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Climate Change Adaptation Strategies and Technical Efficiency of Cassava Producers in Ikom Agricultural Zone of Cross River State- Nigeria.

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ABSTRACT

This study analyzed Technical efficiency as well as Climate Change Adaptation Strategies of Cassava Producers in Ikom Agricultural Zone of Cross River State, Nigeria. The Multi-stage sampling technique was employed in the selection of 120 respondents which constituted the sample size for the study. The result of the Maximum Likelihood Estimates (MLEs) of the Cobb-Douglas stochastic frontier production function showed that the coefficient of farm size (X_1), labor (X_3), contact with extension agents (X_4), cassava cuttings (X_5) and fertilizer use ((X_6) were positive and significant at 1 and 5% levels. This implied that an increase in any of these inputs will result in a further increase in output of cassava producers. The coefficient of farming experience (Z_1), educational level (Z_3), household size (Z_5), and association membership (Z_6) were positive and significant at 1 and 5% levels. The results of the Principal Component Analysis revealed that the first component of PCA (Fac_1) was strongly related with nine original variables that are mutually exclusive with planting different crops (-0.743) being the most prevalent adaptation strategy. In the second component (Fac_2), three (3) mutually exclusive and major strategies were identified, they were; insurance (-0.755) which was the most prevalent followed by collaboration with extension agents (-0.644) and lastly appropriate application of fertilizer (0.669). The study recommends that the negative effect of age on technical efficiency levels of cassava producers in the area can be addressed by the formulation and implementation of policies that would encourage the younger ones to be interested and continue in cassava production. In addition, labor reducing technologies should be introduced to the farmers to reduce the drudgery associated with farming.

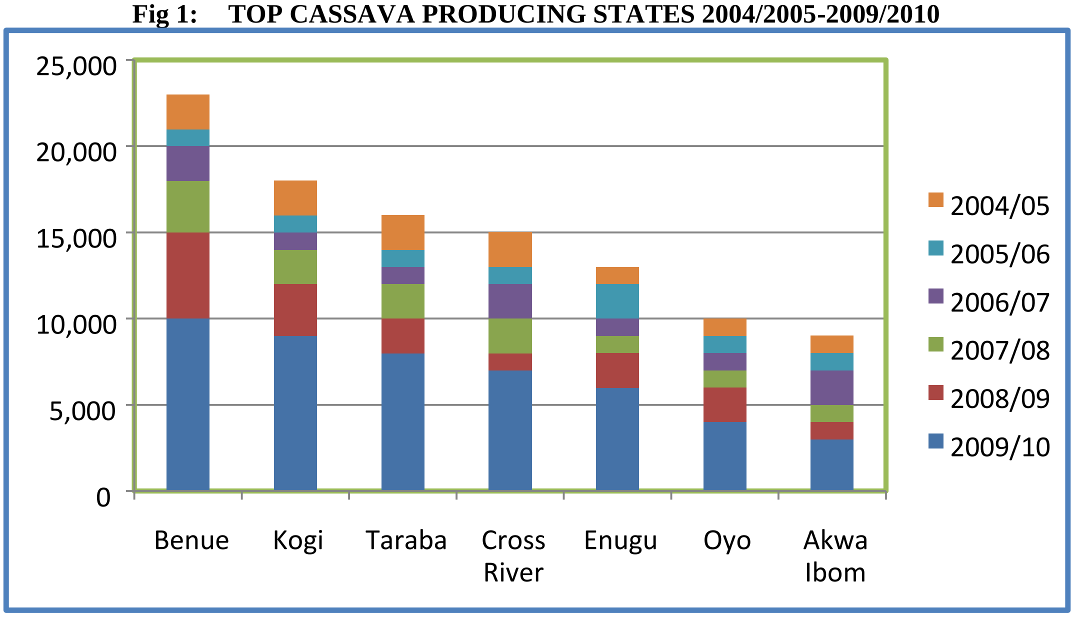
Keywords: Technical efficiency, Climate change, Cassava producers, Maximum likelihood estimates, Principal Component Analysis.

