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Effects of Climate-Smart Agricultural Practices on Total Factor Productivity of Arable Farmers in Northwest Nigeria

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Abstract
This study was carried out to determine the effect of Climate-Smart Agricultural (CSA) practices on the total factor productivity of arable farming households in North-western Nigeria. A four-stage sampling technique was adopted. Katsina and Sokoto States were randomly selected from North-western Nigeria. Ten Local Government Areas (LGAs) were also randomly selected from Katsina (six) and Sokoto (four) states, proportionate to size. Additionally, 30 villages were randomly selected from all the LGAs proportionate to size. After that, 577 households were randomly selected from all the villages using structured questionnaires. Data were analyzed using descriptive statistics, Total Factor Productivity (TFP) index, and Ordinary Least Square (OLS) regression. Results from this research work indicated that the household heads had an average age of 48.4±9.8 years with a household size of 10.9±5.7 persons, male (91.0%), married (92.2%), and acquired quaranic education (45.1%). Farm size and farming experience were 4.2±3.3 hectares and 25.6±10.9 years, respectively, with the majority owning livestock (84.9%) and inherited land (77.5%). The TFP of most household heads was at a deteriorating level (63.0%), while 37.0% were at a progressive level. The OLS regression results showed that seed (β=0.01), organic manure (β=0.0002), and being a high-user of CSAP (β=0.60) increased TFP, while labour (β=-0.01) and inorganic fertilizer (β=-0.001) decreased TFP. A high level of use of CSA practices had a positive and highly significant effect on the Total Factor Productivity of the arable farming households. This study therefore recommends that stakeholders in the agricultural subsector should educate farmers on the benefits of using CSA practices in their cropping activity via extension agents and government agencies like the Bank of Agriculture (BOA) should provide farmers with agricultural credit at discounted rate, which would be used to procure productive resources to increase crop productivity.
Keywords: Crop productivity, Climate-Smart Agricultural Practices, Total Factor productivity, and North-west Nigeria

Introduction
Climate change remains a danger to agricultural productivity and likewise affects the poverty alleviation programmes in poor and vulnerable parts of the universe, that rely mainly on rain-fed agriculture. Although climate change has a strong impact on health, water resources, land use, coastal infrastructure, and the environment, the most affected is agriculture, especially in a growing economy like that of Nigeria where irrigation is seldom practiced. This is because agriculture is greatly predisposed to weather extremes like floods, droughts, and storms (Onu and Ikehi, 2015). The research work of Singh *et al*. (2013) revealed that agricultural production activities could be significantly impacted by a rise in temperature, changing patterns of rainfall, deviations in regularity of occurrence, and degree of extreme climatic events. There are five key factors reported by the World Bank (2007) by which climate change affects agricultural crop production. These factors include temperature, precipitation change, climate variability, fertilization by carbon dioxide (CO_2), and surface water overflow.

Deressa *et al*. (2005) also noted that agricultural activities are usually more susceptible to climate change effects than other sectors of the economy and that developed nations have attempted to compute the magnitude of its economic impact as it affects agriculture as compared with the developing countries that are more adversely impacted. Ajetomobi *et al*. (2010) reported that policymakers have been concerned about the susceptibility of the Nigerian agricultural sector to climate change since this sector is the mainstay in Nigeria's economy and accounts for a little above 60% of our workforce as well as contributes 30-40% of Nigeria's GDP, which is now 24.7% as at 2020 after the rebasing (NBS, 2020). A minimum of 22% of the cultivated area of significant crops around the world is predicted to have the adverse effects of climate change by 2050 and 56% of these lands are in sub-Saharan Africa (SSA) (Campbell *et al*., 2011). Also, predicted estimates for 2050 showed that the joint impact of rising temperatures, reduced rainfall, droughts, and frequent floods could lead to an average decrease in the crop yields for major crops like rice (14%), wheat (22%), and corn (5%), and Sub Saharan Africa's food availability will decrease on the average by 500 calories per individual, translating into 21% decline in food availability (IFPRI, 2009). The impacts may not be much up to 2050, but higher impacts are expected beyond 2050.

