STATUS OF CLIMATE SMART AGRICULTURE AMONG VILLAGE ALIVE DEVELOPMENT INITIATIVE FARMERS IN NORTH-CENTRAL NIGERIA

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ABSTRACT

This paper assessed the status of climate smart agriculture (CSA) among VADI farmers in North-central Nigeria using qualitative and quantitative methods in data collection. Two hundred and forty-seven farmers were randomly selected from the study area. Also, focus group discussions were conducted. Data collected were subjected to qualitative analysis and logit regression. The study identified five broad and important practices relevant to CSA in North-central Nigeria, which include: mobility and social networks, adjusting agricultural production systems, diversification on and beyond the farm, farm financial management, and knowledge management and regulations. The determinants of CSA in north-central Nigeria include: farming experience, education, extension, livestock ownership, income, land ownership, household size, credit, land area cultivated, distance to the market and water resources, leadership position, risk orientation, gender, and mass media exposure. Government policies need to support research and development that develops and diffuses the climate-smart technologies to help farmers respond to changes in climatic conditions.

Keywords: *Climate-smart agriculture, Determinants, Status, North-central Nigeria*

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INTRODUCTION

Agriculture sector is vital in eradication of extreme poverty and hunger, and supports livelihoods of close to 1.5 billion people worldwide living in smallholder households in rural areas (World Bank, 2018). Despite its vital importance, the sector is highly sensitive and susceptible to climate change and variability (Van de Steeg *et al.,* 2019), and small scale farmers are disproportionately affected, as a result of poverty, high dependency on natural resources and inadequate capability to adopt new livelihood strategies (Omoro, 2017).

Intergovernmental Panel on Climate Change (IPCC, 2017) affirmed climate change occurrence and has projected further change and upsurge in the mean climate characteristics. This is likely to cause more severe effects on agriculture that has already registered instability in production, decreases in crop yield and livestock productivity. This will subsequently enhance hunger among millions of people worldwide, particularly in Latin America, Small Island States, Africa and some parts of Asia. This precarious situation is as a result of low adaptive capacity attributed to poor resource base, weak institutions and limited technology (IPCC, 2017). Estimates of the impacts of climate change on agriculture suggest that in future, both productivity and production stability will decline in areas experiencing food insecurity (FAO, 2020).

Climate change and variability has resulted into decline and instability in production worsening the existing food insecurity and poverty in developing countries. The effects of these climatic changes will become even more pronounced among small scale farmers, whose farming activities are weather dependent and vulnerable to climate change, and already adversely affected by environmental degradation and socio-economic risks (Van de Steeg *et al.,* 2019). To ensure resilience, adoption of climate smart practices among small scale farmers is required. In spite of the vital role played by climate smart practices in not only enhancing resilience, but also increasing productivity, reducing greenhouse gas emissions, and addressing environmental degradation, their adoption by small scale farmers has been low global (FAO, 2020). This is due to several lapses and challenges that have not been explored (Dzanku & Sarpong, 2019). Most studies tend to focus on the impact of climate change on agriculture and adaptation measures (Mburu, 2018; Van de Steeg *et al.,* 2009), but few have examined the status of climate smart agriculture among farmers. Critically lacking, however, is the determinants of CSA among VADI farmers in North-central Nigeria, based on detailed and consistent field data. It is this gap in knowledge that this study strives to fill.

The Village Alive Development Initiative (VADI) was initiated by Agricultural and Rural Management Training Institute (ARMTI) as an action oriented research which initially took off in 1995 as Village Alive Women Association (VAWA) in the communities of Idofian, Elerinjare, Jimba-oja and Kabba-owode in Kwara State (VADI, 2018). The intervention of VAWA was aimed at reducing the challenges of women in the selected communities in food processing, value addition and other farming enterprises. It was found out that women were often idle during the dry season and they experience severe food shortage resulting in extreme poverty, low productivity and the resultant effect was low income and poor standard of living. At the initial stage in 1995, the introduction of VAWA in the communities greatly increased the productivity of community members through improved access to modern farm inputs, extension services, reduction in postharvest losses and enhanced access to credit facilities provided by the project. Unfortunately, the intervention after some years became inactive due to poor funding. ARMTI management resuscitated the project as the Village Alive Development Initiative (VADI) in 2011 and the concept was changed to include Men, Women and Youths as beneficiaries (VADI, 2018). Several farmers are registered under this project across Kwara, Oyo, Benue, and Nasarawa States, Nigeria.

