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Influence of Contracted Extension Service Delivery Model on Uptake and Use of Cassava Technologies, Innovations and Management Practices in Nakuru and Busia Counties, Kenya

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ABSTRACT

Adoption of Technologies Innovations and Management Practices (TIMPs) by farmers is critical in improving farmers' livelihoods. The Kenyan Government, through Kenya Agricultural Productivity and Agribusiness Project (KAPAP), implemented the Contracted Extension Service Delivery Model (CESDM) across various agricultural value chains. In the cassava value chain, nine TIMPS were promoted which included the use of improved cassava planting materials, organic manure/ inorganic fertilizers, rotational crops, intercrops, pest and disease management, drying, milling, blending and collective marketing. Using a cross-sectional approach and a sample of 816 respondents, this study employed a multivariate and an ordered probit to determine the effects of CESDM on adoption of cassava TIMPS in Busia and Nakuru counties of Kenya. The results showed that the CESDM influenced certain practices positively. These included use of improved cassava varieties, crop rotation, fermentation and milling. The CESDM was negatively associated with fertilizer use, intercropping and disease control. Generally, factors that influenced adoption of cassava TIMPS included household size, land tenure, cassava yield, credit use, off-farm employment, ownership of cassava machineries, gender of household head, access to cassava information, higher cassava acreages, cassava experience and agricultural group membership. Factors that explained the extent of use of cassava included household size, gender of household head, land ownership, and age of household head. The study concluded that indeed government support and interventions are key in enhancing adoption of selected cassava TIMPs, and such initiatives are necessary in building a critical mass of trained farmers for increased welfare gains.

Keywords: Technology, Innovations, Management Practices, Contracted Extension, Cassava, Multivariate Probit, Ordered Logit

INTRODUCTION

Cassava as a staple crop contributes significantly to food security and plays a key role in cushioning rural populations against sharp rise in food costs that often affect other marketed staples crops like maize, rice, and wheat ([21]; [49]; [17]. Additionally, cassava is more climate resilient and does well in drier lands as compared to maize and other common staples [38]. Improving agricultural productivity through adoption of technologies, innovations and management practices (TIMPs) is crucial for economic prosperity of Sub-Saharan Africa [27]; [66], [62]. Increased productivity has the potential to increase earnings, enhance food security, and lead to overall improvements in community welfare, particularly for people residing in rural regions [64]; [59]; [21]. However, the adoption rate of TIMPs in the cassava value chain is low [22]; [51]. Research has shown that adoption of improved technologies is a precursor to commercialisation [5]; [44]. Hence through commercialization, cassava could stimulate economic growth of rural economies through value-addition, industrial processing thus key to improved rural livelihoods [2]. These reasons justify the need for continued interest by governments and development partners in the crop.

Despite the potential for cassava, [17] showed that Africa has 173% lower productivity compared to Asia, which has the highest cassava productivity in the world. Further to this, the study attributed the yield gap to low adoption of TIMPs in Africa, low research and development support to cassava as compared to staples like rice and maize, to the point where the crop has been considered "orphaned" [14], [28]; [41]. Additionally, other studies have found that biotic and abiotic constraints such as diseases and poor environmental conditions have significantly contributed to reduced cassava output and consequently deter adoption [9]; [31]; [34]; [52]. Also, adoption of cassava by farmers depends on access to appropriate cassava planting materials [60]; et al. [62] which are often bulky and may require additional handling costs as compared to other staples [29]. Furthermore, hindrances to adoption could also result from socio-economic characteristics of farmers such as perceptions about the cassava crop [60], education level, age and gender of household head [43]: [29]. Support by institutions is also critical in promoting the adoption of TIMPs. However, for majority of African countries, farmers continue to face limitations in their access due to inherent inadequacies of these institutions [10]; [42]; [61]; [18]. Through effective extension, information channels and messaging have the potential to boost TIMPs adoption by raising farmer awareness and enhancing perceptions about cassava TIMPs [35]; [19]; [26].

To improve agricultural productivity of farmers, information access and availability on improved TIMPs is necessary. The Government of Kenya, with other development partners have over the years supported farmers to access information through a public extension system. Different extension approaches have evolved over the years, all seeking to influence farmer's behaviour and perceptions for increased adoption of TIMPs and ultimately improving the welfare of the farmers. KAPP 1, a Government of Kenya and World-bank project was implemented within 2005-2009. Two of its four components focused on i) facilitating policy and institutional reforms and ii) support to extension reform [64]. Through these efforts, in the year 2012, the National Agricultural Sector Extension Policy (NASEP) on pluralistic extension was passed in Kenya allowing public and private extension players to offer extension services to the farmers [32].

It is within the framework of NASEP that CESDM was implemented by KAPAP, the second phase of KAPP, within 2010-2016. The project sought to increase productivity and incomes of farmers through a Contracted Extension Service Delivery Model (CESDM). The project aimed at empowering farmers to increase agricultural productivity through several activities that included training on GAPs, value-addition, agribusiness and markets, gender mainstreaming, strengthening of farmer institutions that included farmer groups, CIGs, farmer cooperatives and farmer fora activities. Trainings on GAPs was done on the premise that knowledge and information are key in transforming behaviour. The project aimed to empower farmers by providing support to farmer institutions and other grassroots organizations that play a crucial role in accelerating change processes. Extension agents may interact with more farmers through these organizations, and through group dynamics, farmers within the groups could be encouraged to adopt specific techniques that increase production. It was anticipated that these efforts could culminate to tangible shifts in adoption of improved practices, raising the participating farmers' earnings and productivity. It is however not known to what extent the CESDM did influence adoption of cassava TIMPs in Kenya. This study therefore aimed to fill this information gap by investigating the influence of CESDM on adoption rates and extent of use of cassava TIMPs among farmers in Busia and Nakuru Counties of Kenya.

The Study Area

The study was undertaken in Nakuru and Busia Counties of Kenya as shown in Figure 1 below. These counties were among 20 selected project areas receiving project’s interventions on different value-chains. However, it’s only Nakuru and Busia counties that had chosen cassava as a priority value chain for support. Nakuru represents a non-traditional cassava growing area, where farmers have been growing other crops, and especially maize as the most important energy source. The area has seen efforts by the government of Kenya and other development partners push for increased adoption of the cassava crop for food security reasons, as well as climate change interventions. Efforts to promote the crop in earnest by the government of Kenya started during the first phase of KAPP-I project. In Nakuru, two sub-counties were selected; Subukia and Rongai. Subukia represented the treatment ward, while Rongai acted as the counterfactual. On the other hand, Busia, situated in the western part of Kenya, represents one of the traditional cassava growing areas in the country, where cassava is an established staple and constitutes daily diets of the people. From this County, Funyula Sub-county was selected as treatment area, and two wards (Nangina and Nambogoto) selected as treatment wards. Further to this, Teso Sub-county was selected as the control area with Teso North and Teso South Wards being the control wards.