Climate-Smart Agriculture (CSA) was the key concept discussed during the first International Convention on Agriculture, Food Security as well as Climate Change in 2010, which took place at the Hague. At this conference, CSA was defined as agriculture that sustainably improves agricultural productivity and income, adapts to climate change by building resilience, removes Greenhouse Gas (GHG) emissions, and adds to the realization of the national food security and developmental goals (FAO, 2010). CSA has helped to direct our attention to the climate change–agriculture link and has also unified agriculture and climate change with developments as one component. After the second conference in Hanoi in 2012, the CSA sourcebook was published. This has helped to further advance the idea of Climate-Smart that would benefit first and foremost, the smallholder farmers and those who are exposed to danger in developing countries (FAO, 2013). Thus, farming households that use Climate-Smart Agricultural Practices (CSAP) will be better off than households that do not practice them (Elizabeth and Sophie, 2014). Kaptymer *et al*. (2019) opined that climate change is pounding on smallholder farmers very hard, especially in Sub-Saharan Africa, which is most susceptible to the impacts of climate change. Therefore, Climate-Smart Agriculture works towards enhancing crop productivity in an environmentally and socially sustainable way, strengthening farmers' resilience to climate change, and reducing agriculture's contribution to climate change by reducing GHG emissions and increasing carbon storage on farmland.

In light of the above assertions, there is a need to expose our rural farming households to practices and technology that would curb the menace of climate change and improve their crop productivity to bring about food security, since the agricultural sector provides most of the food we eat. This is what CSAP tends to achieve via its 'triple win' benefits of improving food security, increasing resilience against climate change, and reducing GHG emissions, if farmers are enlightened of its benefits and encouraged to practice it.

Methodology

Study area

This study was carried out in North-western, Nigeria, which falls within the Sudano-sahelian agro-ecological zone (Abaje *et al*., 2015). North-western Nigeria lies between latitude 14º to the North and 10º to the south and longitude 4º2' to the West and 10º15' to the East. It has boundaries with Niger Republic in the North, Bauchi, Yobe, and Taraba States in the East, FCT, Niger, and Nasarawa States in the South and Benin Republic in the West (Adefila and Madaki, 2014; Abaje *et al*., 2015). The climate has distinctive wet and dry seasons with relatively low humidity. The dry season exists from October to April, whereas the rains commence in May and stop in September. The annual mean rainfall ranges from less than 500mm (northern part) to 1800mm (southern part), with a mean minimum temperature of 15-17ºC in the harmattan period and 35-38ºC in the dry season. North-West Nigeria covers approximately an area of 216, 065 km^2 in Nigeria and the vegetation is typically Sudan and Northern Guinea Savannah (Abaje *et al*., 2015). The total estimated population of North-Western Nigeria as of 2020 is about 54,276,570 persons (projected from NBS (2017) data using the Nigeria population growth rate) and they are predominantly agrarian. The climatic condition of the zone supports farming of crops such as millet, maize, rice, sorghum, groundnut, cotton, benne seed, potato, cowpea, watermelon, *et cetera*.

Sampling procedure and Sample size

A four-stage sampling procedure was used in this study. The first stage includes a simple random selection of two states out of the total of seven states in North-Western Nigeria, which were Katsina and Sokoto States. The second stage entails a random selection of ten (10) Local Government Areas (LGAs) from the two states selected proportionate to sizes. In Katsina State, 6 LGAs were selected out of 34 LGAs, and in Sokoto State, 4 LGAs were selected out of the 23 LGAs, using the proportionality formula following Ibrahim (2011) as shown in equation 1:

$$S = \frac{n}{N} \times q \quad \ldots\ldots (1)$$

Where:
S = number of LGAs to be selected
n = total number of LGAs in a particular State
N = sum of LGAs in the two (2) States selected
q = sample size (10 LGAs)

For the third stage, thirty (30) villages were selected using convenient sampling from the Ten (10) selected LGAs, while the last stage entailed the use of convenient sampling to select three hundred and sixty (360) respondents from the villages selected in Katsina State and two hundred and forty (240) respondents from the villages selected in Sokoto State, making a total of 600 arable farming households. A total of 600 well-structured questionnaires were administered. However, information from 577 respondents was finally used for the analysis as the remaining 23 questionnaires were either poorly filled or contained contradictory entries. It should be noted that all the arable farming households used for this study were users of one or more CSA practices.

Analytical Techniques

Total Factor Productivity (TFP) analysis

The TFP index was utilized for computing the productivity levels of farming households. All the crop output from the respondents was converted to Maize Grain Equivalent using the Nigerian Food Balance Sheet prepared by the Nigerian Institute of Social and Economic Research, Ibadan, Nigeria. The approach used by Key and Mcbride (2003) as well as Fakayode *et al*. (2008) is as stated below:

$$\text{TFP} = \frac{Y}{TVC} \quad \ldots\ldots\ldots (2)$$

Y = output quantity (in Kg of maize grain equivalent)
TVC = total variable cost (N)

$$\text{TFP} = \frac{Y}{\sum P_i x_i} \quad \ldots\ldots\ldots (3)$$

P_i = unit price of the i[th] variable input.
x_i = quantity of the i[th] variable input.