INTRODUCTION

Cassava (Manihot esculenta) has become ever increasingly relevant in Africa because of its diverse uses, tolerance to environmental stress such as drought, low soil fertility and its relatively high productivity where many other crops fail. Recognized as the third-most significant source of calories in

Africa's tropical and subtropical regions after rice and maize, the region currently produces half of the cassava consumed worldwide and assumes the status of the world's largest cassava growing region, producing about 193.62 million metric tones (Food Agricultural Organization, 2020; FAO, 2022). Nigeria remains the highest producer of cassava in the world followed by South-East Asia, Brazil, Indonesia, Thailand, and Vietnam having her current production at about 60 million metric tonnes. Cassava is rated among the top five agricultural products in Nigeria and considered the most important because of the dominant role it plays in the rural economy in the southern agro ecological zones as well as other parts of the country justifiable by the routine consumption of the crop by over 90% of households. (Oluwafemi, Omonona & Adepoju, 2019; FAO, 2021; FAO, 2022; Osuji, Igberi and Ehirim, 2023). this success story is more often than not, linked to the country's warm and humid climate with temperature and rainfall ranges between 28 to 33 and 1000 and 1400 mm respectively.

Fig 1: TOP CASSAVA PRODUCING STATES 2004/2005-2009/2010



Source: (National Bureau of Statistics (NBS) 2012.

Cross River State is the fourth highest cassava producing State in Nigeria, with an annual output of 15,000 tons. The following states record the highest figures in terms of per ha of land cultivated and tons produced: Benue (403,000ha), Kogi (395,000ha), Taraba (355,000ha) followed by Cross River State (345,000ha), Enugu (242,000ha) (NBS, 2012). Pelletized cassava for export is a good investment option in Cross River State especially with abundant raw materials and a seaport. Despite being widely recognized as a hardy crop with significant potential to adapt to climate change, soil infertility and drought stress, recent studies have shown that climate variables have varying impact on the yields and net revenue of cassava Agriculture and that negative seasonal variations and changes brought on by climate change poses threat to cassava output. In fact cassava has proven more sensitive to the infinitesimal change in climate with predicted climate scenarios showing that extreme climate condition is dangerous to cassava and reduces the net revenue generated from cassava production(Ajala and Ajetomobi,2023;FAO,2022; Kemi and Olusegun 2020).

The agricultural sector used to be the dominant contributor to the Nigeria's Gross Domestic Product (about 40%) in 2010, but this has been diluted as other sectors such as finance, construction, entertainment and other sectors have braced up their contribution to the economy (Arigor, Asuquo, and Ibeagwa, 2021), hence, a decline in the country's agricultural gross domestic product. The recent decline in Nigeria's cassava yield below global average yield for producing nations is sadly, not completely attributable to changes in extreme weather events but the result of emphasis on expansion of land for production with little or no recourse to increase in yield per hectare attainable by sufficient and efficient use of agricultural inputs, including seedlings, fertilizers, and pesticides (Anarah, Ezeano, and Osuafor., 2019; Fugile & Rada, 2013; Price Water Coopers, 2016; Akinwumiju, Adelodun, & Orimoogunje, 2020; Kemi and Olusegun 2020). The presidential initiative on cassava is set to mobilize Nigerians to fully and profitably tap into the potentials of cassava, which had hitherto remained unharnessed. This makes it imperative to determine the factors that influence farmers in the area.

output of cassava. the technical efficiency of cassava producers as well as the prevalent climate change adaptation strategies in the area to ensure sufficient food availability, employment, and growth. The study set out to: assess the factors that determine output of cassava producers determine the technical efficiencies of cassava producers; assess the determinants of technical efficiencies of cassava producers in the study area. And identify the prevailing climate change adaptation strategies of cassava

