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Climate Smart Agriculture Strategies among Crop Farmers in North Central Nigeria: Implication on farm Productivity

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***Abstract*: With the aim of identifying the various CSA strategies used by farmers and assessing the productivity effects of identified CSA practices on farm productivity in Kogi State, North Central, Nigeria, this study assessed the productivity effects of Climate Smart Agricultural (CSA) practices on arable crop farmers. Data were gathered from three hundred and fifty (350) farmers using a "three stage sampling technique" and standardized questionnaires. The data were analyzed using "descriptive statistics", "Total Factor Productivity (TFP)," and least squares regression. The farmers were majorly male (86%), married (91.14%) with mean age of 54years and had secondary school education (40.25%). Prevalent Climate smart Strategies were cover cropping (20.86%), Organic manure (16.0%), and minimum tillage (15.14%), crop rotation with legumes (14.86%), mulching (14.57%), Inorganic fertilizer (12.0%) and improved varieties (6.57%). Determinants of TFP estimate reveals the following factors as having a significant contribution to productivity at different levels of significance in the study area; age (-1.328), education (0.427), farm size (0.41), organic fertilizer (0.48), access to extension (0.342), cover cropping (0.023), Inorganic fertilizer (.47), improved varieties (0.503), Crop rotation with legumes (0.54), Amount of credit accessed (0.273). While age impacted negatively on productivity, all others impacted positively on productivity. The study concluded that Climate Smart Agriculture strategies had positive impacts on crop productivity. Promoting sustainable Climate smart Strategies is recommended.**

Keywords: Arable crop; Climate Smart; Determinants; Nigeria; Productivity

I. INTRODUCTION

Nigeria's long coastline, tropical climate, reliance on agriculture, and low family capacity for climate change adaptation all contribute to the country's vulnerability to shocks, particularly those related to climate change (Tambo & Abdoulaye, 2012). The World Bank General Household Survey report (2016) states that "agriculture is the most prevalent income-generating activity in many Nigerian households," which is consistent with the Maplecroft Report (2013) finding that countries susceptible to climate change depend significantly on agriculture. As a result, rural livelihoods in Nigeria are extremely sensitive to climate change.

Climate change is already having an effect on food production, particularly cereal such as rice, wheat, sorghum, and maize (Maplecroft Report, 2015; Khatri-Chhetri, et al., 2017). Through changes in the adaptability of crops grown and agricultural biodiversity, climate change distorts agricultural production. Additionally, it results in a decline in input usage efficiency and a rise in the prevalence of pests and pathogens (Khatri-Chhetri, et al., 2017).

Nigeria's economy is still mostly dependent on agriculture, which generates 22.36 percent of the nation's GDP and employs almost 70 percent of the labor force (Bernard & Adenuga, 2017; National Bureau of Statistic [NBS], 2022). Agricultural sector grew at the rate of 4.1 percent in 2016 and it accounted for 75 percent of non-oil exports. To improve the sectoral performance, the "Federal Ministry of Agriculture and Rural Development" (FMARD) has approved Agriculture Promotion Policy (APP), building on the Agricultural Transformation Agenda (ATA) developed under the administration of President Goodluck Ebele Jonathan. The key themes of this policy are supporting productivity enhancements; crowding in private sector investment and FMARD's institutional realignment with a focus to improving the ease of transacting business in Nigeria's agricultural space (Oredipe, 2017). Also the National Agricultural Resilience Framework (NARF) paper was created by the Nigerian government in 2013. This was done in order to deploy "new agricultural production strategies and risk management mechanisms," both of which aimed to increase resilience in the agriculture industry.

Despite the aforementioned policies and research outputs, there are still many areas where there is a lack of understanding regarding climate-smart adaptation measures. Crop-specific methods, their frequency of use, and their efficacy in relation to farm productivity and the types of climatic hazards farmers in Nigeria confront are of interest. Information about the various climate-smart adaptation techniques used by smallholder farmers of arable crops appears to be scarce. Such information is essential for crop targeting for both farmers and policymakers because using the wrong tactics would have detrimental effects on the farmer's cost and yield. Findings in the literature suggest that farmers have long used climate-smart practices. Empirical evidence, however, is still lacking regarding how these tactics affect farm productivity and how this affects farmer welfare.