The method sets aside the function of the total fixed cost (TFC) as TFC does not affect both profit maximization as well as resource use efficiency. TFC is thus set as a constant.

Cost theory indicates that:

$$\text{AVC} = \frac{\text{Total Variable Cost (TVC)}}{\text{Output Quantity}} \ldots \ldots (4)$$

AVC = average variable cost (N)

Therefore, from equation 2 and 4,

$$\text{TFP} = \frac{1}{AVC} \quad \ldots\ldots\ldots (5)$$

Partial productivity estimation, which represents the marginal products (MP) is stated as

$$\text{MP} = \frac{\Delta TFP}{\Delta X_I} \quad \ldots\ldots\ldots (6)$$

The TVC (N/ha) used included fertilizer cost (both organic and inorganic) (Kg/ha), the number of seeds sown (Kg/ha), labour used (man-days/ha), pesticides (liter/ha) and herbicide (liter/ha) based on the views of Latruffe (2010) and Umar *et al*. (2011). The TFP Index Program (TFPIP) version 1.0 was used in this study for computing the indices for input as well as output quantities, in addition to the resultant TFP index calculated using the Fisher index formula. The inputs and output quantities and their prices were normalized per hectare. The benchmark TFP was 1.00 as reported by Ball *et al*. (2001). Therefore, TFP less than one (TFP < 1) indicates deterioration, while TFP greater than or equal to one (TFP ≥ 1) implies progress, with the difference from one indicating percentage deterioration and percentage progress respectively (Latruffe, 2010).

Ordinary Least Square regression model

Ordinary Least Square (OLS) regression was employed to examine the effect of using CSAP on crop productivity among the arable farm households. Other regression models were used for this analysis but gave spurious results, but the OLS regression model gave a better and more robust result. Therefore, it was used for this analysis. Linear, semi-log, reciprocal, and Cobb-Douglas (double-log) functional forms were analyzed, but the semi-log model was selected as the lead equation. The choice was anchored on the coefficient of determination (R^2), signs of the coefficient, and several significant explanatory variables. The linear function is specified as follows:

$$\text{TFP} = \beta_0 + \beta_1 K_1 + \beta_2 K_2 + \beta_3 K_3 + \beta_4 K_4 + \beta_5 K_5 + \beta_6 K_6 + \beta_7 K_7 + \beta_8 K_8 + \beta_9 K_9 + \beta_{10} K_{10} + \beta_{11} K_{12} + \beta_{11} K_{12} + U \ldots\ldots (7)$$

TFP= Total Factor Productivity; β_0= constant; β_1- β_{11} = coefficients to be estimated and U= error term

The value of TFP obtained from the Fisher index analysis was utilized as the dependent variable in this model.

Based on the works of Hussein and Perera (2004) and that of Fakayode *et al*. (2008), the variables stated below were used as determinants of the Total Factor Productivity model: Seeds in kilogram (K_1), Inorganic Fertiliser in kilogram (K_2), Organic manure in kilogram (K_3), Farming experience in years (K_4), Farm size in hectare (K_5), Education in years (K_6), Labour in man-days (K_7), Farm income in Naira (K_8), Non-farm income in Naira (K_9), Household size (number) (K_{10}) and CSAP measured as reference/baseline category variable (K_{11}).

Results and Discussion

Description of socio-economic characteristics of the farming household by level of use of CSAP