The changing climatic condition in North central Nigeria which manifest through changes in rainfall pattern and increasing heat waves is a concern. CSA is one of those efforts that may help boost resilience to climate change and reduce emissions, thereby making CSA relevant in the Nigerian context. The agricultural policy ambitions of the Nigerian government cannot be met without climate-smart agriculture. Moreover, CSA can be an important element for sustainable agricultural production among VADI farmers in North central, Nigeria. In fact, inadequate research in the area of climate-smart agriculture is listed as a constraint in the newly adopted Nigeria's Agriculture Promotion Policy of 2016–2020 (Federal Ministry of Agriculture and Rural Development, 2016). The Nigeria's Intended Nationally Determined Contribution (INDC) considers climate smart agriculture as one of the emission reduction actions. Thus the paper provides new information relevant for closing knowledge gap in the area. In this regard, the study sought to: examine climate-smart agricultural practices in the study area; determine farmers' adoption of climate-smart agricultural practices in the area; and examine the determinants of climate-smart agriculture in North-central, Nigeria.

METHODOLOGY

The study was carried out in North Central, Nigeria. North-Central Nigeria is situated in the southern Guinea savannah agro-ecological zone and consists of six states, namely Plateau, Nasarawa, Benue, Kogi, Niger and Kwara as well as the Federal Capital Territory, Abuja (National Bureau of Statistics, 2019). The region covers a land area of about 251,425 square kilometres with a population of about 29,266,257 inhabitants (National Population Commission, 2019) and has a high degree of ethnic diversity. Among the dominant ethnic groups are Tiv, Igala and Eggon. Subsistence agriculture is the principal activity in the study area. Farms are generally small, usually less than five hectares and rely on the use of manual labour and crude implements such as hoes and machetes.

The population for the study comprise all VADI farmers in North-central, Nigeria. The study employed a multi-stage sampling technique. The first stage involves a purposive selection of all the local government areas under VADI programme in the study areas (Kwara – Ilorin South and Ifelodun; Benue – Ogbadibo; and Nasarawa – Toto and Kokona LGAs) for the study. The second stage involves a random selection of two communities from each of the VADI Local Government Areas with the exception of Toto LGA that has the programme being run in only one community (Umaisha). For the third stage, a list of registered VADI farmers was obtained from VADI office in each of the communities in the states. From the list, systematic random sampling method was used to select 10% of the farmers on the list of VADI project, to give a total sample size of Two Hundred and Forty-seven (247) farmers. Primary data were collected through the use of structured interview schedule coupled with focus group discussion to elicit information from the respondents in order to accomplish set study objectives. The researchers first conducted one focus group discussion in each Local Government Area. The discussants were mainly adult male and adult female farmers. The focus groups were used to develop lists of specific technologies before data collection from the farmers using interview schedule.

The data obtained were analysed with the aid of descriptive statistics and binary logit regression. Logit regression technique was used to estimate the determinants of practices relevant to climate-smart agriculture. Considering the discrete nature of practices relevant to climate-smart agriculture, dichotomous dependent variables were constructed to indicate whether or not the farmer used such practice. Since the interest was in identifying farmers who used such practice or not, the outcome variables were coded as 1 if the farmers used such and as 0 if he did not use it. The logit model is used in estimating the probability of events based on the dependent dichotomous (binary) variables. A binary variable is a dependent variable that takes only two values (either 0 or 1). The logit regression model used for analysing the determinants of CSA practices is specified as follows:

The implicit model of the regression is $Yi = \log$

$(p/1 - p) = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}, e)$.

Where p is the probability while $(1 - p)$ is the corresponding odds, and the logit of the probability is the logarithm of the odds.