In light of the aforementioned context, this study therefore enumerates the different CSA (climate-smart adaption) tactics that farmers employ in relation to the production of arable crops in Nigeria, and the effects of CSA choices on farm productivity in the research area.

The study's central hypothesis is that, in light of a changing climate, climate-smart agriculture is a strategy for assuring and boosting sustainable agricultural production. Also, the development and implementation of policies for climate-smart agriculture in Nigeria require information to assist the government and international organizations. The study's findings will offer so much useful knowledge.

I. Literature review

Climate change and its effects on agriculture

Natural hazards including storms, floods, and droughts become more intense due to climate change brought on by anthropogenic and natural climate cycle activities. This changes the amount and timing of rainfall as well as the temperature. Climate change poses a severe threat to human socioeconomic and environmental growth, particularly in developing economies (Arimi, 2014; Sanogo, et al., 2017). The majority of African nations are exposed to the whims of climate because of their economic environments (Abidoye, and Odusola, 2015). Climate change is considered to be a problem for emerging nations, especially Nigeria (Ayanlade, et al., 2017)

Studies on the effects of climate change on agriculture have been undertaken in sub-Saharan Africa using a variety of approaches. For instance, a process-based crop model at a regional level for West Africa shows that crop yield over the long term would drastically decline and exhibit inter-annual variability without agricultural intensification for climate adaptation. This is a result of future climate scenarios' higher fluctuation in inter-annual growth season temperature and/or precipitation (Ahmed, et al., 2015).

In their study on the "effect of climate change on rice production in Anambra State, Nigeria," The effects of climate change, according to Nwalieji and Uzuegbunam (2012), include "reduction in crop yield, reduction in grain quality, destruction of farmland by flood, food insecurity, instability, inaccessibility, and poor utilization, incident of pests and diseases, surge of infectious diseases such as cholera, malaria, on farmers, incidence of droughts in rice fields, high incidence of weed, and decrease in soil fertility ."Climate Smart Adaptations" and strategies.

Climate-smart adaptation strategies employed by farmers to address climate change variability have been found in the literature. These include the use of new and improved crop varieties, irrigation, crop diversification, shifting crop planting dates, livelihood diversification (especially from farming to non-farming activities), water and soil conservation techniques, tree planting, mulching, composting, intercropping, improved animal feeding, and climate-risk insurance, among others (Yegbemey, et al., 2013). The majority of traditional/indigenous techniques have existed and will continue to influence climate-smart agriculture initiatives (Douxchamps et al., 2016).

One strategy for minimizing the negative effects of climate change, particularly on agriculture, is adaptation (Esham, and Garforth, 2013; Tambo & Abdoulaye, 2012). This is due to the fact that adaptation measures have the capacity to affect and mitigate the effects of climate change (Smit et al., 2000). These Researchers assert that the term "adaptation" encompasses a variety of contexts, from ecology and the environment to social science and the human dimension, but that all adaptation is response-based.

II. Farm productivity

The term productivity has been used in a variety of ways. The ability of production factors to produce the output (Latruffe, 2010), the "ratio of a volume measure of output to a volume measure of input use" (OECD, 2001), the value of farm output per worker (Dzanku, 2015), and the rate of output produced per unit of input used for a given production process (Burja, 2012). Increased farm productivity is one of the most essential principles of climate-smart adaptation strategies. It was described as the "ratio of final output, in appropriate units, to some measure of inputs" by "Liverpool-Tasie, et al., (2011)". Therefore, productivity implies an input-output relationship in each situation that demonstrates the degree to which the input(s) employed in a production process produce the intended level of output.

Literature refers to three agricultural productivity indicators (partial factor, total factor, and total resource) that are based on the ratio of quantity-based output to input in a production process (Fuglie,et al 2016). The ratio of output to any one of the inputs, typically labor or land, is known as partial factor productivity (Odhiambo & Nyangito, 2003). In developing nations where the majority of family plots are planted with mixed or intercropping crops, price-based farm productivity, whether total or partial, is chosen for productivity studies. The quantity of each crop produced per hectare is typically calculated by multiplying the farm gate or market price of the produce (Peterman, et al., 2011).