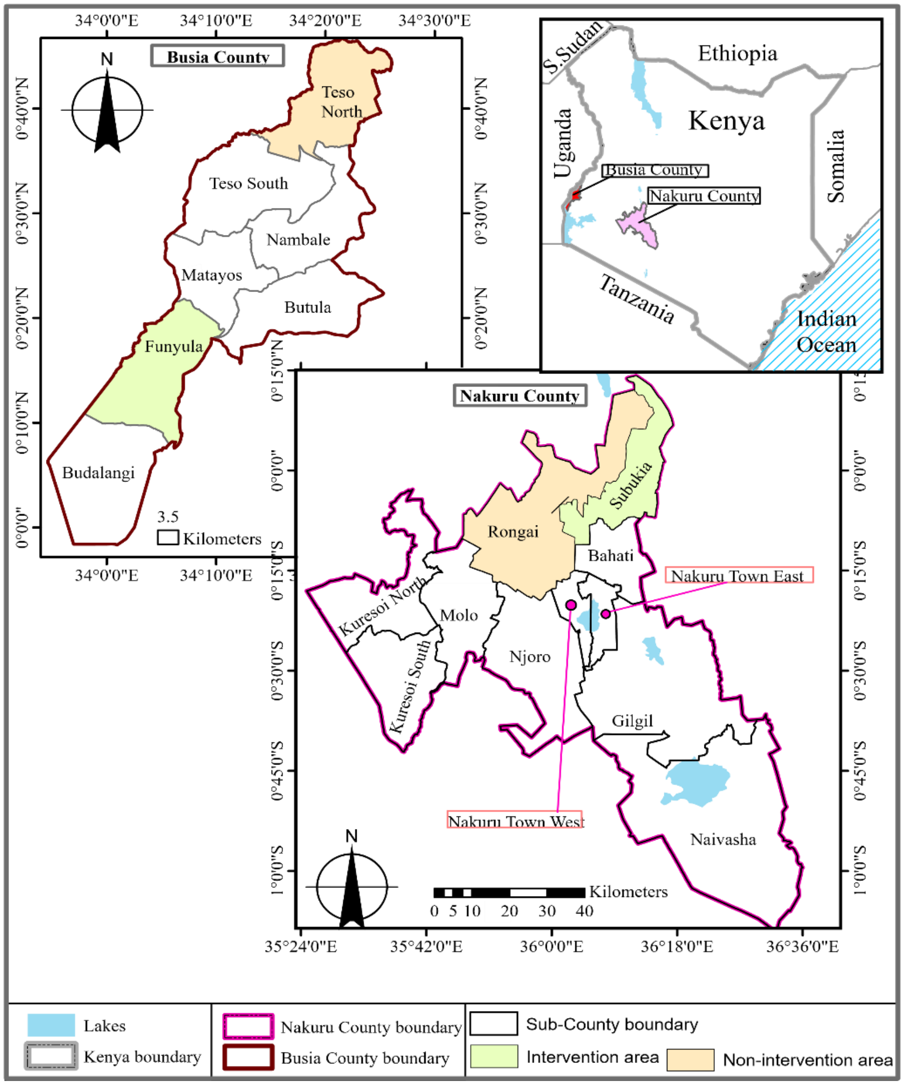

Figure 1: Map of Nakuru and Busia Counties.

Research Design

A survey was undertaken using qualitative and quantitative approaches of data collection. This was important in order to capture mixed data emanating from socio-economic variables and cassava practices by farmers. The study also constructed a counterfactual to understand differences in practices adopted by farmers in interventions areas and those that did not receive interventions.

Target Population

The study targeted farmers who participated in KAPAP project activities in the intervention areas, and were engaged in the Common Interest Groups (CIGs) for Cassava. These farmers in the cassava CIGs had been trained on Good Agricultural Practices (GAPs) and better ways of cassava utilisation. A counterfactual was created from those areas that did not receive interventions and farmers have the same socioeconomic characteristics as those in the KAPAP intervention areas.

The Sampling Procedure

A multistage sampling procedure was used to select respondents. Firstly, two counties were purposively selected from 20 counties who had received interventions from the project. Nakuru and Busia counties were selected because they were the only ones who had cassava among their priority value chains during the project implementation. In the second stage, two sub-counties from each county were selected. One sub-county was an intervention area and the other as control. Two wards were selected from each sub-county and active cassava CIGs were selected and a random sample drawn from the farmers participating in those groups. To obtain a counterfactual, with the help of county administrators, farmers from those sub-counties that did not receive the project interventions were drawn randomly.

Sample Size

To obtain the sample size, [3] formula was employed;

$$n_0 = \frac{z^2\, pq}{e^2}$$

where, n_0 is the sample size, z is the selected critical value of desired confidence level, p is the estimated proportion of an attribute that is present in the population, $q=1-p$ and e is the desired level of precision. To calculate the sample size for the study, since the variability of the population is not known, maximum variability is assumed. Variability is assumed to be 50% (p=0.5) and 95% confidence level with ±5% precision, we arrive at the following;

p=0.5 and hence q=1-0.5=0.5; e=0.05; z=1.96

$$n_0 = \frac{(1.96^2)\,(0.5)(0.5)}{(0.05)^2} = 384$$

Since the study required a counterfactual, common approach of pairing of one to one was used, forming pairs of treated and untreated [4]. The sample was then doubled in order to obtain the required sample size. To allow for error and missing variables, extra respondents were interviewed to arrive at total sample of 816, half of whom were drawn from each county.

Data Collection

A household survey was conducted in the selected counties using a pre-designed questionnaire. Enumerators were trained to conduct the surveys within the selected areas. The survey instruments were pre-tested to validate the instruments before data collection.