The socio-economic characteristics of the arable farming households profiled by their level of use of CSAP are shown in Table 1. The results indicated that on average, the age of household heads across the three categories of CSAP were 46, 50, and 47 years for the low-user, medium-user, and high-user categories, respectively. The pooled average age was 48 years, showing that most household heads were still their active age and thereby were strong enough to engage in farming activity. Also from the pooled results, 91.0% of the respondents were males, with only 9.0% being female, while across the three CSAP groups, 80.2%, 92.8%, and 95.0% of the respondents were of the male gender for the low, medium and high-user categories, respectively, but only 19.8%, 7.2% and 5.0% constitute the female gender in the same order. This result indicated that across all the three categories, the male gender were the major players in terms of farming in the area studied. This is a clear indication of what is obtainable in Northern Nigeria, where most farmers are men, while women engage in farming activities like planting, threshing, and winnowing (Annon, 2006 as cited by Mohammed and Abdulquadri, 2012**)**. The educational level of the household heads revealed that Quranic education (45.1%) was the most acquired form of education, and this was applicable across the various CSAP groups, for the low-user (47.2%), medium-user (48.5%) and high-user (35.3%) categories. Quranic education is the type of education that is more prevalent among the rural dwellers in Northern Nigeria **(**Goodluck and Juliana, 2012). In terms of the percentage of household heads that acquired post-primary education, the high users of CSAP were 32.4%, while medium-user and low users were 31.3% and 19.8%, respectively. The high level of education of the high-user might be the reason why they practice CSAP more. This confirms the fact that education is a vital tool in the adoption of innovation or new strategies (Ali and Erenstein, 2017). Table 1 also showed that household size among the farm households was 11 persons, on average. Low-user category had 10 persons as their average household size, while the medium-user and high-user categories both had 11 persons on average as their household size. Large household sizes constitute more family labour for the rural farmers, but alternatively, it implies more food demand, more consumption, and consequently more expenditure on food on the part of the household head (Osei *et al*., 2013). Across the three CSAP groups, the average farm size cultivated by the household heads included 3.22 hectares for the low-user category, 4.61 hectares for medium-user, and 3.81 hectares for the high-user. On the whole, the average farm size among the farm households was 4.16 hectares. Large farm size implies large-scale farming enterprise and consequently large farm output (Akinola and Adeyemo, 2013). The average monthly farm income acquired by the household heads was N204,202.08 per year. Average yearly farm income among the various CSAP categories was N195,033.84 per year (cropping season) for the low-user category, while the medium-user and the high-user categories earned N205,074.84 per year and N209,109.24 per year, respectively. Whereas the average non-farm income earned was N372,606.48 per year, while across the three CSAP categories, the household heads earned non-farm income of about N293,140.80, N392,268.60 and N386,243.16 per month for the low, medium and high-user categories, respectively, from activities such as petty trading, artisanship, blacksmithing, barbing, mechanical works, motorcycle transportation, butchering, food selling, carpentry, vulcanizing, bricklaying, and tailoring. These results showed that apart from the income earned from their farming activities, a bigger portion of the farmers' earnings is from non-farm activities. This would help to boost their purchasing power and thereby increase their disposable income. The results point out that on average, the household heads had 26 years of farming experience, but across the three CSAP categories, the low user had an average farming experience of 22 years, the medium user an average of 26 years, and the high user an average of 27 years. Farming experience is very vital in agricultural activities as it goes along with skill acquisition, which is fundamental to effectiveness and efficiency in farming activities and this will have a positive impact on agricultural development. Farmers having experience are more disposed to accepting innovative ideas and techniques that would improve productivity in agriculture (Adefila and Madaki, 2014). Table 1 also indicated that most of the farmers (52.9%) belonged to at least one social group or the other, while 47.1% did not belong to any social group. Membership in farmers' associations has immense benefits for the farmers as it is an avenue for enlightenment, education; awareness, having access to incentives, and obtaining vital information that can help the farmers boost his/her farming activity (Saguye, 2016; Ali and Erenstein, 2017). Access to agricultural credit (soft loans) is an imperative factor that helps farmers expand their farming activities, but most of the farmers (71.6%) did not have access to agricultural credit, and only about 28.4% stated that they had access to agricultural credit. This implies that most of the households sourced finance from other sources apart from agricultural credit to perform their farm activities. According to Ojoko *et al*. (2017), access to credit is a vital tool that will enable farmers to invest more in Climate-Smart agricultural practices as a technology, which might be expensive to acquire. Livestock ownership was also a common practice among the farm households as about 84.9% of the respondents kept livestock together with their farming activities, while 15.1% did not keep livestock. Livestock ownership is an asset to the farmer as sales of it serve as an additional source of income (Ali and Erenstein, 2017).

Crop productivity measurement among farming households

The result of the Total Factor Productivity (TFP) estimated is shown in Figures 1 and 2. The TFP index was estimated using the Fisher index in which the inputs and output quantities and their prices were normalized to per hectare. The benchmark TFP was 1.00, therefore, TFP less than one (TFP < 1) indicates deterioration, while TFP greater than or equal to one (TFP ≥ 1) implies progress with the difference from one (1) indicating percentage deterioration and percentage progress respectively (Ball *et al*., 2001; Latruffe, 2010).

Distribution of the farm household by their TFP and level of use of CSAP

Results in Figure 1 showed that 37.0% of the arable farming households had a TFP that was progressing, while 63.0% had a TFP that was deteriorating. The inference from this is that many of the farmers are operating under a deteriorating TFP, that is, their level of productivity is low. On the other hand, the disaggregated results across the three CSAP groups (low-user, medium-user, and high-user) as shown in Figure 2, indicated that most (75.6%) of the farmers who were medium-user of CSAP operated at deteriorated levels of TFP as compared with low-user (47.2%) and high-user (44.6%) of CSAP. The percentage of the low-user of CSAP who operated at the deteriorating level of TFP was higher than the percentage of high-user of CSAP on the same level, that is, 47.2% and 44.6%, respectively; while the percentage of high-user of CSAP who operated at the progressive level of TFP is more than the percentage of lower-user of CSAP on the same level, that is 55.4% and 52.8%, respectively. The implication is that farmers who used CSAP more (that is, high of CSAP) were more likely to be progressive in terms of crop productivity than farmers who were low-users of CSAP (Gwambene *et al*., 2015).