Methodology

The Study Area

Kogi state in the north-central region of Nigeria, was where this study was carried out. Kogi, one of Nigeria's 36 states, is the 20th most populous and thirteenth largest in terms of land area with an estimated 4.5 million persons as of 2016. According to the 2006 census, there are 3,278,487 people living in the state and majorly agrarians; 1,691,737 of whom are male and 1,586,750 are women (National Population Commission [NPC], 2006). Geographically, the state is a part of the tropical Guinean savannas and forest mosaic ecoregion. Important physical characteristics include the two rivers, the Niger and Benue, which meet in the center of Kogi and cut the state in half from north to south. Niger originates in the northwest and Benue originates in the northeast (Abiodun, 1985). Agriculture dominates Kogi State's economy, with a focus on the cultivation of cashew, yam, coffee, rice, cassava, beans, groundnuts, cocoa, and oil palm. Two additional significant businesses are the extraction of crude oil and the rearing of sheep, goats, and other livestock. The state's climate averages between 1,100mm and 1,300mm of rainfall each year. The wet season typically lasts from April to October, whereas the dry season typically lasts from November to March. (Oguntoyin, 1987).

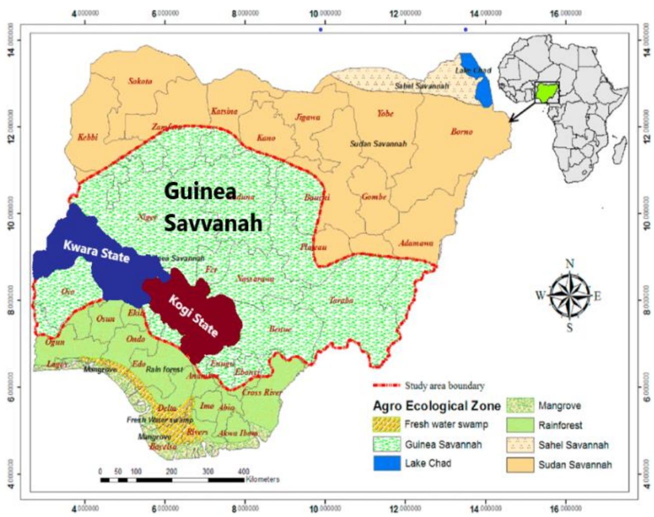

Figure 1: Map of Nigeria showing the study areas

III. Sampling Procedure

Farmers of arable crops who resided in the study area made up the study population, and the information used came from production season 2021. A "three stage sampling technique" was used in the study. In stage one, three Agricultural Zones – Zone A, B and C were randomly selected for the study. At stage two, a sample of three Local Governments were selected from each zone. At stage three, 40 farmers were randomly selected in each local government. 360 farmers in all were chosen and interviewed for the study, but only 350 questionnaires were actually used because 10 questionnaires could not be recovered and had inaccuracies.

Table 1: Sample outlay design of the study

ADP ZONE	LOCAL GOVERNMENT	NO OF HOUSEHOLD
A	Kabba-bunnu Ijumu Yagba Eeast	40 40 40
B	Lokoja Okene Ogorimagongo	40 40 40
C	Ankpa Olamaboro Dekina	40 40 40
Total	9 LGAs	360

Source: Author

Analytical Technique

Based on the study's goals, a variety of analytical tools were used. The tools include multiple regression, total factor productivity, and descriptive statistics. A total factor productivity model, as used by Adepoju and Salman (2013), was used to estimate the productivity value of the farming household heads based on the most commonly used. Descriptive statistics were used to describe the socioeconomic characteristics of the farmers and the Climate Smart Strategies adopted by the farmers. The "Total Factor Productivity" (TFP) method compares an index of agricultural inputs to an index of outputs to determine agricultural productivity (Jean-Paul, 2009). This is the ratio of outputs in naira value to the total variable cost (TVC) of production. According to Foster et al., (2008), TFP measures that employ physical quantities rather than revenue as output measures actually exhibit even greater volatility than do revenue-based measures.

$$TFP = \frac{Y}{TVC} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where Y = Output (Naira)

TVC = "Total Variable Cost"

$$TFP = \frac{Y}{P_i Q_I} \quad i=1,2,3\ldots, n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where:

Y = quantity of output in Naira,

P_i = unit price of ith variable input

Q_i = quantity of ith variable input

In line with Fakayode *et al*., (2008) the inputs that were considered in this study are: cost of labour, cost of planting materials, Cost of inorganic fertilizer, Cost of herbicide and Cost of pesticide. Following Akintayo and Rahji, (2011) to examine the effect of some socio-economic variables as well as Climate smart Strategies on the "Total Factor Productivity" (TFP), the TFP estimate was subjected to ordinary least square regression to obtain the coefficient of multiple determinations (R^2), F-Statistics, standard error and their values. The ordinary least square regression model is a best linear unbiased estimator whose estimate possesses the desirable properties of unbiasedness, efficiency and consistency.