METHODOLOGY : STUDY AREA: This study was carried out in some selected communities of Ikom Agricultural Zone of Cross River State. Found in the tropical rainforest zone of the country, this agricultural zone shares an international boundary with the republic of Cameroon to the East, Obanliku and Obudu LGAs to the North, Ebonyi State to the west, and Biase and Akamkpa LGAs to the south and covers an approximate land mass of 16,280.02km^2. It lies between latitude $5^0$32N and $4^0$27N and longitude 7^0 50^0E and $9^0$$28^0$E with annual temperature range of 27^0C to 33^0C, while rainfall varies between 1500mm-2000mm per annum (Cross River State Geological Survey Agency, 2010). For this study, five (5) communities from each of the four (4) LGAs randomly selected were used.

POPULATION OF STUDY : The population of study comprises all the cassava producers in the study area.

SAMPLE SIZE AND SAMPLING TECHNIQUE : The sample for the study was drawn from the study population using multi-stage random sampling procedure as follows;

Stage I - Random selection of four (4) Local Government Areas.

Stage II - Random selection of five (5) communities from each of the LGAs resulting in a total of twenty (20) communities.

Stage III - Random selection of cassava producers from each community sampled. Using proportionate sampling, 40% of the total number of registered cassava producers from each of the 20 communities was used for the study. This gave a total of 120 respondents. Proportionate sampling was employed to ensure homogeneity, unbiased and representativeness of the sample and also to ensure more accurate result for the study.

SOURCES OF DATA COLLECTION: The study utilized primary data obtained from a cross section of cassava producers through the use of validated structured questionnaires.

DATA ANALYSIS: Data were analyzed using the Stochastic frontier production function and the Principal Component Analysis (PCA).

The stochastic frontier production function which accommodates two error terms that account for random effects and exogenous shocks as well as technical inefficiency was adopted to estimate the variables of the production function. This is specified in line with Coelli,1994; Meeusen and Van. 1977; as;

$$Y = f(X_i ; \alpha) + \varepsilon_i \quad (1)$$

Where,

Y = Output of Cassava X_i = Actual input vectors α = Vector of unknown parameters to be estimated

ε_i= Composite error term defined as V-U (2)

Where,

V = Random error term that accounts for factors beyond the farmers control. It is independently and identically distributed $(N(O\delta^2_v)$

U = Non-negative one-sided error term that accounts for technical inefficiency and assumed to be independently distributed as truncated of the normal or half normal distribution, i.e.

δ^2_u (|N (U_i δ^2_u)|)^2 and $U_i = A_i \delta$ (3)

Where,

A_i is a 1 × e vector of farmers/farm characteristic that will influence inefficiency while, δ is vector of parameters to be estimated with the variance parameters expressed as:

$\delta^2 = \delta^2_v = \delta^2_u$ (4) γ = $\underline{\delta^2_v}$

δ2u

To fulfill the objectives of the study, the stochastic frontier model for cassava production was specified as a Cobb-Douglas function as follows;

$Ln\ Q = Ln\alpha_0 + \alpha_1 LnX_1 + \alpha_2 LnX_2 + \alpha_3 LnX_3 + \alpha_4 LnX_4 + \alpha_5 LnX_5 + \alpha_6 LnX_6 + \varepsilon_i$ (5)

Where,

Q = Output of cassava produced (kg)

X_1= Farm size (ha)

X_2 = Access to credit (Dummy) 0 = No Access, 1= Access

X_3 = Labor (Man-days)

X_4= Contact with extension agent (number of times)

X_5 = Cassava Cuttings (Bundles)

X_6 = Fertilizer use (kg) Ln = Natural logarithm

α_0 = Intercept

α_1-α_6= Coefficients to be estimated

ε_i =Composite error term as earlier defined in equation (1)

The stochastic frontier model for cassava producers characteristics was incorporated into the model with belief that they have direct influence on efficiency (Battese and Coelli, 1995). The specification is shown below:

Y = α0 + α1Z1 + α2Z2 + α3Z3 + α4Z4 + α5Z5 + α6Z6 + εi (6)

