Adoption of Climate-Smart Practices and the Effects on Production Efficiency of Maize Farmers in Northern Nigeria

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Abstract: Adoption of climate-smart practices (CSP) and the effects on production efficiency of maize farmers in Northern Nigeria was carried out with primary data, collected with the use of structured questionnaires and household interview method administered on educated and illiterate farmers, respectively. Descriptive and inferential statistics analysed the data and identified the constraints to the adoption. Richardian net revenue technique estimated the costs and returns, while Multinomial logit statistics interpreted the probability of CSP-adopter or non-adopter based on farmers’ characteristics. Marginal factor productivity analysis determined the influence of CSP-adopter in the production efficiency, while Likert scale established severity of adoption constraints. Kano’s 168 CSP adopters’ and 110 non-adopters’ mean incomes were ₦140,198 and ₦34,622 at N2 and N0.8 returns, respectively. Nasarawa’s 107 CSP-adopters and 106 non-CSP incomes were ₦162,545 and ₦85,570 at N1.8 and N0.9 returns, respectively. Kano and Nasarawa CSP-adopters’ estimated Pseudo-R² were 51% and 50% at 52% and 51% significant Log likelihood ratios (LR), respectively. Access to credit, extension, educational level and income were significant and positively related to CSP-adoption decisions at P≤0.5 and P≤0.1 in Kano and Nasarawa, respectively. The CSP-adopters were technically efficient and Z-test 2.61 and 2.83 at P≤0.1 for Kano and Nasarawa, respectively, at 35% coefficient of variation rendered the hypothesis of no significant difference between the mean incomes of both farmersto be rejected. High cost of inputs was the most severe constraint to CSP-adoption. Thus, maize farmers are advised to join cooperative societies to enjoy cheaper production cost and increase production efficiency.

Key words: Climate-smart practice, adoption, production efficiency, Northern-Nigeria

INTRODUCTION

In Nigeria, food scarcity is a major problem despite the abundance of natural and productive resources. The agricultural practice is subsistence, traditional and climate based with low production output (Central Intelligence Agency (CIA), 2014). Farmers in Northern Nigeria constantly seek for new farm practices that are adaptable to the climate change to maintain crops productivity. Climate-smart practice (CSP) is thus inevitable, as it refers to the precise way of farming, tilling, fertilizing, weeding, tending and harvesting of agricultural produce. Lipper et al. (2014) defined it as an approach by which new realities of transformation and re-orientation are carried out for agricultural development.

According to McCarthy et al. (2012), the word, “smart” has been defined as an acronym derived from the words: specific; measurable; achievable; reliable and timely (SMART). Graziano da Silva (2016) assumed it to affect food security, rapid transformation of farming and food systems, which needs to be adopted in order to cope with the critical food scarcity through increased food production and poverty reduction.

Nigeria’s high population growth rate of about 2.7% has resulted in increase in food consumption to about 150kg grains per person. The country is known to be the tenth world’s producer of maize at about 10.4 million tonnes annually (FAO, 2007; and Philip et al., 2006). Maize output in Nigeria is low due to climate change, and the National Bureau of Statistics (NBS) (2016), estimated the Gross Domestic Product (GDP) to be about 78.43 billion Naira in 2015. Although, most of the consumed quantity in Nigeria is known to be produced in Northern-Nigeria, previous studies (Jatto et al., 2015 and Ajao, 2011) did not establish how the CSP-adopter affects the production efficiency in the area. This study, therefore, aimed to provide lasting solution to food scarcity in Nigeria by bridging the gap caused by paucity of research information in the area. This has been achieved by determining the level of awareness and adoption of CSP among maize farmers in Northern Nigeria; estimating the costs and returns of CSP-adopters and non-adopters; identifying the farmers’ socio-economic factors which influence the adoption of CSP and the constraints that limit its adoption among the maize farmers in the study area. Policy makers are expected to be guided by this information to know whether the existing CSP has fully been adopted and optimum efficiency achieved in the study area. Investors are expected to be guided by such policies to make investment decisions, while the rural poor and small scale farmers are expected to adjust their productions resources to improve maize output, earn more income and develop themselves. The study has indicated more areas for further studies.

Theoretical and Conceptual Framework:

Agriculture is very important to Nigeria’s economy, but the severe climate-change has become a major economic concern. The adoption of climate-smart practice (CSP) ensures food security and environmental preservation against climatic destruction (Beddington et al., 2011). The repairs and mitigatess of adverse effects on agricultural productivity through food security, based on the farmer's socio-economic characteristics. This must have made Terdoo and Adekola (2014) to assume that climatic change assessment in Africa requires integrative sustainability concept in the research framework to reduce arbitrariness.
Agricultural production efficiency can be allocative (scale), technical or economic. Economic efficiency is the combination of minimum factors of production to obtain optimum output. Scale efficiency is the optimization of total output at the least cost of production in term of size (Lee et al., 2011). Technical efficiency is the ability to obtain maximum output by utilizing a certain amount of technology (Ajetomobi and Abiodun, 2010). Climate change affects agricultural production efficiency at every stage and its economic impacts is felt through reduced farm output and incomes for farming households (FAO, 2016).

