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DETERMINANTS OF FACTORS AFFECTING ADAPTATION STRATEGIES TO CLIMATE CHANGE OF CASSAVA PROCESSING IN SOUTH WEST, NIGERIA.

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ABSTRACT

This study identified adaptation strategies adopted by the processors in the study area and also assessed factors affecting adaptation strategies to climate change in cassava processing in South West, Nigeria. Descriptive statistics was used to identify adaptation strategies used by cassava processors while multivariate probit model was employed to determine the factors affecting adaptation strategies engaged by farmers. Adaptation strategies adopted by processors include monitoring weather change by indigenous means, diversify into non processing activities, changing processing time, storing of produce, diversify into other processing and increasing quantity of cassava purchased the following season. Multivariate probit model identifies gender, educational level, processing experience, household size, extension contact, secondary income and marital status have statistically significant influence on climate change adaptation. This study therefore recommends improved education and awareness of climate change adaptation options in form of formal and extension education be disseminated to processors.

Keywords: Climate Change Adaptation, Cassava Processing, Multivariate Probit Model, South West Nigeria.

INTRODUCTION

Agriculture places serious burden on the surroundings within the method of providing humanity with food and fibre, where climate is the primary determinant of agricultural productivity (Apata and Adeola,2009).Studies signify that Africa's agriculture is negatively tormented by global climate change (Ward *et al.*, 2014; Kahsay and Hansen, 2016). Many Local, Federal and International organizations have expressed apprehension regarding elemental role of agriculture in human welfare, with respect to the potential effects of global climate change on agricultural productivity.

However, the interest in this area has motivated a substantial body of research on climate change and agriculture over the past decade (Fischer *et al.*, 2002; Wolfe *et al.*, 2005; Lobelle *et al.*, 2008; Ali, and Erenstein 2017). Climate change and variability presents a major obstacle to agricultural production, processing and welfare of rural households. It affects approximately 2.5 billion persons whose livelihood in part or in full dependent on agricultural production systems. Climate change adaptation is an important component of any policy response to minimize the undesirable impact of climate changes on agriculture (Brooks and Adger, 2005; Deressa *et al.*, 2009; Gbetibouo, 2009). Conversely, this poses serious challenges to their social, economic and ecological systems (Ali, and Erenstein 2017)

Adaptation to global climate change refers to adjustment in natural or human systems in response to actual or expected environmental stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001). The adaptation strategies in agriculture include: use of recent crop varieties and farm animal species that square measure a lot of suited to drier conditions, irrigation, crop diversification, mixed farming systems and changing planting periods(Bradshaw *et al.*, 2004; Kurukulasuriya and Mendelsohn, 2006; Nhemachena and Hassan,2007; Makuvaro *et al.* 2018).

Adaptation measures are so crucial to assist vulnerable communities 'better face severe weather and associated climatic variations (Adger *et al.* 2003; Bosello *et al.* 2012).The impending nature of adaptation strategies can considerably contribute to reductions in negative impacts from changes in weather conditions in addition as alternative dynamical socioeconomic conditions, like volatile short changes in native and international markets (Kandlinkar and Risbey, 2000; Bosello *et al.* 2012).

Lamboll *et al*., 2018 affirmed that cassava is a widely grown by small-holders. Nigeria is the world's largest cassava producer, producing over 50 million tonnes of roots in 2017 (FAOSTAT, 2017). Processed cassava can help meet the expanding demand for more anddifferent types of agri-food products (garri, fufu and cassava flour) in Africa. This suggests that a negative effect of climate change on cassava processing may have huge impact on livelihood of rural households. In Nigeria, cassava is currently being promoted as an industrial raw material in the form of starch, flour and ethanol. Phillips *et al*., 2004 and PIND, 2011 also iterated that cassava has the potential to industrialize Nigeria more than any other agricultural product if its potential is properly harnessed. Thus the objectives of the study include:

1. to identify cassava products processed in the study area.
2. to identify the adaptation strategies adopted by cassava farmers.
3. to determine the factors affecting adaptation strategies employed by farmers.

The ability and capability to adapt are influenced by system attributes (e.g., agro-ecological) that are called the 'determinants of adaptation' (Smit *et al*., 2000; Alam, *et al*., 2016). Understanding the determinants of adaptation is germane inclarifying the local adaptation process. This knowledge assists policy development by strengthening adaptation through investing in these factors (Yohe and Tol, 2002; Alam, *et al*., 2016)

Nhemachena and Hassan 2007 with the use of multivariate discrete choice model identified the determinants of farm-level adaptation strategies. Results obtained confirmed that access to credit and extension and awareness of climate change are some of the important determinants of farm-level adaptation.