ANALYTICAL FRAMEWORK

KAPAP promoted various practices for cassava farmers. These practices were categorised into three groups: i) Practices that enhance GAPs ii) Value-addition practices and iii) marketing practices. The first category includes use of improved cassava planting materials, soil management practices encompassing use of organic manure/ inorganic fertilizers, use of rotational crops and intercrops that help improve soil nutrient status, and pest and disease management practices. The second category on value addition practices included cassava d drying, milling and blending. The third category was collective marketing. These practices if adopted had the potential to spur productivity, improve incomes through commercialisation of surpluses and improve the general welfare of participating farmers in the project. The socioeconomic status of the farmers and the agro-ecological conditions prevailing in their area influenced adoption of the practices promoted by KAPAP. The multiple adoption decisions of the above practices could thus be modelled using a multivariate Probit [11];[12].

The utility derived from adopting the *jth* practice is denoted asU_j andU_0,if the farmer does not adopt the practice, while the difference between the two utilities as Y^*. This is based on rational choice of adopting the practice when they perceive that the gain from adoption is higher than not adopting. The decision to adopt is thus guided by the function below:

$$Y^* = U_j - U_0 > 0. \tag{1}$$

Since this is a multivariate probit function, we have a set of binary dependent variables Y_{ij} that equals 1 if a farmer adopts a practice, and zero otherwise as follows;

$$Y_{ij}^* = \beta\chi_{ij} + \mathcal{E}_{ij} \quad \text{with} \quad Y_{ij} = \begin{cases} 1 \; if Y_{ij}^* > 0 \\ 0 \;\; otherwise \end{cases} \tag{2}$$

where, $j = 1, \ldots \ldots m$ denotes the practices available, $Y_{ij}^*$is a latent variable for the *ith* farmer that captures unobserved preferences associated with *jth* choice of practices. This latent variable is assumed to be a function of observed characteristics (χ_{ij}) that influence the adoption of *jth* practices and unobserved characteristics ($\mathcal{E}_{ij}$)

In the Multivariate Probit Model, the error terms are assumed to jointly follow a multivariate normal distribution with zero conditional mean and variance normalized to unity, given as follows;

$$\Omega = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} & \cdots & \rho_{1j} \\ \rho_{21} & 1 & \rho_{23} & \cdots & \rho_{2j} \\ \rho_{31} & \rho_{32} & 1 & \cdots & \rho_{3j} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ \rho_{j1} & \rho_{j2} & \rho_{j3} & \ldots & 1 \end{bmatrix}$$

where ρ (rho) is the pairwise correlation coefficient between error terms of any adoption equation to be estimated in the model. It shows the nature of the relationship between the adoption equations, whether significant or not, and if in the positive or negative direction. When there is positive correlation, we deduce a complementarity between practices and when there is a negative correlation, we deduce a substitutability relationship.

As discussed above, the number of technologies/practices promoted by the project ranged from cassava management, value addition and marketing practices. Farmers adopt a mix of these technologies and practices depending on their socioeconomic situations. Adoption in this case can be modelled in terms of number of practices as a measure of extent of use. To model this, the ordered Probit is used. Since adoption of these practices doesn't follow a systematic pattern, we count the number of practices adopted by the farmers. Further to this, we construct 5 levels scale of adoption following [23]. In total we have 9 practices that were promoted by the KAPAP project for the cassava value chain. For each farmer, a count is taken to gauge the level of adoption the farmer falls in. The levels are as follows; level 1: 0% adoption; level 2: 1-25% adoption; level 3; 26-50% adoption; level 4: 51-75% adoption; and level 5: 76-100% adoption. The observed response can now be modelled through a latent variable y_i^* that is dependant linearly on explanatory variables X. The description of variables used in the model is shown in Table 1. The adoption model can be expressed as:

$$y_i^*=x_i\beta + e \tag{3}$$

where y_i^* the dependant variable taking on values 0,1,2,3,…j, β is the vector of coefficients and X_i is the vector of independent variables and observed and e is the error term

$$y_i = \begin{cases} 0 \; if \; y^* \leq 0 \\ 1 \; if \; 0 < y^* \leq \alpha_1 \\ 2 \; if \; \alpha_1 < y^* \leq \alpha_2 \\ \vdots \\ j \; if \; \alpha_{j-1} \leq y^* \end{cases} \tag{4}$$

where values of y are observed and α are unknown parameters to be estimated. e is assumed to have a normal distribution with zero mean and unit variance. The probabilities of each outcome can be stated as:

$\Pr(y = 0|x) = \Phi(-x'\beta)$
$\Pr(y = 1|x) = \Phi(\alpha_1 - x'\beta) - \Phi(-x'\beta)$
$\Pr(y = 2|x) = \Phi(\alpha_2 - x'\beta) - \Phi(\alpha_1 - x'\beta)$
$\vdots$
$\Pr(y = j|x) = 1 - \Phi(\alpha_{j-1} - x'\beta)$

We could have applied the Poisson regression model assuming that the number of cassava practices adopted as a count variable. However, Poisson regression assumes the equal probability of adoption of each alternative practice. We therefore cannot use the model because of the probability of adopting one practice and subsequent ones is different due to different stimuli in the farmer environments ([11].

Table 1: Description of variables used in the study

Variables	**Description**	**Expected sign**
Dependent		
Level of technology use	Number of technologies adopted by a household converted to percentage level. *(1 if Y <=25, 2 if Y >25 <=50, 3 if Y >50 <=75, 4 if Y >75)*	

Cassava TIMPs	Binary dependent variables (1=Use of technology, 0= did not use technology) Technologies (Drying, Milling, Fermentation, Soil improvement, Intercrop, Improved varieties, Rotation, Disease management, Group Marketing)	
Independent		
Intervention area	KAPAP intervention area (*Dummy, 1=Intervention area*)	+
Household size	Number of household members (*Continuous)*	+
Gender	Sex of the household head (*Dummy, 1= Male)*	+/-
Cassava information	Number of times the respondent sought for cassava information in a year (*continuous)*	+
Number of plots	Number of plots of land the respondent had (*continuous)*	+
Cassava acreage	Size of land under cassava in acres (*continuous)*	+/-
Yield	Cassava output per acre (*continuous)*	+/-
Education Level	Education level of the household head (*categorical, 0= None, 1=Adult education, 2= Primary Level, 3= Secondary level,4=college /certificate, 5= University)*	+/-
Land Ownership	Household had ownership of cassava land (*Dummy, 1= Yes)*	+
Total Acreage	Total land owned by the household *(Continuous)*	+
Off-farm Income	Household had other non-agricultural income (*Dummy, 1= Yes)*	+ /-
Electricity Access	Household is connected to electricity (*Dummy, 1= Yes)*	+/-
KAPAP CIG membership	Household member belonged to a KAPAP/CIG (*Dummy, 1= Yes)*	+
Piped water	Household is connected to electricity (*Dummy, 1= Yes)*	+
Credit use	Household borrowed credit for use in cassava (*Dummy, 1= Yes)*	+
Cassava Experience	Number of years as a cassava farmer *(Continuous)*	+
Group Membership	Household member belonged to a (*Dummy, 1= Yes)*	+