Conceptually, the Ricardian regression models did reveal increasing precipitation by 1mm and decreasing temperature by 1°C to affect the net revenue of maize and sorghum significantly in Northern Ghana (Bawayelaza et al., 2016). This confirms the link between climate and crop revenue, as the model involves the use of both linear and quadratic terms for the climatic variables may indicate higher temperatures and variations in precipitation levels (Lipper et al., 2014). It has been found to be the most suitable in determining the net revenue of both farmers. Multinomial logit regression equation enabled the differentiation of farmers into CSP-adopters and non-adopters. Meanwhile, the quest to end hunger and reduce poverty in Nigeria requires adoption of CSP. Although, findings from some African countries, who adopted CSP have indicated positive improvement in output (Terduo and Adekola, 2014), it is yet to be proven with empirical data in Nigeria, thus, the need for this study.

RESEARCH METHODOLOGY

Study Area:
The study was carried out in Kano and Nasarawa States in northern zone of Nigeria. The zone is located between longitude 2°44' and 14°42' East and latitude 02°27’N and 14°00’ North. It occupies about 773,373 square kilometres and is populated with about 52.4 million people (United Nations, 2018). Kano State represents the Sahel Savannah region and is made up of about 20,760 square Km2, with 86,000 hectares of dry-season irrigation farmland, 75,000 hectares of fallow and grazing land and 1,754,200 hectares of ordinary farmland (Kano ADP, 2011). The State has 400-1,200mm average rainfall per annum and temperature range of 14.02°C-32.03°C. The citizens are mostly farmers, traders and parisans and own about 4 hectares of farmland per person on the average (Shuaibu, 2018). Nasarawa State represents the Guinea Savannah region and is a cosmopolitan State, which lies in the central part of Nigeria within Longitude 7°0’E-9°37’E and Latitude 7°45’N-9°25’N. It covers about 27,137.8Km2 and is populated with about 2,523,400 people (NBS, 2016). The State has rich fertile soil from the cretaceous sand, silt, lime and iron stones and shale (Agidi et al., 2017). It has about 6-7 months average annual rainfall of about 1100-2000mm from April to October. Agricultural practices in both States are subsistence and traditional with bush clearing and burning, which exposes the soil surface to erosion, drought and desert encroachment (Farauta et al., 2011).

Method of Data Collection:
Primary data collected for this study were mainly on the maize farmers’ socio-economic characteristics and the production data from the selected farmers. Both structured questionnaires and household interview schedules for the literate and illiterate farmers, respectively, were used by trained enumerators between June and September, 2018 to collect the data. The production data included maize annual outputs (kilogrammes), inputs, such as farm size cultivated (hectares), maize seed (kilogrammes), labour (man-days), fertilizer (kilogrammes) and capital (Naira and Kobo). Multi-stage sampling technique enabled the selection of maize farmers with the desired characteristics since there was no proper record of the target population. Ten percent of registered sample frame, which was 491 (275 CSP and 216 non-CSP) made up the sample size for the study. This technique was straightforward, unbiased, and cost effective.

Analytical Techniques:
Descriptive and inferential statistics, Richardian net revenue technique, multinomial logit and Marginal factor productivity analysis were used in analyzing the data. These were to analyze the awareness and CSP-adoption; estimate and compare costs and returns of both farmers; assess the influence of farmers’ socio-economic factors on CSP-adoption and determine the adoption or non-adoption of CSP, respectively. The expected value of the dependent variable Y is interpreted as the probability that a farmer with certain characteristics X will adopt CSP or not adopt CSP, and the scored is 1 or 0. Marginal factor productivity analysis determined the influence of CSP-adoption on maize production efficiency (allocative, technical and economic). The intensity of the constraints was measured with the use of Likert scale (1 = very serious; 2 = serious; 3 = not serious; 4 = not a problem and 5 = no response). The results of the analysis were compared between the States studied and presented in Tables.

Model Specification:

Richardian Farm Net Revenue Function:
This was used in achieving the estimates, comparing the costs and returns of CSP-adopters and non-adopters. The influence of CSP-adoption on production efficiency of maize is:

\[ R = \sum P_i Q_i (X, F, G, Z) - \sum P_i X \]  (1)

Where:
- \( R \) represents the net revenue per hectare; \( P \) is the price of maize; \( Q \) is the maize output (kg); \( X \) is the purchase output;
- \( F \) is the climate variable; \( G \) is the set of economic variables;
- \( Z \) is the farm size variables and \( P_x \) is the costs of input. Following Mendelsohn et al. (1994, 2003), the specified net revenue model is as shown in equation (2), as:

\[ V = \beta_0 + \beta_1 F + \beta_2 F_2 + \beta_3 G + \beta_4 Z + U \]  (2)

Where:
- \( V \) represents the net farm revenue; \( F \) is the climatic variable; \( G \) is the economic variables; \( \beta \) is the coefficient and \( U \) is the error term.