Where Y_i = Use of CSA practice (Dummy variable; use = 1, not use = 0)

i = CSA practices

These are defined as follows:

1. Adjusting production systems

2. Mobility and social network

3. Farm financial management

4. Diversification on and beyond the farm

5. Knowledge management and regulations

Any respondent who reported the adoption of a strategy was coded 1 and 0 otherwise. Therefore, five different binary logit regressions were done-one for each broad CSA practice.

X_1 = Educational level (years)

X_2 = Income (₦)

X_3 = Access to credit (₦)

X_4 = Contact with extension agents (number of yearly visits)

X_5 = Household size (number of persons)

X_6 = Farming experience (years)

X_7 = Farm size (Ha)

X_8 = Exposure to mass media (number mass media outfits accessed)

X_9 = Distance to the market (km)

X_{10} = Livestock ownership (number owned)

X_{11} = Leadership position (Dummy variable; leader of any farmers' association = 1, otherwise = 0)

X_{12} = Gender (Dummy variable; male = 1, female = 0)

X_{13} = Land ownership (Dummy variable; owner = 1, otherwise = 0)

X_{14} = Risk orientation (Dummy variable; ready to take farming related risk =1; otherwise =0)

X_{15} = Distance to water sources (km)

e = Error term

RESULTS AND DISCUSSION

Climate-smart agricultural practices

Table 1 describes the agricultural practices in the study area that are of relevance to climate-smart agriculture. The niche offered by climate-smart agriculture (CSA) is the triple possibility of simultaneously raising productivity, enhancing resilience and mitigating carbon emission (Nwajiuba *et al.,* 2017). From the responses of the focus group discussions, the researchers delineated five broad categories of climate-smart agricultural practices in the area and they are presented in Table 1.

Agricultural practices that increase productivity and reduce greenhouse gas emissions can promote climate resilience. In north central Nigeria where aggregate precipitation volumes are expected to reduce with climate change, the greatest impacts on agriculture are expected from changes in rainfall variability, such as reduced periods of rainfall intensity and changes in the seasonal pattern of rainfall. Therefore, agricultural practices that reduce yield variability during extreme events, such as erosion or floods, or because of erratic rainfall will provide the greatest benefit to farmers (Ngugi *et al.,* 2017). The discussants agreed that these practices provide multiple benefits in most cases. Result in Table 1 reveals that there are many climate-smart agricultural practices practiced by farmers in North-central Nigeria that provide multiple benefits in terms of productivity, resilience, and mitigation.

Adoption of practices relevant to climate smart agriculture by the farmers

Table 2 shows farmers' adoption of climate-smart agricultural practices in the study area. The result from table 2 reveals the local practices relevant to CSA in the area that is of relevance in increasing yield and productivity, reducing the vulnerabilities or enhancing resilience to climate change, as well as enhancing carbon sequestration. From the farmers' responses, the researchers delineated five broad categories of CSA practices in the study area which are presented in Table 2. Adjusting production systems have considerable potential for strengthening the adaptive capacity and resilience of VADI farmers in North-central, Nigeria. Similar findings have been reported by studies of rural adaptation practices by farmers in sub-Saharan Africa (Gbetibouo 2019; Onyeneke *et al.,* 2017).

Furthermore, Table 2 shows that 69.2% of the farmers adopted high yielding cassava varieties, which thrived well in the area. The high proportion of farmers using this practice in the area was associated with the increasing precipitation intensity observed in the area which, was causing erosion and flood of different magnitude. Also, Table 2 shows that 78.1% of the farmers practiced mixed cropping, 10.9% practiced construction of bonds and 11.7% practiced mounds. About 27.5% of the farmers adopted terraces. The lower adoption of terraces could be that the farmers either have constraints to its use or that they are not very knowledgeable of its benefits. The analysis shows that 65.2% of the farmers engaged in mulching. The high use of mulching observed could be attributed to the fact that mulching is known to protect soil against erosion, suppresses weeds, increase water infiltration and promotes soil biological activities (Onyeneke *et al.,* 2017). Furthermore, 60.3% of the farmers engaged in crop rotation, 68% practiced agroforestry, while 43.3% used cover cropping. This result agrees with the findings of Onyeneke *et al.,* (2017). These practices reduce the soil temperature by some degrees in the upper centimetres of the topsoil and provides better moisture conservation by reducing the intensity of radiation, wind velocity, and evaporation (Mburu, 2018). Crop rotation reduces the risk of serious pest and disease outbreaks, check erosion, improve soil fertility, and balance nutrient removal from the soil among others (IPCC, 2017).