RESULTS AND DISCUSSIONS

Adoption of improved cassava technologies raises productivity of the crop, and subsequently enables commercialisation of surpluses of the staple. On average, farmers in Busia had bigger cassava plots than Nakuru. Even though total land ownership is not significantly different in the two counties, farmers in Busia allocated more than double of what farmers in Nakuru allocated to cassava. This shows the importance of cassava in Busia visa-vis Nakuru. Yields in Busia were also significantly different than that of Nakuru. Household sizes in Busia were also larger in Busia compared to Nakuru. Similarities in the two counties included percentage of gender of household head, showing that most of the households are male-headed depicting a patriarchal society. The majority of the farmers also grow cassava for subsistence which is similar in the two counties.

Table 2: Socio-economic and demographic characteristics of sampled farmers.

Variables n=816	***Busia n=407***	***Nakuru n=409***	***t***	***Pr = 0.0029***

Age	68.83	56.9	-1.46	
Household size	6.87	5.27	-7.13	.000***
Acreage under cassava	0.62	0.26	-3.09	.002**
Total Acreage	3.13	3.22	0.27	.7851
Quantity Harvested	2372.86	319.69	-10.52	.000***
Farming experience	30.1	27.86	-2.20	.02**
Cassava farming experience	25.64	10.63	-16.53	.000***
Cassava information	3.33	1.74	-6.29	.000***
Number of plots	1.50	1.33	-2.98	.002***
Yield	39.41	43.20	1.46	.14
Electricity Access	206	194		
			Percentage %	*Chi2 -P-Value*
Off- farm income *(1=Yes)*	31	48	9.68	.042**
Gender of household head *(1=male)*	209	300	74.63	.399
Access to piped water *(1=Yes)*	36	120	19.12	.000***
Ownership of land *(1=Yes)*	139	312	55.27	.000***
Group membership *(1=Yes)*	123	33	19.12	.000***
KAPAP CIG member *(1=Yes)*	195	81	33	.000***
Credit use	74	54	15.69	.05*
Electricity Access	206	194	49.02	.36
Education Level				
None=0	30	21	6.25	.25
Adult education=1	6	1	0.86	
Primary=2	177	188	44.73	
Secondary=3	138	150	35.29	
College/diploma=4	44	46	11.03	
University =5	6	9	1.84	

*Note: *** the difference in means is statistically significant at 1 %, ** significant at 5%, *significant at 10%.*

Other socio-economic variables that were significantly different between the two counties included engagement in off-farm incomes where Nakuru had more household heads engaged. Access to piped water was higher in Nakuru and more people in Nakuru owned land that they farmed on. More farmers in Nakuru had access to value-addition machinery compared to Busia. More farmers that had maintained KAPAP CIG groups were found in Busia.

Table 2 below shows the number of technologies adopted among the sampled respondents. Fermentation practice was significantly different in the two counties with almost 100% of farmers who were practicing coming from Busia. More farmers blended their cassava in Nakuru compared to Busia while more farmers chipped and dried their cassava in Busia.

The results show that while rotation and disease control were the most used practices among the farmers, majority did not adopt group marketing and fermentation practices.

Table 2: Frequency of Technologies, innovation and management practices adopted in cassava

Technology adoption	No	Yes
(n=816)		
Drying	56.25	43.75
Fermentation	81.00	19.00
Soil Improvement	69.24	30.76
Milling	67.28	32.72
Intercrop	71.45	28.55
Rotation	42.52	57.48
Group Marketing	98.53	1.47
Improved Varieties	56.86	43.14
Disease control	44.24	55.76

Econometric Analysis

Correlation Analysis:

Cassava farmers generally adopt various combinations of technologies and practices as shown in Table 3. These cassava TIMPs could complement each other or otherwise. For example, a farmer who adopts improved cassava varieties may get higher yields. A higher yield necessitates adoption of addition technologies and practices such as drying and milling to prolong cassava shelf-life due to high perishability of roots. An increased yield may mean that a farmer has surplus for marketing thus the need to sell individually or join a cassava marketing group. This complementarity of technologies and practices show that there's a likelihood of correlation between the TIMPs chosen by a farmer. To test whether there's a correlation between the TIMPs chosen by a farmer, pairwise correlation coefficient test was used. The pairwise correlation shows the relationship between the decision to adopt the cassava TIMPs after controlling for socio-economic and institutional variables in the equation. The likelihood test *chi2* (36) =100.861 *Prob.chi2*=0000 shows that there's no covariance of the error terms across the equations and that the multiple decisions to adopt the cassava TIMPs are correlated.

Table 3: Correlation of cassava TIMPs

	Drying	Fermentation	Soil Improvement	Milling	Intercrop	Rotation	Group Marketing	Improved Variety	Disease control
Drying	1								
Fermentation	-0.137	1							
	0.000[a]								
Soil Improvement	-0.063	-0.269	1						
	0.071[c]	0.000[a]							
Milling	0.064	-0.045	0.033	1					
	0.067[c]	0.202	0.343						
Intercrop	0.011	-0.182	0.143	0.004	1				
	0.748	0.000[a]	0.000[a]	0.900					
Rotation	0.054	0.328	-0.071	0.050	-0.093	1			
	0.123	0.000[a]	0.042[b]	0.150	0.008[a]				
Group Marketing	0.036	-0.007	-0.037	0.067	-0.010	0.064	1		
	0.306	0.836	0.287	0.057[c]	0.784	0.068[c]			
Improved Variety	0.120 0.001[a]	-0.144 0.000[a]	-0.093 0.008[a]	0.057 0.103	-0.041 0.240	-0.012 0.741	0.120 0.001[a]	1	

Disease control	-0.020	-0.097	0.059	-0.099	-0.005	-0.082	-0.055	-0.091	1
	0.564	0.006 [a]	0.092 [c]	0.005 [a]	0.886	0.019 [b]	0.115	0.009 [a]	