Multinomial Logit regression equation:
Multinomial logit regression equation uses linear probability model and estimates in a linear form for the discrete dependent variable \( Y \), according to the farmer’s characteristics \( X \). This can be translated into adoption (1) or non-adoption (0) of CSP. The model is expressed thus:

\[ Y_i = \beta X_i + \mu_i \]  (3)
Where:

\[ E(\mu_i) = 0 \quad \text{and} \quad X_i = \text{farmer's socio-economic characteristics}. \]

Non-linear estimation method was used since error term may not be normally distributed and may cause heteroscedasticity in the estimation of \( \beta \), with ordinary least square method. Logit model was employed for its cumulative logistic probability function, which is easier to determine and is:

\[ P_i = f(A + \beta X_i) = \frac{1}{1 + e^{-A + \beta X_i}} \]  
(4)

Where:

- \( e \) represents the natural logarithm (2.718);
- \( P_i \) is the probability of CSP-adoption;
- \( X \) is the socio-economic characteristics of \( i^{th} \) farmer;
- \( \beta \) is the regression coefficient; and
- \( A \) is the constant term. Maximum likelihood estimation (MLE) of Logit model was applied for the smallness of the data. Students’ Package for Statistical Studies (SPSS) was used to analyze the data. Explicit form of the model is as expressed in equation (5).

\[ \log\left(\frac{P(\text{adoption})}{1-P(\text{adoption})}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_e X_e \]  
(5)

Where:

- \( X_1 \) is the age of the farmer;
- \( X_2 \) is the household size;
- \( X_3 \) is the educational level; \( X_4 \) is the farm size; \( X_5 \) is access to credit; \( X_6 \) is access to extension service, \( X_7 \) is fertilizer used, and \( X_8 \) is the climatic variable (increase/reduction in rainfall (mm families))

Production efficiency of maize farming in Northern Nigeria:

Marginal factor productivity (MFP) analysis was used to achieve this objective and is:

\[ r = \frac{\text{Marginal Value Product}}{\text{Marginal Factor Cost}} = \frac{\text{MVP}}{\text{MFC}} \]  
(6)

Results and discussions

Awareness of Climate Change and Adoption of the CSP in Maize Production in Northern Nigeria:

The result of the descriptive statistics, used in analyzing the data on farmers’ awareness of climate change and the adoption of the CSP in maize production is as presented in Table 1. Tofo Local Government Area of Kano State has the highest percentages (34% and 28%) of both maize farmers who were aware and adopted the CSP and those who were not aware and did not adopt CSP in maize production, respectively. In Nasarawa State also, majority of the CSP-adopters (20%) and non-adopters (26%) were from Keffi LGA.

Table 1. Farmers level of awareness and adoption of climate-smart practices (CSP) in Northern Nigeria.

| State Studied | LGA Selected | Village Selected | Number/Percentage of Respondents |
|---------------|--------------|-----------------|----------------------------------|
|               | Sub-total    |                 |                                  |
| Kano          | Dawakinofa   | Dawaki          | 40 76 27.6 26 50 23.1            |
|               | Tofa         | Marke           | 36 24 18.5 30 25.9               |
|               |              | Diotfo          | 51 92 33.5 32 60 27.8            |
|               |              | Tsakuma         | 41 28                           |
|               | Sub-total    |                 | 168 168 61.1 110 110 50.9        |
| Nasarawa      | Karu         | Gitata          | 26 51 18.5 30 50 23.1            |
|               |              | Uke             | 25 20                           |
|               |              | Keffi           | 27 56 20.4 28 56 25.9            |
|               |              | Sabon           | 29 28                           |
|               | Sub-total    |                 | 107 107 38.9 106 106 49.1        |
|               | Total (a+b)  | 4 LGAs          | 8 Villages                      |
|               |              |                 | 275 275 100 216 216 100         |

Note: \( \% = \) percentage; CSP = climate smart practice; AAS = awareness, adoption and skill; LGA = Local Government Area

Source: Field survey (2018)

ii) Costs and returns of CSP adopters and Non-CSP adopters in maize production in Northern Nigeria:

Average costs and returns for both CSP maize adopters and non-CSP maize adopters are as presented in Table 2. Kano CSP-adopters produced the maize at a gross margin of about ₦149,711 against their non-CSP counterparts’ ₦71,885 gross margin and the CSP-adopters net farm incomewas about ₦140,198, while that of the non-CSP adopters was about ₦54,622. The CSP and the non-CSP adopters gained about N2 and N0.8 respectively to every N1 invested in the maize production in Kano State. In Nasarawa State, the CSP-adopters produced about ₦109,301 gross margin, while the non-CSP adopters produced about ₦88,288 gross margin in the maize production. The net farm income of both CSP and non-CSP adopters were ₦162,545 and ₦85,570.
respectively, which also indicated that to every ₦1 invested, the CSP-adopters gained ₦1.8 while the non-adopters gained ₦0.9. This result is in agreement with the findings of

Farauta et al. (2011), where climate change and adaptation measures in Northern Nigeria was found to be more beneficial than non-adoption of climate smart practice.

Table 2. Average Cost and returns for CSP and non-CSP maize farmers in the study area