Hassan and Nhemachena, 2008 utilised multinomial discrete choice model was used to analyse the determinants of farm-level adaptation measures. The results showed that warming in all seasons promoted adoption of multiple cropping and mixed crop-livestock systems. Farmers appear to employ adaptation as temperatures increases. With most parts of the region already warm and dry, any further warming compels them to take up various multiple and mixed crop livestock adaptation measures. The results suggest that the influence of warming on the probability of switching to more adapted systems is more powerful than the influence of changes in rainfall. This means that the risk of mono-cropping under dry land is higher with warming in general.

Deressa *et al.* 2011 assessed farmers' adaptive capacity to climate change adaptation strategies in Nile basin of Ethiopia. The result revealed thateducation level of the head of the household, household size, gender, extension contact andavailability of credit were significant variables affecting farmer's decisions to adopt.

Evengelista, 2013 carried out a research on farmers' adaptation to climate change in Chivi district of Zimbabwe and found out that household characteristic and institutional factors such as education of the household head, farm household size, farming experience, access to credit, exposure to information on climate change all had a positive and significant influence on adaptation to climate change in Chivi district. The age of the household head, non-farm income, soil fertility and farm size were found to be statistically insignificant in influencing the farmer's decision on whether to adapt to climate change or not. Increased knowledge about climate change, more farm labour and access to credit enhance to adaptation capacity of the farmer to reduce the negative impact of climate change. The choice of the adaptation strategies are determined by the farmer's factor endowment such as labour and capital.

Gebrehiwot, and van der Veen., 2013. Using multinomial logit model, from a survey of 400 peasant farmers in three districts in Tigray, northern Ethiopian examined farmers' perception of change in climatic variables and the determinants of farmers' choice of adaptation strategies to climate change and variability. The estimated findings from the models illustrates that educational level, age and wealth of the head of the household; access to credit and agricultural services; information on climate, and temperature all influence farmers' choices of adaptation. Moreover, lack of information on adaptation measures and lack of finance are seen as the main factors inhibiting adaptation to climate change.

Udinn*et al.,* 2014, found out that the socio economic factors such as, age, educational level, farm size, household size, and family income are the variables significant that affect the adaptation strategies adopted by the farmers in the study area.

Adams, 2015 assessed climate variability and adaptation strategies in cassava production in Ogun State, Nigeria. The results of the study showed that farmers in this area are aware of climate variability, and identified increases in temperature and rainfall intensity as the element of climate variability mainly perceived to be affecting cassava production. Results of multinomial logit obtained showed that age, household size, extension contact, farm experience and length of residence in the community some of the important determinants of farm-level adaptation by cassava farmers.

Tambo, 2016 using multivariate probit model iterates that age, gender, extension contact and awareness of climate change are important determinants of farm-level adaptation to climate change. Arunrat, *et al.* 2017, conducted a study on farmers' perceptions and adaptations to climate change in Phichit province of Thailand where they found out that years of farming experience, household size, years of education, access to credit facilities, access to extension services, access to credit and gender are among the significant determinants of climate change adaptation measures.

Mulwa, *et al.* 2017 studied response to climate risks among smallholder farmers in Malawi. Descriptive statistics were used to describe farmers' adaptation strategies to climate change while multivariate probit model was utilized to identify the factors determining households' choice of adaptation strategies to climate change. Findings confirmed that sex, literacy status, farming experience, family size, extension contact, off/non-farm income and asset have a statistically significant impact on climate adaptation strategies.

Ali and Erenstein 2017 examined factors influencing the use of climate-change adaptation practices in Pakistan. Results obtained show that younger farmers and farmers with higher levels of education are more likely to use these adaptation practices, as do farmers that are wealthier,

Boansi *et al.*, 2017 examined farmers adaptation to weather extremes in West Africa Sudan Savannah where the report revealed that multivariate probit model to identify the major factors that influence the number and choice of strategies adopted, we discovered that, limited access to credit, markets, and extension services, smaller cropland area, and low level of mechanization could impede effective adaptation to weather extremes.

Mase, *et al.* 2017 with the use of cross sectional survey assessed adaptation behavior of mid-western crop farmers. The result analyzed with the use of binary logistic regression shows that gender have a significant impact on choice of climate change adaptation method.

METHODOLOGY

Multi-stage sampling techniques were used to select the cassava processors. The first stage of sampling involved a purposive selection of two (2) states (Ogun and Oyo in the rainforest and derived savanna zone of the country). The second stage entaileda random selection of three (3) zones each (6 zones in total) from the Ogun State Agricultural Development Programme and Oyo State Agricultural Development Programme zones.The third stage involved a random selection of two (2) blocks from each zones. The fourth stage was a random selection of two cells from each of the selected block while the last stage involveda random selection of 30 (thirty) cassava processors from each of the selected cells thereby giving a total number of 720 respondents.