Notes: Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho61 = rho71 = rho81 = rho91 = rho32 = rho42 = rho > 52 = rho62 = rho72 = rho82 = rho92 = rho43 = rho53 = rho63 = rho73 = rho83 = rho93 = rho54 = rho64 = rho74 > = rho84 = rho94 = rho65 = rho75 = rho85 = rho95 = rho76 = rho86 = rho96 = rho87 = rho97 = rho98 = 0: $chi^2(36) = 100.861$ Prob > chi2 = 0.0000

From this analysis as presented in Table 3, fermentation and improved varieties are highly significant and have a negative association. This implies that fermentation as a practice is carried out by farmers who grow traditional unimproved varieties. Other practices that show significant and negative association include fertilizer application, disease control and intercropping. This points to a likelihood that farmers that grow traditional varieties do not undertake any disease control. Association of fermentation with rotation is significant and positive, showing that a farmer that grows traditional varieties are likely to rotate their crops. Drying is significantly and positively associated with milling and improved varieties. This shows that the three practices complement each other. While fermentation and soil fertilization were negatively associated, fertilizer application was positively and significantly correlated with use of intercrops and disease control showing that farmers who used fertilizers were more likely to complement the practice with intercropping and disease control. Those farmers that chose drying were likely not to ferment their cassava, showing a substitution relationship. Farmers who milled their cassava had a positive association with group marketing. Intercropping was significant and positively correlated with group marketing while it was negatively correlated with rotation and disease control showing substitutability of practices. Adoption of improved varieties show a negative and significant association with disease control, which may imply that improved varieties have better attributes of disease resistance and thus few disease incidences, thus reduced disease control practices.

Table 4: Multivariate analysis of factors influencing adoption of cassava TIMPs

	Drying	**Fermentation**	**Soil improvement**	**Milling**	**Intercrop**	**Rotation**	**Group Market**	**Improved varieties**	**Disease control**
Intervention Area	0.027	0.812 [a]	-0.558 [a]	0.184 [c]	-0.272 [b]	0.212 [b]	0.051	0.636 [a]	-0.827 [a]
	(0.105)	(0.143)	(0.114)	(0.108)	(0.110)	(0.108)	(0.328)	(0.106)	(0.106)
Household size	0.044 [a]	0.031	0.003	0.033 [b]	-0.017	0.022	0.042	0.017	-0.001
	(0.015)	(0.020)	(0.017)	(0.015)	(0.016)	(0.016)	(0.038)	(0.015)	(0.015)
Gender	-0.181 [c]	-0.275 [c]	0.237 [b]	0.003	-0.180	-0.054	-0.290	-0.020	-0.057
	(0.110)	(0.148)	(0.121)	(0.111)	(0.113)	(0.113)	(0.323)	(0.111)	(0.111)
Information	-0.016	0.001	0.014	0.064 [a]	-0.037 [b]	0.036 [b]	0.103 [a]	0.039 [a]	0.001
	(0.014)	(0.017)	(0.015)	(0.014)	(0.016)	(0.015)	(0.031)	(0.014)	(0.013)
Number of plots	0.025	-0.094	0.219 [a]	0.169 [a]	0.126 [c]	0.099	-0.116	-0.100	-0.170 [a]
	(0.062)	(0.084)	(0.068)	(0.063)	(0.065)	(0.070)	(0.221)	(0.063)	(0.065)
Cassava Acreage	0.047	0.427 [a]	-0.408 [a]	-0.039	-0.010	0.444 [a]	0.215	-0.261 [a]	-0.122
	(0.094)	(0.128)	(0.127)	(0.099)	(0.102)	(0.118)	(0.249)	(0.097)	(0.099)
Yield	0.000 [b]	0.000 [a]	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Education Level	-0.016	0.081	0.094	-0.057	-0.057	0.008	0.105	-0.040	0.010
	(0.051)	(0.068)	(0.057)	(0.051)	(0.054)	(0.053)	(0.156)	(0.051)	(0.051)
Land ownership	0.261 [b]	-0.543 [a]	0.443 [a]	0.263 [b]	0.197 [c]	-0.174	0.893 [b]	0.280 [a]	0.047

	(0.107)	(0.142)	(0.117)	(0.108)	(0.111)	(0.110)	(0.426)	(0.108)	(0.106)
Total Acreage	0.005	-0.024	-0.012	0.001	-0.003	0.013	-0.010	0.018	0.028 ^{c}
	(0.010)	(0.026)	(0.012)	(0.010)	(0.010)	(0.013)	(0.051)	(0.011)	(0.017)
Off farm income	-0.061	0.629 ^{a}	-0.433 ^{b}	-0.121	-0.328 ^{c}	0.251	-0.238	0.175	0.099
	(0.163)	(0.191)	(0.183)	(0.166)	(0.185)	(0.177)	(0.517)	(0.160)	(0.163)
Electricity Access	-0.037	-0.161	0.075	-0.187 ^{c}	-0.121	-0.041	-0.001	-0.051	0.082
	0.098	0.134	0.107	0.100	0.103	0.102	0.310	0.099	0.099
KAPAP CIG	0.761 ^{a}	-1.609 ^{a}	-0.489 ^{a}	0.084	0.100	-0.345 ^{a}	0.487	0.663 ^{a}	-0.028
	0.106	0.188	0.122	0.108	0.112	0.112	0.338	0.107	0.106
Credit use	0.254 ^{b}	0.326 ^{b}	0.113	0.068	-0.385 ^{c}	0.279	0.698 ^{b}	-0.124	-0.115
	0.128	0.163	0.139	0.130	0.147	0.138	0.332	0.129	0.129
Cassava Experience	-0.001	0.025 ^{a}	-0.008 ^{c}	-0.003	-0.004	0.023 ^{a}	-0.002	-0.004	0.002
	0.004	0.006	0.004	0.004	0.004	0.004	0.012	0.004	0.004
Group Membership	-0.040	0.011	-0.168	-0.107	-0.115	0.303 ^{b}	-0.206	0.242 ^{b}	0.040
	0.124	0.157	0.143	0.126	0.133	0.133	0.378	0.123	0.123
Age	-0.004	-0.006	-0.005	-0.003	-0.007 ^{b}	-0.009 ^{b}	0.003	-0.002	-0.006
	0.004	0.006	0.004	0.004	0.004	0.004	0.013	0.004	0.004
Market distance	-0.002	-0.001	-0.002	0.002	-0.006	0.001	-0.001	0.000	0.000
	0.003	0.007	0.004	0.003	0.005	0.004	0.010	0.003	0.004
Constant	-0.358	-0.858 ^{b}	-0.608 ^{c}	-0.872 ^{a}	0.441	-0.183	-3.907 ^{a}	-0.593 ^{b}	0.986 ^{a}
	0.291	0.396	0.319	0.294	0.305	0.302	0.925	0.294	0.298