| Categories                      | Kano State CSP Maize Adopters | Non-CSMaize Adopters | Nasarawa State CSP Maize Adopters | Non-CSMaize Adopters |
|---------------------------------|-------------------------------|-----------------------|-----------------------------------|----------------------|
| A Inputs/Costs:                |                               |                       |                                   |                      |
|                                 | Qty (Kg/ha)                   | Cost/ Value (₦000)    | % of TC                           | Qty (Kg/ha)          | Cost (₦000)        | % of TC          | Qty (kg)         | Cost (₦M)        | % of TC |
| 1 Variable inputs:             |                               |                       |                                   |                      |
| Maize seed (Kg)                | 50kg                          | 2,500                 | 1.5                               |                       |                     |                   |                 |                   |        |
| Fertilizer (Kg)                | 150Kg                         | 9,000                 | 5.5                               |                       |                     |                   |                 |                   |        |
| Agrochemicals(l)               | 3litres                       | 4,200                 | 2.5                               |                       |                     |                   |                 |                   |        |
| Labour (man-day):              | 1.65M                         | 62,100                | 37.6                              |                       |                     |                   |                 |                   |        |
| Family labour                  | 904                           | 854                   |                                   |                       |                     |                   |                 |                   |        |
| Hired labour                   | 749                           | 654                   |                                   |                       |                     |                   |                 |                   |        |
| 2 Total Variable Cost (TVC)    | 77,800                        |                       | 47.2                              |                       |                     |                   |                 |                   |        |
| 3 Fixed inputs:                |                               |                       |                                   |                      |
| Farm land rent                 | 1ha                           | 2,500                 | 1.5                               |                       |                     |                   |                 |                   |        |
| Matchet/Cutlass                | 20                            | 34,000                | 20.6                              |                       |                     |                   |                 |                   |        |
| Hoes                           | 30                            | 24,500                | 14.8                              |                       |                     |                   |                 |                   |        |
| Axe                            | 15                            | 15,250                | 9.2                               |                       |                     |                   |                 |                   |        |
| Farm tools depreciation        | 10%                           | 7,375                 | 4.5                               |                       |                     |                   |                 |                   |        |
| Farm tools maintenance         | 5%                            | 3,688                 | 2.2                               |                       |                     |                   |                 |                   |        |
| b Total Fixed Cost (TFC)       | 87,313                        |                       | 52.9                              |                       |                     |                   |                 |                   |        |
| Total Cost (TC=a+b)            | 165,113                       | 100                   | 161,56                            | 100                   | 145,88              | 100               | 154,71          | 100               |        |
| Outputs/Revenue:               |                               |                       |                                   |                      |
| Maize (kg)                     | 455,022                       |                       | 227,511                           |                       | 288,069             | 144,03            | 287,044         | 200,93            | 206,126 |
| C Total Revenue (Naira)        | 227,511                       |                       | 288,069                           |                       | 144,03              | 200,93            | 206,126         | 144,28            |        |
| Gross Margin (C-a)            | 149,711                       |                       | 71,885                            |                       |                      | 109,38            | 88,288          |                   |        |
| Net Farm Income (C-b)          | 140,198                       |                       | 54,622                            |                       |                      | 162,54            | 85,570          |                   |        |
| Average Rate of Return (NFITV) | 2.0                           |                       | 0.8                               |                       | 1.8                 |                   | 0.9             |                   |        |

Note: CSP = climate smart practice; Kg= Kilogramme; Qty=Quantity; 1,000kg = 1tonne; % = percentage; Price of maize is ₦50/kg in Kano State and ₦70/kg in Nasarawa State.

Source: Field survey, 2018

iii). Influence of Farmers’ Socio-economic Factors on Adoption of CSPs Maize in the Study Area:

The socio-economic factors of the farmers studied from the two States in Northern-Nigeria is as shown in Table 3a and 3b. Majority of the farmers from both Kano and Nasarawa States who adopted the climate smart practice in maize production were found to be 85% and 83% male respectively. The non-CSP adopters too were mostly males in both States. This indicates the imbalance of gender distribution in the agricultural sector as the maize farmers were mostly male, who are known to be the sole owners of major agricultural production assets in Northern Nigeria. This result is in agreement with the findings of Omonwagwa et al. (2017), where male dominance in agriculture was reported to exist in Nigeria. The highest percentage of the CSP maize adopters and non-CSP adopters from Kano State was found to belong to the age group of 41-50 years old. This indicated that the farmers were still young and productively active. In Nasarawa State, the highest percentage (38%) of the maize farmers were found to be the non-CSP adopters who belonged to the age grade of 51 and above years old. They were also still relatively young and active, which could boost the increase in maize production. This result is in agreement with the findings of Okojie(2019), where the average age structure of Nigerian farmers was found to be 60 years old. Majority of the farmers interviewed in the study area were married, which indicated their seriousness and emotional stability, while in maize production. This result agrees with the findings of Adeniyi and Ogunsola (2014) and Simonyan et al. (2011), where marital status was found to be one of the major characteristic of farmers in Nigeria. The greatest percentage of the CSP-adopters interviewed from both Kano (49%) and Nasarawa (46%) States indicated to have had at least the primary school level of education. The majority of the non-CSP adopters (83% of Kano and 52% of Nasarawa), on the other hand, indicated to have had no formal education. Thus, while the educated CSP farmers could understand basic farming principles, the non-CSP farmers could not. This result is in agreement with the findings of Etim et al. (2013) and Ojo et al. (2009), where education was found to be a significant factor that influence farm decisions in Nigeria.

The greatest percentages (66% and 38%) of the Kano non-CSP adopters and CSP adopters indicated to have less than 5 members in the household, while in Nasarawa State, the majority (53% and 37%) of the CSP-adopters and non-adopters indicated to have 6-10 household members respectively. This implied that there was readily available family labour if the household members were up to the productive ages, which could lead to increased maize
production. This result is in compliance with the report of the National Bureau of Statistics (2013), indicates the North-Central Nigerian farmers have an average household size of less than 10 persons per household. Average number of the non-CSP adopters (46% and 51%) in both Kano and Nasarawa States owned about 1.1-2.0 hectares of farm lands, which suggests that they were mostly small scale farmers. This agrees with the estimates of Mgbenka et al. (2015), which reported through the Federal Office of Statistics in 1999 that farm sizes of 0.4 to 1.01 hectares, are grouped under the small scale and 1.01 to 3.03 hectares are grouped under the medium scale farms.