Estimating the effect of using CSAP on the TFP of arable farming households

The Ordinary Least Square (OLS) regression outputs as shown in Table 2 are the estimates of the effect of using CSAP among other variables on the Total factor productivity among the arable farming households. Different econometric specifications of the OLS regression were applied, which included linear, reciprocal, semi-log, and Cobb-Douglas functional forms. The semi-log model for the OLS regression was chosen above other functional forms, as the lead equation, since it gave the best fit of the independent variables in terms of significant explanatory variables, sign of the coefficient, adjusted R^2 value, and the F-statistic value. The results of the lead equation as discussed here showed a R^2 value and adjusted R^2 value of 0.33 and 0.32, respectively. This implies that 33% of deviations in total factor productivity amidst the arable farming households are described by the explanatory variables specified. F-statistic values of 23.47 were significant statistically at $p<0.01$, denoting the correctness and fitness of the model. From the results, the quantity of seed used significantly and positively influenced productivity among the arable farming households at $p<0.01$. This implies that seed was a vital input in crop production since the viability of seed used in production activity is a determinant of the output the farmer will get from his farm. The higher the quantity of viable seed used, the more the output from the farm. This result agrees with the research findings of Adeola *et al*. (2011), who discovered that seed had a significant positive relationship with output. The use of inorganic fertilizer significantly and negatively influenced crop productivity in the study area at $p<0.01$. This result was congruent with the *a priori* expectation**.** The use of inorganic fertilizer is a very vital input used in crop production in Northern Nigeria. Farmers in Northern Nigeria hardly carry out their farming activities without the use of either organic or inorganic manure (Omotesho *et al*., 2010; Usman and Kundiri, 2016). However, the results showed a negative relationship between inorganic fertilizer and productivity; this was expected as the continuous use of inorganic fertilizer though beneficial at the onset of its usage becomes detrimental to crop productivity with continuous usage as a result of soil acidity (Gupta and Hussain (2014). The result concurs with the works of Usman *et al*. (2015), who submitted that regular application of inorganic fertilizer results in soil acidity and that toxic concentrations of salts will build up in the soil, bringing about chemical imbalances, thereby impeding productivity. Conversely, the use of organic manure positively and significantly influenced crop productivity in the study area at $p<0.01$, which was also in line with *a priori* expectation. Organic fertilizers are far less detrimental to crops as compared with inorganic fertilizers and they add nutrients to the soil by improving the soil biomass and soil structure (Gupta and Hussain, 2014). This study corroborates that of Uzoma *et al*. (2011) who reported that organic manure from cow dung significantly increased the productivity of maize crops. Evidence shows that organic manure contains important soil nutrients that are more sustainable in crop production than inorganic fertilizers (Uzoma *et al*., 2011; Usman and Kundiri, 2016). The use of this fertilizer should, therefore, be encouraged among farmers in Nigeria. Table 2 also revealed that the farm size of the farmers had a positively significant influence on crop productivity among the arable farming households at $p<0.1$. The implication of this is that increased farm size is expected to bring about an increase in crop output/productivity thereby increasing the farm income of rural farm households (Domanska *et al*., 2014). The result corroborates that of Akinola and Adeyemo (2013) who opined that farmers with larger farm sizes would have bigger yields since they would be enjoying economies of large-scale production. The result is also incongruent with the findings of Clay (2008) as cited by Akinola and Adeyemo (2013), who also reported that when larger farm sizes are put into farming, there would be a greater area under cultivation, therefore, more output would be expected. It is noteworthy that farm size still plays a significant role as a growth determinant among developing nations (Rahman and Salim, 2013). Results as put together in Table 2 also revealed that the use of labour significantly and negatively influenced crop productivity in the study area at $p<0.01$. In almost all agricultural ventures, labour plays a vital role as a factor of production, especially in farming activities. But as the size of the farm starts increasing, the cost of using labour for farming activities would increase and this would culminate in the overall cost of production, which among rural farmers can negatively affect the total factor productivity. The result aligns with the outcome of the work of Obasi *et al*. (2016), who stated that the high cost of labour can negatively affect productivity. The results also showed that household size significantly and positively influenced crop productivity in the study area at $p<0.1$. The result tallies with the *a priori* expectation. A large household size that is composed of working/productive members would have a positive effect on agricultural productivity as this would add to the labour force involved in the farming activity. This aligns with the work of Thapa (2007), who found out that family size (household size) had a positive effect on crop output. He further stated that household size performs an important role in farm size-productivity and labour/land ratio. From the results in Table 2, the use of CSAP positively and significantly influences crop productivity among the low-users and high-users of CSAP at $p<0.01$, using the medium-users as a baseline. The reason for using the medium-user of CSAP as the baseline is because most (58.0%) of the rural farm households were medium-user of CSAP (using between 4 and 6 CSAP) and likewise, to clearly show the impact CSAP would have on the productivity of new entrant (users of CSAP) and that of those who would move upwards from medium-user to high-user. The result clearly showed that if anyone who is not a user of CSAP starts using CSAP even at a low level (that is, low-user), the productivity of such a farmer will significantly improve, as seen in the results ($\beta = 0.5483$). Alternatively, if the farmers in the area under study, who are mostly medium-users of CSAP move their level of use of CSAP upwards, that is, move up to being a high-user of CSAP, their productivity will significantly increase (β = 0.6014). This is in line with the *a priori* expectation, as the use of CSAP serves as a form of resilience against climate variability; thereby reducing the threat that climate change poses to crop productivity and consequently improving farmers' crop production. This result is congruent with that of Gwambene *et al*. (2015), who opined that farmers adopted CSAP to boost their crop yield and also improve soil fertility. Furthermore, it also agrees with the findings of Meybeck and Gitz (2013), who opined that CSAP would help to boost productivity and serve as an adaptation measure, which would consequently add to solving the problem of increasing global demand for food.