Effects of CESDM Intervention on Adoption of Cassava TIMPs:

KAPAP project, through a contracted extension delivery model, promoted various practices. Certain interventions were seen to be influenced by the intervention positively, while others were negative. The estimates showed that the probability of adoption of improved cassava varieties were highly significant ($P<0.01$) and positive for the intervention area. Rotation practice was also moderately significant ($P<0.05$) and positive. Fermentation was highly significant ($P<0.01$) and positive. This is contrary to expectation that with an increase in uptake of improved varieties, which do not require much fermentation, this practice would decrease. This implies that while farmers in intervention areas positively adopted improved varieties, they still grew their traditional varieties alongside the improved ones. From the data, Busia and Nakuru were significantly different in terms of adoption of the improved varieties. Further to this, tastes and preferences remain important drivers to cassava technology adoption. Studies by et al. [8, 1], and [63] found out that farmer's tastes and preferences are heterogeneous and may include such traits as bitter taste, in-storage properties, leaf production, tuber colour, disease resistance, high yielding and early maturity. Milling was also positive and significant at ($P<0.1$). This is expected since some of the intervention activities involved project grants that acquired value addition machineries to enable farmers to value-add their cassava through drying, and other technologies to increase shelf life and commercialisation. Fertilizer use, intercropping and disease control were significant but negative. This may point to an inherent attitude that cassava is a low input crop [7] thus farmers are not likely to adopt soil improvement practices such as fertilizers and intercrops that may require extra investments. On the other hand, this study shows an increased adoption of improved varieties in the intervention area. One advantage of improved varieties is lower disease incidences and increased resilience from the traditional diseases that affect cassava such as mosaic viruses, cassava CBD, and green mites. This may then explain the decreased adoption of disease control practice with increased adoption of improved varieties.

Being in a KAPAP CIG, was highly significant and positive in adoption of drying and improved varieties but highly significant and negative in fermentation, fertilizer use and rotation. This indicates that the project was successful in increasing adoption of improved varieties as well as drying technologies for increased shelf life of cassava. Furthermore, these improved varieties promoted by the project are sweeter and does not require fermentation [60].

Factors Influencing Adoption of Cassava TIMPS:

Adoption of cassava TIMPs is influenced by several variables. Household size is critical for adoption of these practices. In this study, the variable influences significantly drying and milling. This indicates the very nature of cassava as a labour-intensive crop, and therefore much of the family labour is required in these value addition practices. This finding is in tandem with et al. [48] that found household size critical in value-addition of cassava in terms of providing cheap labour. On the other hand, a large household size may deter commercialisation due to family consumption demands that reduce cassava market surplus [48].

Yield significantly influenced drying positively while influencing fermentation negatively. A higher harvest motivates a farmer to adopt value-addition techniques like drying in order to prolong the shelf life of cassava. This finding is affirmed by a study by et al. [53] that established that an increase in farm output was a significant factor influencing the adoption of cassava value-added innovation by rural women in Abia state, Nigeria. On the other hand studies by et al. [16], also found that farmers who adopted value-adding practices had higher yields. While this is ultimately what is desirable by any farmer, high yields in cassava means increased labor requirements for value-addition. This is in tandem with a study that found that value-addition processes such as fermentation demands higher labor requirements and time [30]. For a farmer who has higher yields, value-addition through fermentation processes may not be desirable given that cassava deteriorates within 3-4 days [66]. This may imply higher labor costs together with increased losses or lower quality of products if this value addition technique is opted for.
Land remains a critical resource base that anchors many initiatives for productivity and welfare improvements for farmers [40]. The status of land ownership gives the farmer rights of use to that land and is therefore an important attribute that drives adoption of new technologies and other land investments [24]. In this study, land ownership significantly influenced adoption of the following TIMPs positively; improved varieties, soil fertilization, intercropping, drying, milling and group marketing. This indicates that land ownership gives farmers security and are able therefore to invest and adopt productivity enhancing technologies. As opined by et al. [65], land tenure motivates adoption of technologies whose investments are higher and whose benefits may take longer to be realised such as Natural Resource Management (NRM) technologies. A review of studies by [6], found that different attributes of land influenced adoption of agricultural technology differently. Tenure security influenced adoption of technologies that took longer to reap benefits such as tree planting, mulching and organic manure application. Farmers who had fixed rent systems were more likely to use mineral fertilizers, while those that had sharecropping did not adopt soil-improving technologies. Other

studies by et al. [61] found that land tenure influenced farmers to adopt new rice technologies and increased the rate of adoption after the initial decision of adoption.

Credit use significantly influenced those farmers undertaking drying, fermentation, crop rotation and group marketing positively. However, it highly influenced use of intercrops negatively. This points to the fact that those farmers practicing cassava processing such as drying and fermentation may require extra investments on specialised machineries as well as incur extra labour costs. This finding is in tandem with studies by et al. [16], that found that access to credit influenced adoption of value-addition among cassava farmers in Nigeria and Kenya respectively. Further to this, other studies found that women cassava processors who had credit access positively improved their processing enterprises compared to those who had limited access and that commercial banks gave higher amounts of loans [60]. While credit significantly enhances adoption of value addition technologies, gender inequalities in the society may undermine women's performance in enterprises that they are involved in. Additionally, et al. [16] found out that women received less credit from credit institutions compared to male actors along the value chain. On group marketing, the marginal effect was high at 59% indicating that those farmers who accessed credit were highly likely to market their cassava through groups. This also indicates that credit use may influence commercialisation of cassava. This is in tandem with a study by [3] that found out that market participation choices for cassava processors was influenced by access to credit.