Average number of the maize farmers belonged to cooperatives and as such were able to get access to information and community assistance. This result complies with the findings of Akudugu et al. (2009), who found farmers to have joined cooperative societies in order to increase the chances of acquiring credit for the farm activities. Majority of the non-CSP farmers from both States indicated to have gotten credit for the maize production through personal savings, while the least of them also indicated to have acquired theirs through bank loans.

The socio-economic factors of the farmers studied from the two States in Northern Nigeria, such as access to extension services, reason for adoption of a particular practice, cropping system and farming experience are as presented in Table 3a. The whole CSP adopters from both Kano (100%) and Nasarawa (100%) States indicated to have access to extension services, while the majority of them also indicated to have adopted the crop for its high yield and were sole maize croppers. About 58.9% of the CSP adopters in Kano State had 11-15 years of farming experience, while average (60.0%) number of the non-CSP adopters from Nasarawa State indicated to have had more than 16 years of farming experience.

Table 3a. Socio-Economic Characteristics of the Farmers in the Study Area

| Variable                      | Kano State CSP Maize Adopters | Kano State Non-CSP Maize Adopters | Nasarawa State CSP Maize Adopters | Nasarawa State Non-CSP Maize Adopters |
|-------------------------------|-------------------------------|-----------------------------------|-----------------------------------|---------------------------------------|
|                               | Freq  | %             | Freq  | %             | Freq  | %             | Freq  | %             |
| Gender                        |       |               |       |               |       |               |       |               |
| Male                          | 142   | 85            | 92    |               | 84    | 89            | 83    | 76            |
| Female                        | 26    | 15            | 18    |               | 16    | 18            | 17    | 30            |
| **Total**                     | **168** | **100** | **110** |               | **100** | **107** | **100** | **106** | **100** |
| Age of farmer (years)         |       |               |       |               |       |               |       |               |
| Less than 30                  | 11    | 6.5           | 21    |               | 19.1  | 14            | 13.1  | 13            |
| 31 - 40                       | 51    | 30.4          | 28    |               | 25.5  | 33            | 30.8  | 15            |
| 41 - 50                       | 62    | 37.0          | 36    |               | 32.7  | 42            | 39.3  | 38            |
| 51 and above                  | 44    | 26.1          | 25    |               | 22.7  | 18            | 16.8  | 40            |
| **Total**                     | **168** | **100** | **110** |               | **100** | **107** | **100** | **106** | **100** |
| Marital Status                |       |               |       |               |       |               |       |               |
| Married                       | 144   | 85.7          | 108   |               | 98.2  | 103           | 96.3  | 95            |
| Single                        | 3     | 1.8           | 0     |               | 0     | 1             | 0.9   | 2             |
| Divorced                      | 10    | 6.0           | 1     |               | 0.9   | 1             | 0.9   | 4             |
| Widowed                       | 11    | 6.5           | 1     |               | 0.9   | 2             | 1.9   | 5             |
| **Total**                     | **168** | **100** | **110** |               | **100** | **107** | **100** | **106** | **100** |
| Educational Level             |       |               |       |               |       |               |       |               |
| No formal education           | 22    | 13.1          | 91    |               | 82.7  | 13            | 12.2  | 55            |
| Primary Education             | 83    | 49.4          | 17    |               | 15.5  | 49            | 45.8  | 41            |
| Secondary Education           | 31    | 18.5          | 2     |               | 1.8   | 38            | 35.5  | 10            |
| Tertiary Education            | 32    | 19.0          | 0     |               | 0     | 7             | 6.5   | 0             |
| **Total**                     | **168** | **100** | **110** |               | **100** | **107** | **100** | **106** | **100** |
| Household Size (No.)          |       |               |       |               |       |               |       |               |
| Less than 5                   | 64    | 38.1          | 72    |               | 65.5  | 41            | 38.3  | 19            |
| 6-10                          | 36    | 33.3          | 29    |               | 26.4  | 57            | 53.3  | 39            |
| 11 and above                  | 48    | 28.6          | 9     |               | 8.1   | 9             | 8.4   | 48            |
| **Total**                     | **168** | **100** | **110** |               | **100** | **107** | **100** | **106** | **100** |
| Farm Size (ha)                |       |               |       |               |       |               |       |               |
| Less than 1.0                 | 21    | 12.5          | 51    |               | 46.4  | 6             | 5.6   | 53            |
| 1.1 - 2.0                     | 40    | 23.8          | 23    |               | 20.9  | 55            | 51.4  | 35            |
| 2.1 - 3.0                     | 35    | 20.8          | 22    |               | 20.0  | 38            | 35.5  | 12            |
| 3.1 and above                 | 72    | 42.9          | 14    |               | 12.7  | 8             | 7.5   | 6             |
| **Total**                     | **168** | **100** | **110** |               | **100** | **107** | **100** | **106** | **100** |
| Membership of Cooperatives    |       |               |       |               |       |               |       |               |
| Full member                   | 168   | 100           | 80    |               | 72.7  | 1007          | 100   | 65            |
| Non-member                    | 0     | 0             | 30    |               | 27.3  | 0             | 0     | 41            |
| **Total**                     | **168** | **100** | **110** |               | **100** | **107** | **100** | **106** | **100** |
| Source of Credit              |       |               |       |               |       |               |       |               |
| Personal Savings              | 32    | 19.1          | 91    |               | 82.7  | 32            | 29.9  | 72            |
| Loan from Cooperatives        | 78    | 46.4          | 18    |               | 16.4  | 44            | 41.1  | 21            |
| Loan from Banks               | 58    | 34.5          | 1     |               | 0.9   | 31            | 29.0  | 13            |
| **Total**                     | **168** | **100** | **110** |               | **100** | **107** | **100** | **106** | **100** |