Model Specification

$$Y = f(X_1, X_2, X_3, X_4 \ldots\ldots, X_{14}, u) \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where:

Y = TFP estimate

Based on the view of Adepoju and Salman, (2013) the following factors were hypothesized as the determinants of TFP of arable crop farmers in the study area.

X_1 = Age of household heads (years),

X_2 = Number of years of formal education,

X_3 = Household size (number),

X_4 = Farming Experience (years),

X_5 = Amount of credit accessed (Naira),

X_6 = Farm Size (ha),

X_7 = Extension contact (Dummy Variable; Yes = 1 otherwise = 0),

Vector of index of Climate smart Strategies (Dummy Variable; Yes = 1 otherwise = 0),

X_8 = Mulching,

X_9 = organic fertilizer,

X_{10} = Cover cropping,

X_{11} = Inorganic fertilizer,

X_{12} = improved varieties,

X_{13} = Minimum tillage,

X_{14} = Crop rotation with legumes

X_1 = error term which is assumed to be normally distributed and with mean zero and constant variance.

IV. Results

Table 2: Socioeconomic Characteristics of the farmers

Characteristics	**Category**	**Frequency (n=350)**	**%**	**Mean**	**Standard Deviation**
Gender of Household head	Male	301	86		
	Female	49	14		
Household head Marital Status	Single	9	2.6		
	Married	319	91.14		
	Divorced	3	0.86		
	Widow(er)	12	3.43		
	Separated	7	2.00		
Household head Age	≤ 30	21	6.00	54	11
	31 – 40	40	11.43		
	41 -50	102	29.14		
	51 – 60	176	50.29		
	>60	11	3.14		
Household size	≤ 5	202	57.71	5	2
	6 – 10	143	40.86		
	>10	5	1.43		
Household head Educational Status	No formal Education	92	26.29		
	Primary Education	93	26.57		
	Secondary Education	141	40.29		
	Tertiary Education	24	6.86		
Rural farming Experience (Years)	≤ 10	113	32.29	12	4.3
	11 – 20	211	60.29		
	>20	26	7.43		
Rural Farm Size (ha)	<1.00	39	11.14		
	1.00 – 5.00	194	55.43		
	5.1 – 10.00	86	24.57		
	>10.00	31	8.86	5	3.5
Primary Occupation of rural household head	Farming	279	79.71		
	Non-farming	71	20.29		
Cooperative membership status	Member	223	63.71		
	Non-Member	127	36.29		
Extension Visit on Climate change	No	265	75.71		
	Yes	85	24.29		

Source: field survey, 2021

Table 3: Climate smart Strategies in the Study Area

Climate smart Strategies	Frequency	%
Cover crop	73	20.86
organic fertilizer/manure	56	16
Minimum Tillage	53	15.14
Crop rotation with legumes	52	14.86
Mulching	51	14.57
inorganic fertilizer	42	12
Improved varieties	23	6.57
Total	350	100.00