Off-farm employment significantly influenced fermentation positively. This variable also influenced fertilizer use and intercrops but negatively. This may point to the fact that those farmers that fermented their cassava grew traditional varieties, and are not likely to adopt improved practices such as fertilizer application and intercrops. While labour requirements for fermentation may be high, the process may be longer allowing farmers to undertake other off-farm activities. On the other hand, fertilizer may require a farmer to have access to information on cassava management while those employed out of their homes may not afford. This is because cassava information may be passed through farmer groups and extension visits and these avenues may not be available for farmers who are undertaking other off-farm activities. This result is in tandem with a study by et al. [65], that found out that labour availability influenced the relationship between off-farm employment and agricultural innovation. A study by et al. [68], found out that competing off-farm activities substituted cassava incomes slowly over the years. These activities offered higher welfare gains for the farmers engaged in off-farm activities.

Ownership of cassava machinery significantly influenced milling. This is an important indication to the positive effects that government support had on farmers. Value-addition equipment was distributed to farmers who were in groups by government and this influenced positively these value-addition practices. Milling was also influenced by years of experience as a cassava farmer. Farmers who had grown cassava for longer were likely to mill their cassava. This indicates that time is a factor in building capacity of farmers in terms of technology adoption and in terms of diversification of practices.

Gender of the household head had moderate negative influence on drying and fermentation while positively influencing fertilization. This indicates that if the household head was male, he was likely to adopt use of fertilizers to enhance his yield. On the other hand, women household heads were likely to adopt fermentation and drying practices. This could suggest that men are likely to afford practices that require a higher investment compared to women. This is in tandem with et al. [51] that found out that male headed households adopted soil fertility practices than female headed households. On the other hand, since drying and fermentation require more time and patience, women, due to their reproductive roles stay more around their homes and are able to adopt practices that require more intensity in their management. It may also show that women adopt practices that assure their families of food security, which the two practices offer.

Access to cassava information had an effect on more than half of the TIMPS. Those TIMPS that were positively and highly influenced included milling, use of group marketing, use of improved varieties and to a moderate extent rotation practice. This finding is in tandem with [20] and [15] that found that information access by farmers from farmer –farmer exchange systems and extension systems were key in influencing farmer's decisions on adoption of technologies. On the other hand, access to cassava information negatively influenced intercropping of cassava.

The number of plots a farmer cultivated on highly and positively influenced fertilization and milling and also intercropping at 10% significance level. However, this had a high negative significance on disease control. Access to multiple plots is an indicator of wealth, meaning that these farmers are able to adopt practices that require extra investments such as fertilizer application and milling. This finding is in tandem with a meta-analysis by et al. [50] that found out that wealth is an important influence to adoption of fertilizers. The lack of use of disease control as a practice may also indicate that the farmer has adopted improved varieties that are no susceptible to many cassava diseases and therefore reduces the need for disease control. Higher cassava acreage highly influenced fermentation and rotation while negatively influencing fertilization and use of improved varieties. This shows that farmers who had bigger parcels of cassava may not be able to afford investments into more costly technologies such as fertilizers and improved seeds. This then means that farmers cannot achieve a high productivity due to low adoption of productivity enhancing technologies such as fertilizers and seeds.

Cassava experience variable highly influenced fermentation and rotation, while negatively influencing fertilizer application slightly. This affirms that some practices such as fermentation which are a traditional practice in cassava value-addition requires experience and also certain preferential tastes that have been developed over time. For rotation practice, farmers with long cassava growing experience may have experienced the benefits of the practice due to soil depletion over time and may be using this as a strategy for replenishing their soils. Group membership influenced two practices positively albeit in a moderate extent. These practices include improved varieties and rotation.

Factors Explaining the Extent of Use of Cassava TIMPS:

Farmers generally adopt a combination of cassava TIMPS with varying degree of use by each farmer. From this study, the maximum number of Cassava TIMPs a farmer could adopt was nine

(9). A count was taken from every farmer, and an adoption level constructed. Four categories of the level of use of cassava TIMPS were constructed; 0-25% (level 1); 26-50% (level 2); 51-75 % (level 3); 75-100 % (level 4).

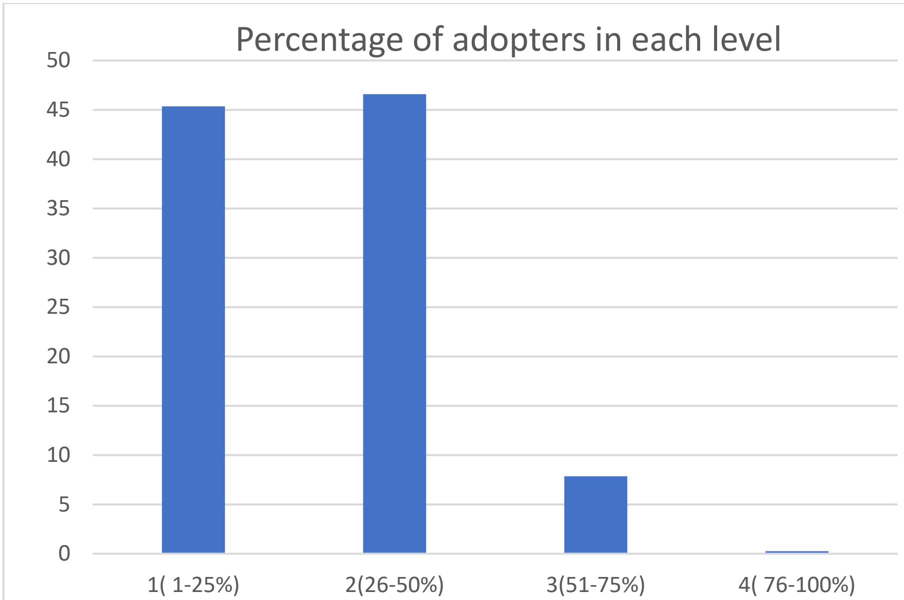

Figure 2: TIMP adoption level

The level of adoption was then used as an outcome variable in the ordered probit. The marginal effects of the outcome variable and standard errors are presented in the table below.