Where,

Y = Technical efficiency of the cassava producers

Z_1 = Farming experience (Years)

Z_2 = Age of farmer (Years)

Z_3 = Educational level (Years)

Z_4 = Gender (Dummy) 0 = Male, 1 = Female

Z_5 = Size of household (Number)

Z_6 = Membership of Organization (Dummy)0 = Member, 1= Non-member

α_0 = Intercept

α_1 –α_6 = Coefficient to be estimated

Principal Component Analysis was used to identify the prevailing climate change adaptation strategies in the area. Principal Component Analysis is a technique of removing relevant variables from a wide set of variables present in a data set. The principal components may now be utilized as criterion variables in further analyses. A principal component is a translational mix of peak weighted identified variables. The general form of the principal component analysis is as contained in this equation;

$C1= b_{11} (x_1) + b_{12} (X_2) + b_{1n} (Xp)$ ---------- (7)

$C2= b_{21} (X_1) + b_{22} (X_2) + b_{2n} (Xp)$ ---------- (8)

$C3= b_{31} (Z_1) + b_{32} (X_2) + b_{3n} (Xp)$ ----------- (9)

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$C_1= b_{n1} (X_1) + b_{n2} (X_2) +$ ---------- $+ b_{nn} (X_p)$ ----------- (10)

Where,

C_1= Subject's score on principal component (the first component extracted)

b_{1p}= Regression coefficient for seen variable "p"

X_p= Subject's score on observed variable "p"

Its interpretation relies on finding which variables are most strongly related with each component. It needs to be determined at what extent the relationship is of significance. For the purpose of this study, a correlation of 0.5 is deemed important. The PCA result is then interpreted with respect to the value that is considered important or significant.

RESULTS AND DISCUSSION:**Factors that influence output of cassava producers in the area:** The maximum likelihood estimates (MLEs) of the Cobb-Douglas stochastic production frontier function of cassava producers in selected communities in Ikom zone of CRS are presented in Table 4.1. The result showed that the coefficient of farm size (X_1), was positive (as expected) and significant at five percent level. This implies that an increase in farm size will result in a further increase in output of cassava producers in the area. Hectarage change from small farm sizes to larger sizes could create economies of size which would benefit producers. This is in line with the study conducted by Krishna, Mishra, Mohanty,(2016) and Gbigbi (2020).

Access to credit (X_2) had no significant coefficient although it carried a positive sign on a priori basis. The coefficient of labor (X_3) also had a positive sign and was significant at 5 percent implying that increasing labor will cause increases in output. It should be noted that cassava production is labor intensive and the producers resort to the use of family labor in order to cut cost of hiring labor. However, increase use of family labor can result in labor saturation and lower returns on labor use and inefficiency. Also, the coefficients of contact with extension agent (X_4), cassava cuttings (X_5) and fertilizer use ((X_6) were positive and significant at one and five percent levels respectively. Hence, an increase in the use of fertilizer will result in an increase in the output of cassava especially where producers are constrained by land availability to allow for fallow or rotation. Also, increase in extension contact for technology transfer and extension education will increase output of cassava producers. Similarly, increasing the quantity of cassava cuttings used per hectare and number of nodes in cassava cuttings will also determine the quality and quantity cassava output. This conforms with the findings of Ezeibe, Edafiogho, Okonkwo, and Okide,(2015).

Table 4.1 Maximum likelihood estimate of the stochastic production frontier function for cassava producers in Ikom Agricultural zone ofCross River State.

Variables	Coefficients	Standard Errors	t-ratios
Intercept	3.125	0.5093	6.12***

Farm size (X_1)	0.245	0.0936	2.704**
Access to credit (X_2)	0.083	0.0776	1.06
Labor (X_3)	0.835	0.2886	2.88***
Contact with extension agent (X_4)	0.125	0.0422	2.98***
Cassava cuttings (X_5)	0.235	0.2472	2.66**
Fertilizer use ((X_6)	0.188	0.0763	2.46**
Returns to Scale (RTS)	1.711		
Gamma (γ)	0.898	0.256	3.51***
Sigma square (δ^2)	0.731	0.212	3.46***
Log Likelihood function (LLF)	98.54		
Log Likelihood Ratio (LLR)	33.32		

Note: * Significant at 1%, ** Significant at 5%, * Significant at 10%**
Source: Computed from field survey data, 2014 using frontier 4.1 by Coelli (1994).

