improved technologies like using of drought resistant seeds/varieties from recent breakthrough in agricultural researches to curb fluctuating rice yield and enhanced smallholder rice farmers' livelihood.

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