Marginal Effects of Adoption Levels of Cassava TIMPS:

Table 5: Marginal effects after Ordered Probit

	Level 1	**Level 2**	**Level 3**	**4 Level**
Margins (predict)	*0.38*	*0.52*	*0.095*	*0.005*
Variable	*dy/dx*	*dy/dx*	*dy/dx*	*dy/dx*
Intervention Area	-0.001 (0.035)	0.001 (0.020)	0.001 (0.014)	0.000 (0.001)
Household size	-0.011[b] (0.005)	0.006[b] (0.003)	0.004[b] (0.002)	0.000 (0.000)
Gender of Household Head	0.088[b] (0.035)	-0.047[a] 0.017	-0.039[b] (0.017)	-0.003 (0.002)
Cassava information	-0.017[a] (0.004)	0.010[a] (0.003)	0.007[a] (0.002)	0.000[b] (0.000)
Number of plots	0.011 (0.021)	-0.006 (0.012)	-0.004 (0.008)	0.000 (0.001)
Cassava Acreage	-0.035 (0.031)	0.020 (0.018)	0.014 (0.013)	0.001 (0.001)
Yield	0.000[a] (0.000)	0.000[b] (0.000)	0.000[b] (0.000)	0.000 (0.000)
Education Level	0.024 (0.017)	-0.014 (0.010)	-0.010 (0.007)	-0.001 (0.001)

Land Ownership	-0.095 [a] (0.035)	0.056 [b] (0.021)	0.037 [a] (0.014)	0.002 (0.001)
Total Land size	-0.008 [b] (0.003)	0.004 [b] (0.002)	0.003 [b] (0.001)	0.000 (0.000)
Off-farm income	-0.046 (0.051)	0.025 (0.026)	0.020 (0.024)	0.001 (0.002)
Electricity Access	0.054 [c] (0.033)	-0.031 (0.019)	-0.022 (0.013)	-0.001 (0.001)
KAPAP CIG	-0.083 [b] (0.034)	0.046 [b] (0.018)	0.035 [b] (0.016)	0.002 (0.002)
Credit use	-0.042 (0.042)	0.023 (0.022)	0.018 (0.019)	0.001 (0.001)
Cassava experience	-0.003 [b] (0.001)	0.002 [b] (0.001)	0.001 [b] (0.001)	0.000 (0.000)
Group membership	-0.003 (0.041)	0.002 (0.023)	0.001 (0.016)	0.000 (0.001)
Age of Household head	0.004 [b] (0.001)	-0.002 [b] (0.001)	-0.001 [b] (0.001)	0.000 (0.000)
Market distance	0.002 (0.001)	-0.001 (0.001)	-0.001 (0.001)	0.000 (0.000)
Cassava variety Knowledge	-0.069 [b] (0.031)	0.040 [b] (0.018)	0.027 [b] (0.012)	0.002 (0.001)

Log likelihood = -748.30134, LR chi^2 (19) = 67.42 , Prob > chi^2 = 0.0000, Pseudo R2 = 0.0431. [a, b and c] significant at 1%, 5% and 10% respectively, Standard error in parenthesis.

The marginal effects show the influence of the changes of the explanatory variables on the probability of different adoption levels of cassava TIMPs in the ordered response. The table above shows that, an increase in household size reduced the propensity of adoption of level 1 of technology adoption while increasing the propensity of adoption of higher levels (2&3) of technology adoption. This may be attributed to higher family welfare requirements that drive them to adoption [60]; [37]. Gender of household head had a positive association with adoption of level 1 technology use, but was negatively associated with higher level of technology adoption. This may indicate that women were less likely to adopt a combination of more than 2 cassava TIMPS due to gender disparities in technology access and use [25]; [63], [61]; [52]. Land ownership had a negative association with lower levels of use of cassava TIMPs, but was positively associated with farmers who adopted a combination of 3-6 technologies in the 2nd and 3rd level of technology use. This indicates that land tenure is an important driver to cassava technology use and is supported by several studies [34]; [23]; [39] that show secure land tenure is a motivation factor in improving adoption and continued use of cassava TIMPs. Another important land attribute for increased adoption and use of cassava TIMPs was ownership of bigger land acreages. The study showed that farmers with larger total acreages were associated with adoption level 2-3 of cassava TIMPs' adoption and use. This could imply that farmers with larger farms (an important wealth indicator) were likely to invest in more technologies to improve their productivity unlike their counterparts. The age of the household head was positively associated with lower intensity of use of cassava TIMPs and negatively associated with higher levels of use of cassava TIMPs. This could be an indication that older farmers were laggards in terms of technology adoption and are associated with use of fewer but trusted TIMPs.

Association with KAPAP's Intervention:
While those farmers in the treated and non-treated areas were not significantly different in terms of use of TIMPS, those farmers in KAPAP CIGs were positively associated with use of more TIMPs in level 2&3 and negatively associated with level1. This may indicate that the project interventions impacted positively on the CIGs more than any other group. From the study, those in other groups had no significance association with use of cassava TIMPs. This is in tandem with findings from et al. [47] that found out that group participation had positive association with technology adoption. Further so, partnership with development agencies had positive significant influence on technology adoption at household levels. Et al. [33] found out that farmer groups had a catalytic effect on technologies thus reducing adoption lag of those members in those groups. Other studies by [13], affirmed that indeed groups were important in increasing technology uptake. This points to the need for increased mobilization and targeting in order for farmers to actively participate in agricultural groups.

CONCLUSIONS

The study employed a multivariate and an ordered probit to explain the influence of CESDM on uptake and extent of use of cassava TIMPs promoted among cassava farmers in Busia and Nakuru Counties of Kenya. The study contributes to literature on the essence of government intervention on extension approaches on adoption of agricultural practices. The study found out that the CESDM was successful in influencing adoption of improved cassava varieties and milling, an important value-addition technology that is important in adding shelf life and commercialization. The study found out that other factors that influenced adoption of cassava TIMPs included household size, cassava yield, land ownership, credit access, off-farm employment, ownership of cassava machinery, gender of household head, access to cassava information, number of plots cultivated, higher cassava acreage, and group membership. Factors that were associated with extent of use of cassava TIMPs included household size, gender of household head, land ownership, larger total acreages, age of household head, and being in a KAPAP CIG.

The study found that indeed the CESDM had positive outcomes in enhancing technology uptake of cassava farmers and particularly on improved varieties and value addition technologies essential for commercialization of the value chain. While the CESDM may not have influenced all the considered TIMPS, it is notable that such government initiatives and interventions are key in changing farmers' mind-sets and driving change. Considerations on out-scaling of these technologies using such a model is key in empowering a critical mass of farmers in order to modernise the cassava value chain.

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All the authors contributed significantly to the research work and have approved the final manuscript.

Data Availability: The authors certify that the data used in this article was primary data collected for the study and can be availed by the corresponding authors upon request.

DECLARATION

Consent for Publication: Participants consented to the submission of findings for the journal article publications

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