CSP = Climate Smart Practice; Freq = Frequency; % = Percentage

Source: Field survey, 2018
Average number (72%) and (80%) of the CSP-adopters and non-adopters, respectively, from Kano State indicated not to have sufficient rainfall for the maize production, while majority (79% and 87%) of both CSP and non-CSP adopters, respectively in Nasarawa State indicated to have sufficient rainfall for the maize production. This result is in agreement with the findings of Terdoo and Adekola (2014), where lack of coherent climate mitigation approach and poor institutional structures were found to be both detrimental to adoption of CSP in Nigeria.

**Table 3b. Socio-Economic Characteristics of the Farmers in the Study Area**

| Variable                      | Kano State CSP Maize Adopters | Kano State Non-CSP Maize Adopters | Nasarawa State CSP Maize Adopters | Nasarawa State Non-CSP Maize Adopters |
|-------------------------------|-------------------------------|-----------------------------------|-----------------------------------|---------------------------------------|
|                               | Freq  | %      | Freq  | %      | Freq  | %      | Freq  | %      |
| **Extension Services:**       |       |        |       |        |       |        |       |        |
| Has Access                    | 168   | 100    | 10    | 9.1    | 107   | 100    | 41    | 38.1   |
| Does not have access          | 0     | 0      | 100   | 90.9   | 0     | 0      | 65    | 61.9   |
| **Total**                     | **168** | **100** | **110** | **100** | **107** | **100** | **106** | **100** |
| **Reasons for Adoption**      |       |        |       |        |       |        |       |        |
| High Yield                    | 124   | 73.8   | 2     | 1.8    | 58    | 54.2   | 27    | 25.7   |
| Early Maturity                | 16    | 9.5    | 30    | 27.3   | 41    | 38.3   | 32    | 29.5   |
| Pest resistant                | 28    | 16.7   | 78    | 70.9   | 8     | 7.5    | 47    | 44.8   |
| **Total**                     | **168** | **100** | **110** | **100** | **107** | **100** | **106** | **100** |
| **Cropping System**           |       |        |       |        |       |        |       |        |
| Sole                          | 142   | 84.5   | 61    | 55.5   | 76    | 71.0   | 42    | 40.0   |
| Mixed                         | 26    | 15.5   | 49    | 44.5   | 31    | 29.0   | 64    | 60.0   |
| **Total**                     | **168** | **100** | **110** | **100** | **107** | **100** | **106** | **100** |
| **Farming Experience**        |       |        |       |        |       |        |       |        |
| Less than 10 years            | 42    | 25.0   | 25    | 22.8   | 22    | 20.6   | 12    | 11.4   |
| 11-15 years                   | 99    | 58.9   | 37    | 33.6   | 53    | 49.5   | 31    | 28.6   |
| More than 15 years            | 27    | 16.1   | 48    | 43.6   | 32    | 29.9   | 63    | 60.0   |
| **Effect of rainfall (mm)**   |       |        |       |        |       |        |       |        |
| Not sufficient for maize      | 121   | 72.0   | 88    | 80.0   | 23    | 21.5   | 14    | 13.2   |
| Sufficient for maize          | 47    | 28.0   | 22    | 20.0   | 84    | 78.5   | 92    | 86.8   |
| **Total**                     | **168** | **100** | **110** | **100** | **107** | **100** | **106** | **100** |

CSP = Climate Smart Practice; Freq = Frequency; % = Percentage

Source: Field survey, 2018

**Influence of Farmers’ Socio-economic Factors on Adoption of CSP in the Study Area:**

The estimated coefficients of the socio-economic factors that influence the adoption of CSP and non-CSP maize in Northern Nigeria are as presented in Table 4. The estimated pseudo R² for Kano and Nasarawa State farmers were found to be 50.5% and 50.4% respectively. The log likelihood ratio (LR) statistics were found to be significant at 52.0% and 50.9% for Kano and Nasarawa States respectively. This implied that the exogenous variables in the model jointly explained the decisions of the maize farmers to adopt the CSP in the maize production.