Variance Inflation Factor (VIF) Diagnostic Test

Variance Inflation Factor (VIF), which is a test for multi-collinearity, as shown in Table 3 was utilized to find out the absence or presence of multi-collinearity in the regression model. The multi-collinearity test results revealed that the mean/average VIF for the explanatory variables used for the OLS regression analysis was 1.42; which means there is no serious multi-collinearity challenge in the modthe el. The rule of thumb for the multi-collinearity test states that mean VIF values for a multiple regression that is from 5 to 10 implies high correlation, which may be a problem. If the mean VIF is beyond 10, one can conclude that the regression coefficient in the model was badly estimated because of multi-collinearity (Akinwande *et al*., 2015; Ekpa *et al*., 2017). But with a mean VIF value of 1.42, it would not be wrong to assume that the regression coefficients in this model were well estimated and devoid of multi-collinearity problems. This study also employed the use of the 'robust' option for the OLS regression, which ensured that the results were void of heteroskedasticity (Rosopa *et al*., 2013).

Conclusion

Productivity of the rural farm households measured in terms of Total Factor Productivity (TFP) showed that the farming households were predominantly operating at a deteriorating level, while few were at a progressive level. When disaggregated along the various CSAP levels, the majority of households who are high-user of CSAP were at the progressive level, while the majority of the households who were low-user of CSAP were operating at a deteriorating level. Also, the use of CSAP significantly influenced crop productivity, since it helps to curb the impact that climate change exerts on crop production. In line with the findings of this research, we, therefore, recommend that farmers in the study area and Nigeria as a whole should be educated and enlightened on the benefits of using CSAP in their cropping activity via farmer field days by extension agents and government agency like the Bank of Agriculture (BOA) should provide farmers with agricultural credit at a discounted rate, which would be used to procure productive resources such as improve seed variety and other farm inputs to increase crop productivity. This will enhance the usage of CSAP among farming households and consequently boost crop productivity.

References

Abaje I.B., Sawa B.A., Iguisi, E.O., and Ibrahim, A.A. (2015). Impact of Climate change and adaptation strategies in rural communities of Kaduna State, Nigeria. *Ethiopian Journal of Environmental Studies & Management*. 9(1): 97 – 108.

Adefila J. and Madaki J. (2014). Roles of Farmers' Cooperatives in Agricultural Development in Sabuwa Local Government Area of Katsina State, Nigeria. *Journal of Economics and Sustainable Development*. 5(12):80 – 87.

Adeola, S.S., Folorunso, S.T, Gama, E.N., Amodu, M.Y, and Owolabi, J.O. (2011). Productivity and Profitability Analyses of Cowpea Production in Kaduna State. Pelagia Research Library. *Advances in Applied Science Research*, 2011. 2 (4):72-78.

Ajetomobi, J. O., Abiodun, A. and Hassan, R. (2010). Economic Impact of Climate Change on Irrigated Rice Agriculture in Nigeria. *Contributed Paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference*, Cape Town, South Africa, September 19-23, 2010.

Akinola A.A. and Adeyemo R. (2013). Effects of Property Rights on Agricultural Production: The Nigerian experience. *Journal of Development and Agricultural Economics*. 5(10): 382-389.