Analytical Framework

Descriptive Statistics: This involved mainly the use of frequency and percentage tables used to describe the various adaptation strategies adopted by the cassava farmers in the study area.

Multivariate Probit Model: This was used to estimate the factors affecting adaptation strategies employed by respondents in the study area. The advantage of the multivariate probit is that it permits the analysis of decisions across more than two categories, allowing the unobserved and unmeasured outcomes to be correlated freely(Greene, 2003; Lin *et al.* 2005;Ali and Erenstein, 2017). Adaptation strategies may be complements or substitutes depending on whether positive or negative correlations exist among strategies. This approach is more appropriate than the multinomial logit because it is not based on assumption of independence of irrelevant alternatives.

Following Ali and Erenstein, 2017;Tambo, 2016; Lin *et al.* 2005 the multivariate probit econometric approach is characterized by a set of *n* binary dependent variables *yi* (with observation subscripts suppressed), such that:

$y_i = 1$ if $x'\beta_i + \varepsilon_i > 0,$

$= 0$ if $x'\beta_i + \varepsilon_i \leq 0, \mathrm{i} = 1,2, \ldots . . \mathrm{n}$……….(1)

where *x* is a vector of explanatory variables, $\beta_1, \beta_2, \ldots \ldots . \beta_n$are comformable parameter vectors, and random error terms $\varepsilon_1, \varepsilon_2, \ldots \ldots . \varepsilon_n$ are distributed as multivariate normal distribution with zero means, unitary variance and an $n \times n$ contemporaneous correlation matrix $R = [P_{ij}]$, with density$\phi(\varepsilon_1, \varepsilon_2, \ldots \ldots . \varepsilon_n; R)$.The likelihood contribution for an observation is the *n*-variate standard normal probability

$$P(y_{1,\ldots\ldots\ldots,}y_{n,}|x = \int_{-\infty}^{(2y_1-1)x'\beta_1} \int_{-\infty}^{(2y_2-1)x'\beta_2} \ldots \times \int_{-\infty}^{(2y_n-1)x'\beta_n} \phi(\varepsilon_1, \varepsilon_2, \ldots \ldots . \varepsilon_n; Z'RZ) d\varepsilon_n., d\varepsilon_2, d\varepsilon_1 \ldots . (2)$$

where Z diag$[(2y_1 - 1) \; ,\ldots . . (2y_n - 1)]$. The maximum likelihood estimation maximizes the sample likelihood function, which is a product of probabilities (2) across sample observations. Computation of the maximum likelihood function using multivariate normal distribution requires multidimensional integration, and a number of simulation methods have been put forward to approximate such a functionwith the Geweke-Hajivassiliou-Keane (GHK) simulator (Geweke *et al.* 1997; Hajvassilion *et al.*, 1996)being widely used, (Belderbos *et al*. 2004).

The marginal effects of explanatory variables on the propensity to adopt each of the different adaptation measure are calculated as:

$\partial P_i / \partial x_i = \phi(x'\beta)\beta_{i,} \;\; i = 1,2, \ldots \ldots n$ ……….(13)

where $P_i$is the probability (or likelihood) of event *i* (that increased use of each adaptation measure),

ϕ (·) is the standard univariate normal cumulative density distribution function,

x and βare vectors of regressors and model parameters respectively (Hassan 1996).

Table 1: Operational definition of variables

Dependent variable	Measurement	Hypothesis
Climate change adaptation strategies		
Independent variables		
Age	Continuous (years)	+
Household Size	Continuous (number)	+
Educational Level	Continuous (years)	+
Length Of Residence In The Community	Continuous (years)	+
Years of Processing Experience	Continuous (years)	+
Gender	Dummy (0= female,1= male)	-
Extension Contact	Dummy (0= no, 1= yes)	+
Marital Status	Dummy (0= otherwise, 1= married)	+
Secondary Income	Continuous (naira)	+/-

RESULTS AND DISCUSSION

The summary of respondents personal characteristics is shown in table 2, as indicated most cassava processors (garri, fufu, and flour (lafun) producers) are females (92.8%), married (91.7%) with an average household size of 7 persons.