The adoption level of water harvesting was 7.7%. The high adoption level of reduced/zero tillage (57.1%) may be explained by the fact that this option is easily accessible, conserves soil moisture and controls erosion. This is an emergent crop production technique, which can increase the amount of water in the soil and decrease erosion. Zanku and Sarpong (2019) identified it as one of the sustainable agricultural practices beneficial to reducing the effect of climate change. The low adoption level of irrigation (22.3%) could be attributed to the need for more capital to set up an irrigation system in the study area. Table 2 further reveals that 41.3% of the farmers adopted fallowing, while 46.5% adopted shifting cultivation. These practices were adopted by smaller proportion of the farmers as against the belief that they are common in north-central Nigeria. Fallow period is reducing in the area while shifting cultivation became an uncommon practice. This is because agricultural lands in north-central Nigeria are under serious threat due to insurgence and banditry attacks in some parts of the region. Membership of developmental associations and cooperative societies recorded a relatively high levels of adoption (53.8 and 48.9% respectively), and this is very encouraging considering the apathy farmers have exhibited in terms of membership to social organizations. Farmers in the area are beginning to understand and appreciate the role of social capital in agricultural production and risk management. About half of the farmers have diversified their activities from farm to non-farm.

Dependence on off-farm activities is not new in farming communities in north-central, Nigeria as farmers have used this method as risk management strategy and climate change adaptation strategy (Onyeneke et al., 2017). About 78.1% of the farmers adopted mixed farming. Many farmers usually practise this option as a way of building resilience to climate change.

Determinants of climate-smart agriculture in North-central Nigeria

The results of the logit regression on the determinants of climate-smart agriculture in north-central Nigeria were presented in Table 3. Results showed that the Likelihood Ratio, Chi Square values for each logit regression is statistically significant (P\0.01). This indicates that all the models had good fit to the data.

From the result in Table 3, education of the farmers was positive and significant across all the CSA practices. A unit increase in the number of years spent in school by the farmers increased the likelihood of adjusting agricultural production systems by 0.4%, mobility and social networks by 0.6%, farm financial management by 1.4%, diversification on and off the farm by 1.2%, and knowledge management and regulations by 0.7%. Level of education of VADI farmers increased the ability to obtain, process, and use information relevant to the adoption of new technology. This result is in line with the findings of Onyeneke et al., (2017) who confirmed that education affects climate change adaptation positively.

The income of farmers had a positive and significant effects on all the CSA practices. This is because higher-income farmers are less risk averse and have more access to information, and a longer-term planning horizon (Omoro, 2017). The result shows that a unit increase in the income of the farmers increased the likelihood of adjusting agricultural production systems by 0.5%, mobility and social networks by 0.3%, farm financial management by 0.38%, diversification on and beyond the farm by 0.9%, and knowledge management and regulations by 0.6%. This result is line with the findings of Onyeneke et al., (2017) who confirmed that income affects climate change adaptation positively in southern Nigeria.

Contact with VADI officers, which denotes access to information, had positive effect across all the CSA practices indicating that contact with VADI officers increases the likelihood of adopting climate-smart agriculture. Access to free information and capacity building by

VADI officers significantly increased the probability of adjusting agricultural production systems, mobility and social networks, farm financial management, diversification on and off the farm, and knowledge management and regulations. VADI officers in this study area work like extension agents and farmers who had regular contacts with these officers have better chances of being aware of climate change and also of the various practices that they can use to adapt. Also, through these officers, farmers can learn mitigation measures to climate change and strategies to enhance their resilience.