Akinwande, M.O., Dikko, H.G. and Samson, A. (2015). Variance Inflation Factor: As a Condition for the Inclusion of Suppressor Variable(s) in Regression Analysis. *Open Journal of Statistics*. 5:754-767.

Ali A. and Erenstein O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management*. 16: 183 – 194.

Ball, E., Bureau, J.C., Butault, J.P. and Nehring, R. (2001). Levels of farm sector productivity: An international comparison, *Journal of Productivity Analysis*. 15:5-29.

Campbell, B., Mann, W., Meléndez-Ortiz, R., Streck C. and Tennigkeit, T. (2011). Agriculture and Climate Change: *A Scoping Report*. Washington, DC: Meridian Institute.

Deressa, T., Hassan, R. and Poonyth, D. (2005). "Measuring The Impact of Climate Change on South African Agriculture: The Case of Sugar Cane Growing Regions". *Agrekon*, 44(4): 524-542.

Domanska, K., Kijek, T. and Nowak, A. (2014). Agricultural total factor productivity change and its determinants in European Union countries. *Bulgarian Journal of Agricultural Sci*ence. 20(6): 1273-1280.

Ekpa, D., Oyekale, A.S., and Oladele, O.I. (2017). Evaluation of Factors Influencing Indicators of Climate Smart Agricultural Practice on Crop in North-West Nigeria. *World Journal of Agricultural Research*, 5(5): 273-278. doi: 10.12691/wjar-5-5-4.

Elizabeth D. and Sophie C. (2014). Climate-smart

agriculture and REDD+ implementation in Kenya. REDD+ Law Project - *Briefing Paper*, pp. 1 – 61.
Fakayode, S.B., Babatunde, R.D. and Ajao, R. (2008). "Productivity Analysis of Cassava-Based Production Systems in the Guinea Savannah: Case Study of Kwara State, Nigeria". *American-Eurasian Journal of Scientific Research*. 3: 33-39.
Food and Agriculture Organisation of the United Nations (2010). *"Climate-Smart" Agriculture: Policies, Practices, and Financing for Food Security, Adaptation and Mitigation*. Rome, Italy: FAO.
Food and Agriculture Organisation of the United Nations, (2013). *Climate-Smart Agriculture Sourcebook*. Rome; 2013.

Table 1: Socio-economic characteristics of the arable farm households by their level of use of CSAP

Characteristics	Low-User of CSAP (n=106)	Medium-User of CSAP (n-332)	High-User of CSAP (n=139)	Pooled (N = 577)	Difference test
Age of household head (average)	46.19	49.62	46.98	48.35	12.64***
Sex of household head					
Male (%)	80.2	92.8	95.0	91.0	19.04***
Female (%)	19.8	7.2	5.0	9.0	
Education					
No formal education (%)	8.5	4.8	1.4	4.7	
Quranic education (%)	47.2	48.5	35.3	45.1	29.66***
Primary education (%)	24.5	15.4	30.9	20.8	
Secondary education (%)	17.0	20.8	20.1	19.9	
Tertiary education (%)	2.8	10.5	12.2	9.5	
Household size (average)	10.42	10.92	11.40	10.94	1.91
Farm size (Ha) (average)	3.22	4.61	3.81	4.16	11.04**
Farm income (₦) (average per year)	195,033.84	205,074.84	209,109.24	204,202.08	7.35*
Non-farm income (₦) (average per year)	293,140.80	392,268.60	386,243.16	372,606.48	8.03*
Years of Farming experience (average)	22.03	26.20	26.82	25.58	14.15***
Membership of farmers' association					
Yes (%)	42.5	48.5	71.2	52.9	25.96***
No (%)	57.6	51.5	28.8	47.1	
Access to agricultural credit					
Yes (%)	30.2	24.4	36.7	28.4	
No (%)	69.8	75.6	63.3	71.6	7.40*
Livestock ownership					
Yes (%)	87.7	80.4	93.5	84.9	13.94***
No (%)	12.3	19.6	6.5	15.1	