Source: Field Survey, 2021

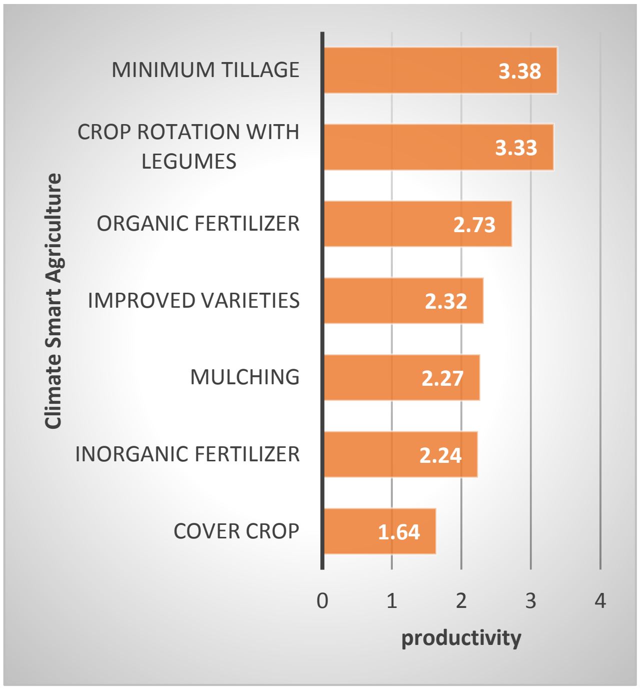

Figure 2: Bar Chart Showing the Mean Productivity Estimates Across the different CSA practices by the farmers
Source: Authors computation, 2021

V. Table 4: Factors Affecting Productivity of Food Crop farmers

Variables	Coefficients	Standard error	T	P>|t|
Age	-1.328	0.2	-6.64***	0.000
Education	0.427	0.158	2.70***	0.006
Household size	0.005	0.016	0.32	0.658
Farming experience	0.006	0.014	0.43	0.648
mulching	0.033	0.102	0.33	0.742
Farm size	0.41	0.074	5.54***	0.001
Organic fertilizer	0.48	0.182	2.63***	0.002
Access to extension	0.342	0.198	1.73*	0.076
Minimum tillage	0.034	0.186	0.18	0.824
Cover cropping	0.023	0.011	2.09**	0.073
Inorganic fertilizer	0.47	0.192	2.45**	0.051
Improved varieties	0.503	0.213	2.36**	0.060
Crop rotation with legumes	0.54	0.186	2.90***	0.004
Amount of credit Accessed	0.273	0.163	1.67**	0.050
Constant	1.066	0.936	1.13	0.261
R^2	0.657			
Prob>F	0			
F(13 147)	581.71			
N	350			

*** 1% significance level; ** 5% significance level; * 10% significance level
Source: Field Survey, 2021.

Years of education had a positive and significant coefficient at 1%, indicating a considerable boost to productivity from the variable. This suggests that an increase in education years have the probability of generally leading to an increase in productivity. This is consistent with Shittu et al., (2015) results that education raises farmers' productivity.

According to the coefficient of farm size, which was positive and significant at the 1% level, a unit increase in farm size will typically lead to 0.41 unit rise in production. This is probably the case since farmers who own big farms typically benefit from economies of scale when purchasing their inputs and selling their output, which lowers the unit cost. The outcomes are consistent with those of Wawire et al., (2021).

The positive coefficient for household size, and farming experience, is an indication that an increase in each of these factors tends to boost productivity by 0.005, 0.006, respectively, even though they were not statistically significant.

Furthermore, the TFP was positively correlated with all of the Climate Smart Strategies, suggesting that higher adoption of any of Climate Smart Agricultural Strategies boosted productivity. It was only mulching and minimum tillage that was not statistically significant among all the CSA adopted by the farmers.

Discussion

VI. Socioeconomic characteristics of the farmers

The gender breakdown of farming households as shown in Table 2 reveals that respondents are overwhelmingly male (86%) and female (14%). This shows that farming is a popular hobby among both sexes in the studied area. However, the higher percentage of men suggests that more men than women are engaged in farming in the research area. This result is consistent with Africa's cultural environment, where men have greater access to farms and other agricultural resources. Gender has an impact on how rights and privileges are exercised in the family and society, as well as how resources, money, employment, decision-making, and political power are distributed (Welch, et al., 2000). According to the age distribution, the majority (50.29%) of respondents were between the ages of 51 and 60, followed by those between the ages of 41 and 50. Over 60-year-old respondents made up about 3.14% of the sample. About 40% of the respondents have up to secondary education while 26.6% are shown to have no form of formal education, with an average age of 54 and an average educational background of roughly nine years (equivalent to completion of Junior Secondary School level). The average household size is eight (5), with the majority of households (57.71%) having a household size of fewer than six people. Following this are those with six to ten and more than ten people, which represent 40.86% and 1.43%, respectively.