The elasticity of production with respect to farm size, access to credit, labor, contact with extension agent, cassava cuttings and manure use indicated that a one percent increase or decrease in these variables will lead to 0.245, 0.083, 0.835, 0.125, 0.235 and 0.188 percent increase or decrease in output of cassava respectively. Returns to scale measures the sum of all the elasticities of production with respect to all the inputs or the proportionate change in output if all the inputs are change simultaneously by one percent (Yakasai, 2000). The various forms of returns to scale are: increasing (Ep>1), constant (Ep = 1) and decreasing returns to scales (Ep<1). The sum of elasticities of production with respect to explanatory variables in the study area was 1.711 indicating that cassava farmers are operating in increasing return to scale in the region (Ep>1). That is, they are operating in the irrational stage of production. This is an indication that producers are producing in stage 1 of the production function and suggestive of the fact that cassava producers in the study area are inefficient in the use of resources. (Abang, Agom, Enyeniyi, and Ele,2008; Adeleke, Fabiyi, Ajiboye, and Matanmi, 2008).

The sigma square (0.731) is statistically significant and different from zero at 0.01. This gives an indication of the goodness of fit and the correctness of the specified distribution assumption of the composite error term. The gamma (γ) estimated to be 89 percent suggests systematic influences that are unexplained by the production function as the dominant sources of random errors. Putting it differently, the presence of technical inefficiency among cassava producers explains 89 percent variation in the output level of the cassava cultivated. The presence of one-sided error component in the specified model is thus confirmed implying that the ordinary least square estimation would be inadequate representation of the data. The generalized likelihood ratio (98.54) was highly significant which implies the presence of one-sided error component. The results of the diagnostic analysis therefore confirm the relevance of stochastic parametric production function and maximum likelihood estimation. This findings conforms with studies carried out by Adeleke *et al*,(2008) and Yao and Liu, (1998).

Estimates of Technical Efficiency: The distribution of efficiencies of cassava producers in the study area are presented in table 4.2. The distribution shows that majority (36.7%) of the producers were within the 81 to 90 percent efficiency class and only about 14.7% had efficiency scores above 90 percent. The mean efficiency of the cassava producers was 70 percent implying that production can still be increased by 30 percent using available technology. Findings emphasize the need for appropriate policy intervention that will curb farmers' technical inefficiency in production among cassava producers.

Table 4.2 Technical Efficiency Distribution of cassava producers in Ikom Agricultural zone of Cross River State.

Efficiency class	Frequency	Percentage
less than 51	10	12.0
51 – 60	8	6.67
61 – 70	19	15.83
71 – 80	32	26.67
81 – 90	44	36.67
91-100	17	14.7
Total	120	100
Mean	0.70	
Standard deviation	31.43	
Minimum	0.48	
Maximum	0.99	

Source: Field survey data, 2014.

The relative high levels of technical efficiency of cassava producers is a suggestion that only a small fraction of the losses in output of the producers can actually be attributed to resource wastage. The result further showed that, for the average cassava producer to achieve the level of the most technically efficient producer, he/she would realize about 29.29 (1 – 70/99) percent cost savings. Similarly, the least technical efficient cassava producer would realize a cost saving of about 51.52 (1 – 48/99) percent, to achieve the level of the most technically efficient producer in the sample. These estimates are similar to findings by Iheke, (2008) in his study on the technical efficiency of cassava farmers in south eastern Nigeria.