Table 2: Summary of Characteristics of Cassava Processors in the Study Area

Dependent variable	Mean	Frequency
Age	47.08 years	
Household Size	7 members	
Educational Level	9 years	
Length Of Residence In The Community	19.64 years	
Years of Processing Experience	21.32 years	
Gender		Male=7.2 Female =92.8
Extension Contact		No= 70% Yes =30%
Marital Status		Married=91.7% Single =8.4%
Secondary Income	N1388.70	

Source: Field Survey

Distribution of Respondents According to Source of Cassava

Majority of respondents (57.78%) source their cassava from farmers in the community as shown in figure 1(see appendix), as observed in figure 2(see appendix), most of the respondents (58.89%),38.83% and6.67% are into fufu, garri and lafun production only whilejust 1.11% of respondents are into the production of all the processed products.

Adoption of Adaptation Strategies

As shown in figure 3 (see appendix),in the study district, processors adopted different strategies to reduce the negative effect of climate change. Monitoring of weather (48%) was the most important adaptation strategies among cassava processors mostly because fufu, garri and flour (lafun) are better produced during dry weather conditions. Diversification into other non-processing activities (45%)is another means of adapting to climate change making up for the losses in income of processing activities. In the study area, 34% of sample households used adjusting processing time, as an adaptation strategy to reduce the adverse effect of climate change. Accordingly, about 23% of sampled processors stored produce as adaptation strategy to reduce the adverse effect of climate changeon farm productivity.

Determinants of Adaptation Strategies employed by respondents

Multivariate probit model was used in this study to estimate the factors affecting adaptation strategies employed by processors. These are:

i. Diversify more into other processing products
ii. Diversify into non-processing activities
iii. Monitor weather change by indigenous knowledge
iv. Increase the quantity of cassava purchased the following season
v. Change processing time
vi. Store produce

The likelihood ratio test from Multivariate probit model showed the overall significance of the model at1% probability level which signifies that the model is useful in explain factors influencing decisions of cassava processors to adapt to climate change. The model results suggested that there was negative and significant interdependence between processors decisions to adapt diversify more into other processing products and forecasting future weather change by indigenous knowledge; changing processing time and products diversification; changing processing time and secondary activity diversification; store produce and change processing time. On the other hand table 3 also illustrates significant and positive interdependence between storing of produce and secondary activity diversification; storing of produce and monitoring weather change by indigenous implying that they are complements.

Age of Household Head: As shown in table 3, age of household head is an important determinant in the decision of processors to change processing periods(1%), product diversification(5%) and monitoring weather by indigenous knowledge (5%) The sign of the parameter is positive implying that as processors get older their probability of diversifying into production of other processing activities, changing processing periods, and predicting weather changes also increases probably due to life experiences. This findings is in support of Alam *et.al*, 2016; Adams, 2015and Hisali *et al.*, 2011but against the findings of Ali and Ereinstein,2017whereage of the household head turned out to be negatively associated with the adoption of the adaptation practices. Boansi, *et al.*2017 also attest that age increases the likelihood of processors to adjust processing periods. He stated that older processors know period within the planting year where processing is better carried out.

Household size: This variable is positive and significant (1%) for the probability of households to change processing time. This is likely due to the prevalence of family labour which makes tasks achievement more effective especially during peak periods doesn't make spontaneous change in decision making dependent on the availability of hired labour Deressa *et.al.*2011, Arshad *et.al.* 2016; Ali and Ereinstein, 2017 revealed similar results of increase in household size increasing the probability of adopting a strategy however Dang *et al*. 2014;Adams, 2015and Temesgen *et al.* (2008) contradicts this result, they opined that household size has negative and significant impact on the probability of choosing adaptation strategies.

Table 3: Parameter Estimates of Multivariate Probit Model of Respondents' Adaptation Strategies