Household size of farmers significantly increased the likelihood of using improved agricultural systems, mobility and social networks, farm financial management, and diversification on and off the farm. This indicates that household size increases the probability of uptake of the CSA practices. Practices like adjusting agricultural production systems, diversification on and off the farm may require additional labour/man-hour from the farmer, which is usually provided by his/her household members. The result shows that a unit increase in the household size of the farmers increased the likelihood of adjusting agricultural production systems by 4.8%, mobility and social network by 2.2%, and farm financial management by 6.7% and diversification on and off the farm by approximately 6.9%. This result is line with the findings of Gbetibouo, (2019) who confirmed that household size affects climate change adaptation positively Limpopo Basin, South-Africa.

Farming experience had positive effect across all the CSA practices indicating that experience increases the likelihood of adopting climate-smart agriculture. Farming experience significantly increased the probability of adjusting agricultural production systems, mobility and social networks, farm financial management, diversification on and beyond the farm, and knowledge management and regulations. This implies that using experienced farmers in promoting climate-smart agriculture among VADI farmers can have significant positive impacts on the uptake of various CSA practices. Farm size were positively related to climate-smart agriculture as it had positive effects on adjusting agricultural production systems. The result showed that a unit increase in land area cultivated by the farmers increased the likelihood of adjusting agricultural production systems by 17.6%.

Distance to the market significantly decreased the likelihood of adjusting agricultural production systems, mobility and social networks, farm financial management, and knowledge management and regulations. Availability of inputs for climate-smart agriculture is very important in farming. However, required inputs may not be available in local markets and, therefore, farmers who are really interested in the technologies have to look for necessary inputs wherever they might be available. The market accessibility of farmers therefore depends on availability of good roads. Hence, the likelihood of climate-smart agricultural decision is significantly related to market access. The result similar to the findings of Onyeneke *et al.,* (2017).

The number of livestock owned by farmers significantly increased the likelihood of adjusting agricultural production systems, farm financial management, and diversification on and beyond the farm. Livestock plays a very important role by serving as a store of value and by providing traction and manure required for soil fertility maintenance (Mburu, 2018). The result shows that a unit increase in the number of livestock owned by VADI farmers increased the likelihood of adjusting agricultural production systems by 0.5%, farm financial management by 0.5%, and diversification on and off the farm by 0.3%.

CONCLUSION

The study concluded that the climate-smart agricultural and management practices among VADI farmers in Northcentral Nigeria are adjusting production systems, mobility and social networks, farm financial management, diversification on and beyond the farm, and knowledge management and regulations. The major determinants of climate-smart agriculture in the study area include farmers' education, income, credit, contact with VADI officers, livestock ownership, farming experience, farm size, distance to the market, and household size. Designing policies that aim to improve these factors affecting adoption of climate-smart agriculture for smallholder farming systems have great potential to improve climate- smart agriculture. Government policies need to support research and development that develops and diffuses the climate-smart technologies to help farmers respond to changes in climatic conditions. The new push by the Federal Ministry of Agriculture and Rural Development in including climate smart agriculture in the new Agricultural and Promotion Policy of 2016 is a right step. The Ministry should see to the implementation of climate smart agriculture elements in that policy.

REFERENCES

Dzanku, & Sarpong, (2019). Agricultural Diversification, Food Self Sufficiency and Food Security in Ghana-Role of Infrastructure and Institutions. (G. E. Djurfeldt, Ed.) African small holders; Food crops, Markets and Policy. CABI, Wallingford, UK, 189-213. Accessed on August 20, 2020.

FAO. (2020). Smallholder Integrated Crop-Livestock Farming Systems: Scoping Study on Climate Smart Agriculture in Kenya. Mitigation of Climate change in Agriculture (MICCA) Programme. Background Report 8. Rome: FAO.

Federal Ministry of Agriculture and Rural Development (2016): The Agriculture Promotion Policy (2016 – 2020). Building on the Successes of the ATA, Closing Key Gaps Policy and Strategy Document. Accessed on April 22, 2020.

Gbetibouo, G. A. (2019). Understanding farmers' perception and adaptations to climate change and variability: The case of the Limpopo Basin, South Africa. International Food Policy Research Institute (IFPRI) Discussion Paper 00849, February 2019. Environment and Production Technology Division, IFPRI.