Determinants of Technical Efficiency:The result in table 4.3 shows the maximum likelihood estimates of the determinant of technical efficiency of cassava producers in Ikom Agricultural zone of Cross River State. The result indicates that the coefficient of farming experience (Z_1) was positive and significant at the one percent level. It indicates that cassava producers with many years of production had higher levels of technical efficiency than those with fewer years of experience. Similar findings were reported by Abdu-Raheem, Oluwatosin, and Ayotunde, (2023) and Eze, Amanze, and Nwankwo,(2012).

Table 4.3 Determinants of technical efficiency of cassava producers in Ikom Agricultural Zone- CRS.

Variables	Coefficients	Standard errors	t-ratios
Constant	-0.5323	0.5331	-0.997
Farming experience (Z_1)	0.9866	0.1646	2.51**
Age (Z_2)	-0.4130	0.3322	2.98***
Educational level (Z_3)	0.2544	0.0622	4.07***
Gender (Z_4)	0.2114	0.1058	1.98
Household size (Z_5)	0.5672	0.1898	2.96***
Membership of organization (Z_6)	0.3545	0.1446	2.48**

Note: ****Significant at 1% level, **Significant at 5% level*. Source: Computed from the Field Survey Data, 2014.

The coefficient of age (Z_2), has negative sign and is significant at five percent level. This implies that the age of the cassava producers inversely influences his/her technical efficiency. That is, the older the cassava producer, the less technically efficient he/she would be. In other words, older cassava producers are less efficient than the younger ones. The implication is that these younger farmers are innovative in ways that guarantee increased efficiency levels than the older ones in production (Onubuogu., Esiobu, Nwosu, & Okereke, 2014; Girei, Dire, Yuguda, & Salihu, 2014; Mabe, Donkoh, & Al-hassan, 2018).They are risk takers and physically strong to do the manual farm work typical of subsistence agriculture unlike the older farmers.

The coefficient of educational level (Z_3) was positive and significant at the one percent level, showing that the level of technical efficiency of cassava producers will increase with his or her level of education. Thus, the farmer's level of education determines his managerial competence. A farmer who has a higher level of education has the capacity to understand and adopt improved technology resulting in shifting upwards of his production frontier. Education affects efficiency via improved quality of labor and improved ability to process information, select inputs and allocate them across competing uses. This result agrees with that reported byAkerele, Onasanya, Dada, Odio, (2018); Abdu-Raheem *et al.*, (2023) and Esiobu, Nwosu, & Onubuogu, (2014)

The coefficient of gender (Z_4) was positive but not significant at 5 percent level. This conforms with studies carried out by Udoh, (2005) and NBS, (2012) . The significance of the coefficients of household size (Z_5) was positive and significant at one percent. This implies that, farmers with larger sizes have higher levels of technical efficiency, due to the fact that increasing household size results in family labor availability. Cassava production and sales often requires a lot of hands and therefore, increases in household size makes labor readily available given the high cost of hired labor in the study area. This result corroborates with studies carried out by. Esiobu, Nwosu, and Onubuogu (2014) in which it was found that large household size complement labour to enhance production and reduce the cost of hired labour(Nwaiwu, Odii, Ohajianya, Eze, Oguoma, Ibekwe, Henri-Ukoha, Kadiri, Amaechi and Oguh,2010).

Finally, the coefficient of association membership (Z_6) was positive and significant as expected at 5 percent. Association membership affords the cassava producers the opportunity to exchange information on improved technology as a result of interaction with other producers. Credit facilities are also passed to members by government to expand and improve their farms. This also corroborates with similar findings by Konja, Mabe & Alhassan,(2019) that a well-functioning agricultural extension system is pivotal to increasing the productivity of staple food crops and thus presents a credible avenue for moving millions of people out of poverty. Eze *et al.*, (2012) affirms that an increase in cassava producers membership in cooperatives or farmers organization will lead to an increase in technical efficiency.

Climate change adaptation strategies : The results presented below indicates the prevailing climate change adaptation strategies in the area using principal component analysis (PCA).