Source: Field Survey, 2016

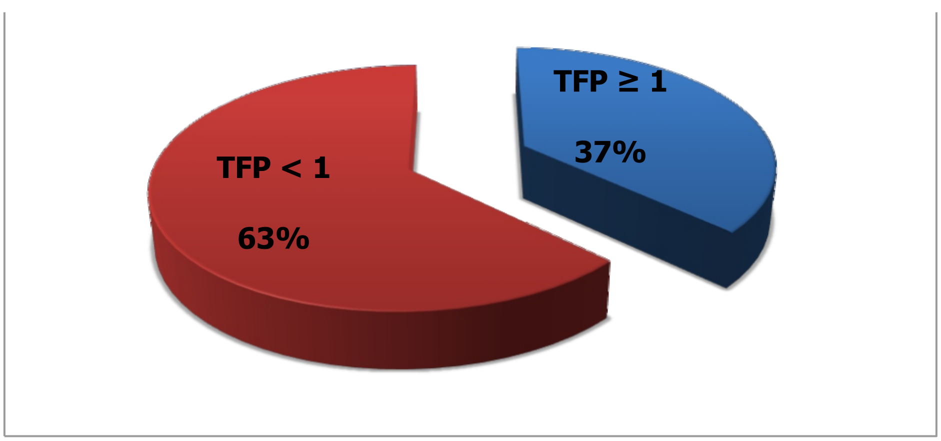

Figure 1: Distribution of the Total Factor Productivity of the arable farming households
Source: Field Survey, 2016

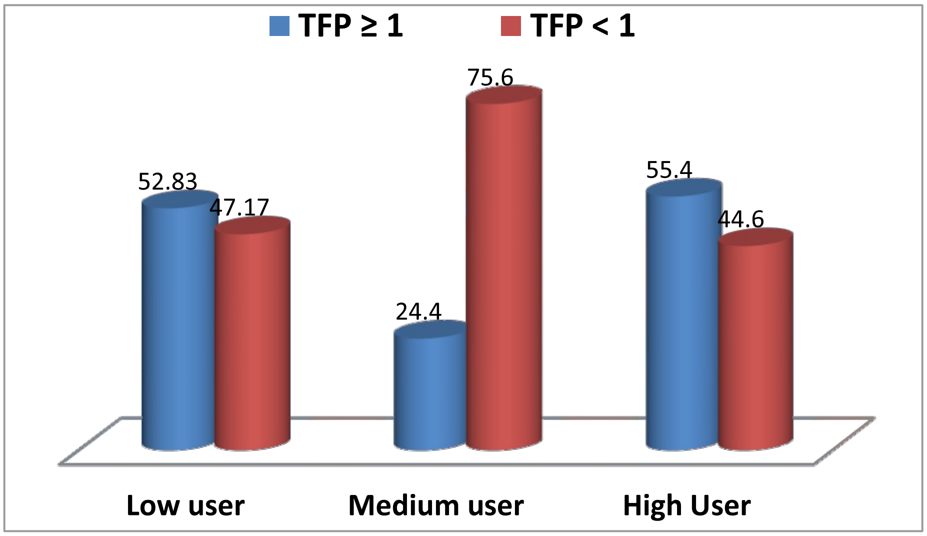

Figure 2: Distribution of farm households by their TFP and level of use of CSAP
Source: Field Survey, 2016

Table 2: Estimates of the effect of CSAP on TFP of the arable farming households

Variable	Coefficient	standard error	Z statistics	P>t
Seed	0.0061***	0.0009	6.65	0.000
Inorganic Fertiliser	-0.0010***	0.0001	-7.79	0.000
Organic manure	0.0002***	0.00003	8.41	0.000
Farming experience	-0.0019	0.0046	-0.42	0.673
Farm size	0.0309*	0.0167	1.84	0.066
Education	-0.0043	0.0092	-0.47	0.638
Labour	-0.0098***	0.0019	-5.13	0.000
Farm income	1.03e-06	1.78e-06	0.58	0.565
Non-farm income	-5.71e-07	1.62e-06	-0.35	0.725
Household size	0.0160*	0.0084	1.91	0.057
Low-user (Base=Medium-user)	0.5483***	0.1177	4.66	0.000
High-user (Base= Medium -user)	0.6014***	0.1075	5.59	0.000
Number of observations	577			
R^2	0.33			
Adjusted R^2	0.32			
F-statistics	23.47			
Prob > F	0.000			
Root Mean Square error	1.02			

Source: Author's computation from Field survey, 2016
Legend: * =significant at p<0.1, ** =significant at p<0.05 and *** =significant at p<0.01

Table 3: Multi-collinearity Test for the variables in the OLS regression model

Variables	Variance Inflation Factor (VIF)	Tolerance
Seed	2.20	0.4552
Inorganic Fertiliser	2.37	0.4216
Organic Manure	1.17	0.8529
Farming Experience	1.38	0.7247
Farm Size	1.75	0.5723
Education	1.14	0.8763
Labour	1.26	0.7926
Farm income	1.01	0.9881
Non-farm income	1.16	0.8654
Household Size	1.26	0.7910
Low-user of CSAP	1.16	0.8630
High-user of CSAP	1.18	0.8482
Mean VIF	**1.42**	

Source: Author's Computation