IPCC. (2017). Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University press.

Mburu, K. (2018). Effects of Climate Variability and Change on Dry land Agriculture and the Adaptation strategies by Small Scale Farmers in Yata District. PhD Thesis. Kenyatta University.

National Bureau of statistics (NBS); Reform Programme, 2019 www.nigerianstat.gov.ng

National Population Commission (NPC) (2019). Population Census of the Federal Republic of Nigeria. Analytical report at the National Population Commission, Abuja, Nigeria.

Ngugi, L. W., Rao, K. P. C., Oyoo, A., &Kwena, K. (2017). Opportunities for coping with climate change and vari- ability through adoption of soil and water conservation technologies in semi-arid Eastern Kenya. In W. L. Filho, A. O. Esilaba, K. P. C. Rao, & G. Sridhar (Eds.), Adapting african agriculture to climate change: Transforming rural livelihoods. Climate change management. Switzerland: Springer.

Nwajiuba, C., Tambi, E. N., &Bangali, S. (2017). State of knowledge on CSA in Africa: Case studies from Nigeria, Cameroon and Democratic Republic of Congo. Accra: Forum for Agricultural Research in Africa.

Omoro, A.P. (2017). Assessment of Selected Factors Affecting Performance of Greenhouse Technology in Small scale Farms in Gusii Highlands, Kenya. Master Thesis.

Onyeneke, R. U., Nwosu, C. S., Nwajiuba, C. U., Okoye, V. K., &Mmagu, C. J. (2017). Comparative analysis of adaptive capacity and autonomous adaptation practices to climate change by farming households in Nnewi South. Local Government Area, Anambra State, Nigeria. Paper presented at the 14th annual national conference of the Nigerian Association of Agricultural Economists, Federal University of Technology, Akure, February 24–27, 2014.

Onyeneke, R. U., Christiana O.I, Uwadoka C.O., & Aligbe J.O. (2017). Status of climate-smart agriculture in southeast Nigeria, Geo-journal. DOI 10.1007/s10708-017-9773-z

Van de Steeg, J., Herrero, M., Kinyangi, J., & Thornton, P. (2019). The Influence of Climate Variability and Climate Change on the Agricultural Sector in East and Central Africa—Sensitizing The ASARECA Strategic Plan to Climate Change. Report 22. ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa), Entebbe, Uganda, and ILRI (International Livestock Research Institute), Nairobi, Kenya.

World Bank. (2018). *World Development Report 2018: Agriculture for Development.* Washington, DC: Accessed on July 4, 2021.

APPENDICES

Table 1: Climate-smart agricultural practices

Practices reported	Productivity impacts (incremental yields, capital)	Climate change adaptation and resilience implication	Mitigation impacts
1. Adjusting production systems High yielding crop varieties,	increased crop yield, productivity	increased resilience against climate change by reducing yield variability	
adjusting planting dates, improved livestock breed, crop rotation	Reduced tendency of crop failure, increased productivity per animal, increased fertility and yields	production is maintained better suited to changing climate, increase fertility, resilience, reduces water loss by erosion	Positive mitigation Mitigation potential especially with legumes
Fallowing	Increase nutrient reserves	Increase resilience to CC	Carbon dioxide sink
Mixed cropping	Increase yields	Increases resilience	Mitigation potential
Shifting cultivation	Increase nutrient reserves	Improves soil fertility	Forest serves as carbon dioxide sink
Strip cropping	Increased yields	Protection from erosion	reduces carbon
Application of manure	higher yields	Improved soil fertility, resilience to climate change	
Irrigation	Improves crop production	Reduces yield variability	Mitigation potential due to energy efficiency
Terraces	Higher yields due to increased soil moisture and reduced erosion	Intercept surface runoff	Net mitigation is positive
Mounds	Increased yields due to increased soil moisture	Possible increase in production	Positive mitigation effects
2. mobility and social network migration	Increased farm investment leading to increased production	Increased income	
Membership of cooperative societies	Benefits from rotational savings, increased productivity	Increased income	
3. farm financial management insurance	Insurance for crop failure and reduced risk	Guaranteed income	
Reduced farm investment by reducing land area cultivated	Productivity gain from scale of production	Maintained production under changing climate pattern	
4.Knowledge mgt. & regulations, forest protection measure	Conservation of forest resources	Increased resilience to climate change due to improved soil	Increased soil carbon
Use of local pesticides	Increased yields	increased resilience against CC	Mitigation potential
5.Diversification on and off the farm non-agric employment, mixed farming	Livelihood diversification Higher crop yields due to manure from livestock waste	Less dependence on weather, benefits in terms of livelihood diversification	