Table 4.4 PREVAILING CLIMATE CHANGE ADAPTATION STRATEGIES

Adaptation strategies	Fac_1	Fac_2	Fac_3	Fac_4
Planting improved cassava varieties	-0.315	0.085	0.179	**0.656**
Erosion control measures	-0.274	-0.172	0.062	**0.528**
Planting different crops	**-0.743**	0.227	0.189	0.132
Livelihood diversification	**0.584**	-0.316	0.414	-0.048
Efficient and effective use of pesticides	**0.532**	-0.073	**-0.652**	0.095
Use of mulch materials to reduce heat	**0.614**	0.297	-0.200	0.106
Appropriate application of fertilizer	0.170	**0.669**	0.153	0.315
Increased land access	-0.033	-0.275	0.216	**0.678**
Change in planting periods	0.229	-0.211	**0.627**	-0.411
Soil and water conservation techniques	**0.511**	-0.043	-0.174	**0.527**
Changes in harvesting date	0.453	0.332	**0.699**	-0.094
Erosion control measures	0.444	0.079	**0.622**	0.204
Collaboration with extension workers/agents	0.472	**-0.644**	0.222	0.099
Minimum tillage operation	**0.675**	0.290	-0.307	-0.144
Insurance	0.400	**-0.755**	-0.029	-0.027
Increasing the size of ridges/heaps	**0.736**	-0.148	-0.286	0.200

Late planting of cassava stems	**0.502**	0.486	0.054	0.077

Source: Field survey, 2024.

Note: Bold values are significant prevalent strategies

The estimate of the Principal Component Analysis in the table above shows that only four mutually exclusive and major strategies were identified by the factor analytic procedure. The Kaiser criterion (1960) was adopted for choosing underlying factors. Only variables with factor loadings of 0.500 and above were considered to be significant and prevalent. The first component of PCA (Fac_1) strongly related with nine original variables that are mutually exclusive with planting different crops (-0.743) being the most prevalent adaptation strategy followed by increasing the size of ridges/heaps (0.736), Use of mulch materials to reduce heat (0.614), Late planting of cassava stems (0.502), minimum tillage operation (0.675), livelihood diversification (0.584), Soil and water conservation (0.511), efficient and effective use of pesticides (0.532) and late planting of cassava stem (0.502). In the second component (Fac_2), three (3) mutually exclusive and major strategies were identified, they are; insurance (-0.755) which was the most prevalent followed by collaboration with extension agents (-0.644) and lastly by Appropriate application of fertilizer (0.669).

For the third component (Fac_3), four (4) mutually exclusive and major strategies were identified, they are; Changes in harvesting date (0.699), erosion control measures (0.622), efficient and effective use of fertilizers (0.652) and Changes in planting periods (0.627). Lastly, for the fourth component (Fac_4), four (4) mutually exclusive and major strategies were identified; Increased land access (0.678) was prevalent followed by planting of improved cassava varieties (0.656), then by erosion control measures (0.528) and lastly by soil and water conservation techniques (0.527).

Resistant varieties, crop rotation, changes in the planting date, mulching/cover cropping, mixed cropping, tree planting, cultivation of early maturing crops, use of weather forecasts, zero tillage, minimum tillage, application of farmyard manure, diversifying from farm to non-farm activities, use of heavy moulds and movement to a different site are all the occasionally and regularly used (prevalent) climate change adaptation strategies

CONCLUSION : Policies that would encourage cassava producers to acquire some form of formal and informal education should be formulated and implemented. This can be done by strengthening the capacity of adult and continuing education centres available in the area, since their educational levels and contact with extension positively and significantly influence their technical efficiency; Labor reducing technologies should be introduced to the farmers. This will reduce the drudgery associated with farming; The negative effect of age on technical efficiency levels of cassava producers in the area can be addressed by the formulation and implementation of policies that would encourage the younger persons to go into cassava production. School to farm programmes should be resuscitated; More farmers should be encouraged to become members of cooperatives ; andThere is need for farmers to adopt good climate change adaptation strategies to improve cassava production in the area.

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