**Table 4. Estimated coefficients of the socio-economic factors that affect the adoption of CSP and non-CSP maize in Northern Nigeria**

| Variables               | Kano State CSP Adopters | Kano State Non-CSP Adopters | Nasarawa State CSP Adopters | Nasarawa State Non-CSP Adopters |
|-------------------------|-------------------------|-----------------------------|------------------------------|---------------------------------|
| Gender:                 | 3.0193                  | 2.1561                      | 3.0097                       | -5.2673                        |
| Age of farmer (years)   | 0.0685                  | 0.0844                      | 0.0511                       | -0.1392                        |
| Marital Status          | 0.0732                  | 0.0651                      | 0.0539                       | 0.0517                         |
| Educational Level       | 0.5195                  | 0.4214                      | 0.4738                       | -0.7213                        |
| Household Size (No.)    | -0.4123                 | -0.3543                     | -0.3317                      | 0.3726                         |
| Farm Size (ha)          | 0.2531                  | 0.1694                      | 0.2751                       | -0.1629                        |
| Membership of Cooperatives | 1.2347                 | 1.9993                      | 1.9847                       | 0.8135                         |
| Access to Credit:       | 2.0071                  | 1.9712                      | 2.0082                       | 1.8922                         |
| Quantity of Maize seed (kg) | 0.0098                | 0.0239                      | 0.0113                       | -0.0297                        |
| Labour (man-day)        | 0.0029                  | -0.0091                     | 0.0036                       | 0.0087                         |
| Access to Extension Services: | 1.9253                 | 1.6234                      | 1.5177                       | -2.5601                        |
| Reasons for Adoption    | 2.1393                  | -1.0412                     | 2.0547                       | 3.0124                         |
| Farming Experience      | 0.0257                  | -0.0265                     | 0.0273                       | 0.0522                         |
| Income in Naira          | 1.08E-07                | 0.07E-04                    | 1.06E-09                     | 1.02E-05                       |

Source: Field survey, 2018
Access to credit and income of both groups of farmers were significant and positively related to the farmer’s decisions to adopt both CSP and non-CSP maize production at Ρ≤0.5 and Ρ≤0.1 for Kano and Nasarawa States respectively. Age of the farmers and household size were significant but negatively related to the CSP adoptions at 1% and 5% level of probability for both farmers in both Kano and Nasarawa States respectively. This implied that the older the farmers were and the more the household size, the less the farmer were likely to adopt the CSP or non-CSP maize. Educational level was found to be significant and positively influenced the adoption of the CSP by both States at Ρ≤0.1, but negatively influence the non-CSP adoption for both States at the same level of probability. This meant that the more the educated the maize farmers were, the more they adopted the CSP and also the less they adopt the non-CSP maize production. Access to Extension Services was found be significant and positively influence the adoption of CSP maize at 1% level of probability for both States.

| Volume of rainfall (mm) | 0.8073 | 0.7651 | 0.8453 | 0.6527 |
|-------------------------|--------|--------|--------|--------|
| Number of observations  | 168    | 110    | 107    | 105    |
| Log likelihood          | -49.238574 | -38.538961 |        |        |
| LR Chi-square           | 51.98 * | 50.87 * |        |        |
| Pseudo R²               | 0.5045 |        |        |        |

CSP = Climate Smart Practice; Number in parentheses are Z-values; *** = Significant at 1% level of probability; ** = Significant at 5% level of probability; * = Significant at 10% level of probability

Source: Field data analysis, 2018

### Table 5. Influence of CSPs’ adoption on production efficiency (technical, allocative and economic) of maize in the study area

| Production Efficiencies | Kano State | MSP Maize Adopters | MFC | Non-CSP Maize Adopters | MVP | MFC |
|-------------------------|------------|---------------------|-----|------------------------|-----|-----|
| Allocative              |            | 42,870              | 41,980 | 1.02 | 65,450 | 73,620 | 0.89 |
| Technical               |            | 95,650              | 94,870 | 1.00 | 87,970 | 99,730 | 0.82 |
| Economic                |            | 139,520             | 136,850 | 1.02 | 153,420 | 173,350 | 0.89 |
| Allocative              | Nasarawa State | 58,960             | 57,890 | 1.02 | 62,310 | 64,920 | 0.96 |
| Technical               |            | 78,910              | 77,940 | 1.01 | 74,580 | 76,310 | 0.97 |
| Economic                |            | 137,870             | 135,830 | 1.02 | 136,890 | 141,230 | 0.97 |

Both Kano and Nasarawa non-CSP adopters over-utilized the scale, technology and overall resources management and thus, recorded allocative, technical and economic inefficiencies, respectively in the maize production. Therefore, for optimal level of efficiency to be attained, the non-CSP adopters must reduce the amount of resource such as the maize seed, fertilizer, and agrochemicals by increasing their scale of operation. The labour and farm tools ought to be reduced, while the overall management has to be adjusted to obtain efficiency. This result is in agreement with the findings of Ogunniyi et al., (2012) wherever-utilization or under-utilisation of agricultural production resources were found to be attributed to the cultivation of small farm size and the use of crude farming implement. To increase the maize output, more land should be cultivated, which can be achieved if farmers are provided with modern farm tools and other production resources at affordable prices.

### Influence of CSP Adoption on Production Efficiency (allocative, technical and economic) of Maize Production in the Study Area:

The influence of CSP adoption on production efficiency of maize production in the study area is as shown in Table 5. Marginal Value Productivity (MVP), as the yardstick for measuring the efficiency of resource use at a given level of production process involves the comparison of the cost of the inputs and the value of the outputs. In both Kano and Nasarawa States, the CSP-adopters in maize production recorded allocative, technical and economic efficiencies, while all the non-CSP adopters recorded inefficiency throughout the production process. Technical efficiency was observed to be the most efficient for the CSP-adopters in both States, as Kano recorded 1.00 and Nasarawa recorded 1.01. This implied that the CSP-adopters were most efficient in the technology used in the maize production, which is in agreement with the findings of Babatunde & Boluwade (2004), where it was found that increasing the level of the resources used in crop production can lead to output.