Table 2: Adoption of practices relevant to climate smart agriculture by the farmers

Climate-smart agriculture practice	Frequency	Percentage
1. Adjusting production systems		
High yielding crop varieties like cassava	171	69.2
Improved livestock breeds and species	43	17.4
Adjusting planting dates	39	15.8
Crop rotation	149	60.3
Mixed cropping	193	78.1
Strip cropping	49	19.8
Shifting cultivation	115	46.5
Fallowing	102	41.3
Cover cropping	107	43.3
Application of manure	137	55.4
Mulching	161	65.2
Reduced or zero tillage	141	57.1
Agroforestry	168	68.0
Irrigation	55	22.3
Water harvesting	19	7.7
Terraces	68	27.5
Mounds	29	11.7
Diversion of ditches and drainages	21	8.5
Contour bunds	27	10.9
2. Mobility and social networks		
Membership of development associations	133	53.8
Membership of cooperative societies	121	48.9
Migration	72	29.1
3. Farm financial management		
Reduce investment in the farm by reducing area cultivated	131	53.0
Insurance	36	14.6
4. Diversification on and off the farm		
Mixed farming	173	70.0
Shifting from crop to livestock production	99	40.0
Diversifying from farm to non-farm activities	123	49.8
5. Knowledge management and regulations		
Forest protection measures	65	26.3
Regulations on flood catchment	19	7.7
Use of local pesticides	46	18.6

Source: Field survey, 2020

Table 3 Binary logit estimates of the determinants of adoption of climate-smart agriculture by farmers in Northcentral Nigeria

Variable	Improved agricultural systems	Mobility and social networks	Farm financial management	Diversification on and beyond the farm	Knowledge management and regulations
Education	0.004 (1.69)*	0.006 (2.89)**	0.014 (3.01)**	0.012 (2.44)**	0.007 (3.02)***
Income	0.005 (3.73)***	0.003 (2.46)**	0.0038 (2.77)**	0.009 (2.01)*	0.006 (3.44)***
Credit	0.005 (2.39)**	0.007 (2.09)**	0.0038 (2.99)***	0.0031 (3.42)***	0.0017 (2.33)**
Contact with VADI officers	0.005 (2.44)**	0.007 (3.28)***	0.0014 (3.67)***	0.0017 (3.61)***	0.006 (2.62)***
Household size	0.048 (2.04)*	0.022 (1.54)*	0.0667 (2.33)**	0.069 (2.22)**	−0.031 (−1.34)
Farming experience	0.004 (1.88)*	0.020 (3.68)***	0.021 (3.16)***	0.019 (3.92)***	0.009 (2.66)**
Farm size	0.176 (2.22)**	2.439e−06 (0.41)	8.94e−05 (0.77)	7.01e−04 (0.69)	1.33e−08 (1.29)
Distance to market	−0.031 (−4.46)***	−0.016 (−3.66)**	−0.007 (−1.62*	0.006 (1.38)	−0.004 (−2.31)**
Livestock ownership	0.005 (2.46)**	0.004 (1.99)	0.005 (1.63)*	0.003 (2.64)**	−0.004 (−1.52)
Gender	−0.099 (−1.72)*	−0.127 (−1.26)	−0.088 (−0.69)	−0.159 (−1.54)	−0.130 (−1.22)
Likelihood Chi square	89.30***	62.33***	69.66***	79.44***	59.56***
Number of observations	247				

Source: Field Survey, 2022