About 24% of families have gotten knowledge about climate change as a result of interactions with local extension workers.

Since extension contacts may boost the availability of knowledge and technical help required to foster climate-smart adaptation strategies, this may have an impact on how often adaptation practices are used. Adoption of agricultural technology has been demonstrated to be significantly influenced by social capital or networks among farmers (Knowler & Bradshaw, 2007). Most responses (63.71%) are from various socioeconomic, cultural, and agricultural groups.

VII. Identified Climate Smart Agricultural strategies adopted by the farmers

The identified CSA strategies adopted by the farmers in the study area in order of the usage as shown in table 3 are: cover crop, organic fertilizer, Minimum tillage, crop rotation with legumes, mulching, inorganic fertilizer and using improved varieties. Inorganic fertilizer and improved varieties are the least used strategies by the farmers under study with 12% and 6.57% of the farmers respectively adopting their usage. The frequency of climatic risk occurrence, crop physiology, cost of use, technical know-how, local knowledge/experience, and their perceived contributions to yield all influence the decision of which strategy to employ.

These selections reveal farmers' preferences for low-input, easily-accessible inputs, which are readily available because they are accessible locally or at comparatively low costs when compared to external inputs like fertilizers and improved varieties. This is in consonant with Himanen, et al., (2016)

VIII. Mean Productivity Estimates Across the different CSA practices by the farmers

The mean productivity estimate of the different Smart Agricultural Practices on the farm productivity as shown in Figure 2, indicated that practices of minimum tillage gave the highest farm productivity of 3.38, followed by crop rotation with legumes with productivity estimate of 3.33 while cover crop strategy had the least productivity estimate of 1.64

IX. Factors Affecting Total Factor Productivity (TFP)

As shown in Table 4, the coefficient of determination (R^2) for food crop farmers (0.657) indicates the presence of a high degree of association between productivity (dependent variable) and all independent variables. This implies that 75.8% of the variation in the farmers' productivity is explained by the variations in the independent variables. The F-statistics of the farmers (F-test= 581.71, $P<0.001$) was found to be highly significant, implying that the independent variables were collectively important in explaining the variation in the dependent one. Of the fourteen explanatory variables specified, eight were statistically significant. These were age, education, farm size, mulching, crop rotation, inorganic fertilizer application, minimum tillage and organic manure application. The negative coefficient ($p<0.01$) of age suggests that farmers were less productive as they age, older farmers are not physically able to produce as much as younger household heads because productivity is countered by declining physical strength and perhaps by negative attitudes toward innovation. The negative coefficient, which implies that a unit increase in farmers' age decreases productivity by 1.46, agrees with the findings of Ahmed and Elrasheed (2016).

Conclusion and Recommendations.

The study concluded that the farmers in the study area are using various strategies to mitigate against the effects of Climate change on their farm productivity. The identified strategies are cover cropping Organic manure, minimum tillage, crop rotation with legumes, mulching, Inorganic fertilizer and improved varieties. All the strategies the farmers adopted positively correlated with the farm productivity. The factors driving productivity of the farmers are the Climate Smart Agriculture strategies, education of household heads, farm size and extension contacts. Based on the findings of the study, the following

Age is inversely correlated with productivity; hence it is advised that youth empowerment programs in the area give agriculture primary attention in order to further encourage relatively young farmers to grow arable crops.

Using farmer organizations/Cooperatives as a forum to encourage the implementation of CSA practices should be intensified.

There are very few farmers who have interacted with extension agents. It is crucial to send additional extension agents to rural regions to inform and educate farmers about the usage of CSA practices. Accordingly, the farmers would be able to increase their output and profit. Their output and income from their farms will consequently increase as a result.

Since the level of formal education seems to contribute to the farmers' overall factor production, education is a variable that enhances productivity. This will not come as a surprise because education has a way of encouraging farmers to allocate their resources to any profitable endeavor and also to embrace new technologies/adoptions in a reasonable manner, leading to an increase in productivity. Therefore, it is advised that farmers be encouraged to pursue basic education or adult literacy.

Since all the CSA strategies adopted by the farmers positively contributed to the farm productivity, offering informal education to the farmers in the research area, it should be encouraged, so that they have access to information on ecologically friendly and climate-smart strategies.

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