### Statistical Difference between the Mean Incomes of both CSP and Non-CSP Adopters:

The result of the test of statistical difference between the mean incomes of CSP and non-CSP maize adopters in Northern Nigeria was carried out with the use of Z-test to assess the hypothesis which states that ‘there is no significant difference between the mean incomes of CSP and non-CSP farmers’. The CSP-adopters mean income were estimated to be N140, 198 and N162,545 in Kano and Nasarawa, respectively, while that of the non-CSP adopters were N54,622 and N85,570 in Kano and Nasarawa respectively. The Z- calculated were found to be 2.61 and 2.83 at 1% level of significance for Kano and Nasarawa States respectively. These were greater than the tabulated mean (1.96), which meant that there is a significant difference between the mean incomes of both farmers. The coefficient of variation of the mean incomes of the two
groups of farmers was found to be 35%, thus, the hypothesis that there is no significant difference between the mean incomes of CSP-adopters and the non-CSP adopters, is rejected.

| State       | Group               | Mean Income | Standard Deviation | Standard Error | Z-Calculated | Z-table | Sign. |
|-------------|---------------------|-------------|--------------------|----------------|--------------|---------|-------|
| Kano        | CSP Adopters        | 140.198     | 43.333             | 3.2352         | 2.61         | 1.96    | 0.005*** |
|             | Non-CSP Adopters    | 54.622      |                    |                |              |         |       |
|             | Difference          | 85.576      |                    |                |              |         |       |
|             | Co-efficient of Variation | 34.9879   |                    |                |              |         |       |
| Nasarawa    | CSP Adopters        | 162.545     | 47.11909           | 3.4504         | 2.83         | 1.96    | 0.004*** |
|             | Non-CSP Adopters    | 85.570      |                    |                |              |         |       |
|             | Difference          | 76.975      |                    |                |              |         |       |
|             | Co-efficient of Variation | 34.7659   |                    |                |              |         |       |

CSP = Climate Smart Practice; *** = Significant at 1% level of probability; * = Significant at 10% level of probability

Source, Field survey, 2018

**Constraints that limit the adoption of CSPs among the maize farmers in the study area:**

The constraints that limit the adoption of the CSP in maize production in Northern Nigeria is as presented in Table 7. Majority of the maize farmers indicated high cost of production inputs to be the most severe constraints that affect the adoption of the CSP in the maize production in Northern Nigeria. This scored the highest weighted mean (2.64) and was thus, ranked as the first constraint, while poor transportation problem was recorded as the least severe constraint, and was thus, ranked as the eleventh.

**CONCLUSION AND RECOMMENDATION**

The study of adoption of climate-smart practices and the effects on production efficiency of maize farmers in Northern Nigeria revealed that the CSP-maize adopters earned more net income and were more efficient in the crop production than the non-adopters. The most severe constraint to the CSP-adoption was high cost of production inputs. Maize farmers were advised to adopt CSP and join cooperatives to benefit from cheaper inputs and increase efficiency.

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Table 7. Constraints that limit the adoption of CSPs among maize farmers in Northern Nigeria

| Constraints                        | CSP Adopters | Non-CSP Adopters | Weighted Mean |
|------------------------------------|--------------|------------------|---------------|
|                                    | Freq | Freq | 1% | 2% | 3% | 4% | 5% | Rank |
| High cost of inputs                | 275  | 216  | 56 | 43 | 36 | 9  | 2.64 | 1    |
| Low rainfall                       | 275  | 216  | 52 | 40 | 35 | 23 | 2.32 | 2    |
| Pest and diseases                  | 275  | 216  | 68 | 33 | 27 | 37 | 2.30 | 3    |
| Lack of sufficient credit          | 275  | 216  | 44 | 58 | 22 | 38 | 2.26 | 4    |
| Lack of improved production technology | 275       | 216       | 51 | 54 | 38 | 13 | 2.21 | 5    |
| High cost of labour                | 275  | 216  | 42 | 55 | 21 | 39 | 2.18 | 6    |
| Low Pricing for output             | 275  | 216  | 48 | 37 | 45 | 31 | 2.17 | 7    |
| Insufficient Extension contact     | 275  | 216  | 45 | 46 | 48 | 24 | 2.04 | 9    |
|                                | Number | % | 1 | 2 | 3 | 4 | 5 | Mean | SD |
|--------------------------------|--------|---|---|---|---|---|---|------|----|
| Lack of production subsidy     | 275    | 216| 46 | 59 | 49 | 38 | 59 | 1.86 | 10 |
|                                |        |   | (21.3) | (27.3) | (15.5) | (17.6) | (27.3) |      |    |
| Lack of storage facilities     | 275    | 216| 47 | 53 | 49 | 39 | 28 | 0.63 | 11 |
|                                |        |   | (21.8) | (24.5) | (22.6) | (18.1) | (13.0) |      |    |

Note: CSP = Climate Smart Practice; % = percentage; 1=Serious problem; 2= Problem; 3=Not a serious problem; 4= Not a problem; 5=Indifferent; Figures in parenthesis are percentages

Source: Field survey, 2018