Explanatory Variable	**Diversify more into other processing products**	**Diversify into non-processing activities**	**Monitor weather change by indigenous knowledge**	**Increase the quantity of cassava purchased the following season**	**Change processing time**	**Store produce**
Age	0.035**	-0.01	0.03**	0.03	0.05***	0.09
	(2.15)	(-0.68)	(2.29)	(1.64)	(3.10)	(0.24)
Household Size	0.0007	0.04	-0.04	0.001	0.17***	0 .02
	(0.02)	(0.93)	(-1.32)	(0.03)	(3.92)	(0.56)
Educational Level	-0.001	-0.03	0.06**	0.09**	0.07***	0.03
	(-0.04)	(-0.94)	(2.08)	(2.59)	(2.83)	(0.79)
Length Of Residence In The Community	0.02**	-0.033**	0 .004	0.001	0.01	0.03***
	(2.29)	(-2.13)	(0.54)	(0.75)	(0.75)	(2.90)
Years of Processing Experience	-0.03**	-0.08**	-0.02**	-0.01	-0.01	0.12***
	(-2.24)	(-2.18)	(-2.09)	(-0.52)	(-1.29)	(-3.04)
Gender	-0.32	-0.50	-0.17	-0.14	-0.64	-0.75*
	(-0.58)	(-1.03)	(-0.44)	(-0.25)	(-1.29)	(-1.81)
Extension Contact	-0.25	0.46	0.33	0.303	0.37	1.17***
	(-0.85)	(1.51)	(1.32)	(1.04)	(1.51)	(4.00)
Marital Status	-1.74***	1.17*	-0.03	0.776	-1.54***	1.13**
	(-2.68)	(1.68)	(-0.08)	(0.37)	(-2.87)	(2.24)
Secondary Income	1.22***	2.33***	-0.95***	0.43	-1.54***	-0.52*
	(4.39)	(7.91)	(-3.98)	(1.61)	(-2.87)	(-1.95)
Constant	0.84	-1.82	-0.53	-23.16	-0.68	-22.16
	(0.64)	(-1.35)	(-0.55)	(-0.04)	(-0.62)	(-0.04)
Rho2	-0.24					
Rho3	-0.33**	0.10				
Rho4	0.07	-0.30	-0.27*			
Rho5	-0.51***	-0.42**	0.04	-0.12		
Rho6	0.17	0.67***	0.25***	-0.22	-0.24*	
Observations	**720**	***** *Coefficients significant***	***at 1%***			
Log Likelihood	**-399.62*** **	***** *Coefficients significant***	***at 5%***			
Lr Chi2(33)	**195.07*** **	*** *Coefficients significant***	***at10%***			
P-Value	**0.000**					

Source: Field Survey

Educational level of the household head: This variable significantly and positively affected changing processing time (1%), monitoring weather changes (5%) and increasing future quantity of cassava purchased (5%). This result as shown in table 3 supports the research of Ali and Ereinstein, 2017; Alam *et.al.*, 2016, Alam 2015, Gebrehiwot and van der Veen, 2013. The papers all agreed that educated processors may be more aware and perceive climate change, they can easily understand and interpret information compared to processors with lower level of education.

Years of Processing Experience: Coefficient of years of processing experience as shown in table 3 is also significant ($p<0.01$ and $p<0.05$) and negative for four of the adaptation strategies, implying that an increase in this variable will decrease in the probability that the processor will choose each of these adaptation options respectively. This is in support of Adams, 2015who claimed that experienced cassava farmers recognizes cassava as a climate resilient crop to some degree thus decreases their level of climate change adaptation.This finding however is contrary to thatof Evengelista, (2013); Alam (2015); Nhemachena and Hassan (2008); Deresa (2007); who found out that the more experienced peasant workers are the more likely they are to adapt than the less experienced for other arable crops.

Length of Residence in the Community: This indicator is positive and significant for diversifying into processing of other products (5%) and storing of products but negative for diversifying into non processing activities probably because cassava processing isless affected by climate change compared to other products which is in tandem with Adams, 2015. With increasing length of residence in the community, processors have information about where to get available resource as a cost effective rate, understand the terrain of the locality and also sees processing activities as a profitable business compared to non-processing activities.

Secondary/non-farm income: The result of the model indicated that off/non-farm income increases diversifications as adaptation strategies to climate change. The implication of the result was that availability of off /non-farm income improves farmers' financial position, which, in turn, enables them to purchase farm inputs such as seed, fertilizer and materials needed for irrigation. Mulwa *et al.* 2016; reported contradictory result. However secondary income decreases the adoption of local weather prediction, changing processing time and storage of produce, reasons for these findings may be due to the fact that the latter adaptation strategies requires little or no cost to implement. This finding is in support of Mulwa *et al.*2016, they claimed that farmers with access to non-farm incomes may be less exposed to production risks because their reliance on agricultural income and their own food production is lower than that of the median rural household.

Extension contact: The result of the model indicated that access to extension has positive and significant (1%) impact in the storage of cassava products to reduce the negative impact of climate change. The reason behind it is that extension helps disseminate innovations, efficient and cost effective methods of carrying out agricultural practices. The focus of extension contacts in the study area may promote cost effective means of preserving cassava produce as an adaptation strategy. These findings are in conformity with Boansi *et al.*, 2017; Tambo, 2016; and Aymone, 2009.

Marital Status: Table 3 shows that the married processors have the likelihood to diversify into non- processing activities and storage of produce compared to singles while being married has a negative but significant influence on non-cassava products diversification and change of processing periods. This result may be due the fact that the former requires more labour in form of family labour as compared to the latter adaptation strategies.

Gender of Household Head: Male are less likely store cassava products compared to their female counterparts as shown in table 3 mostly because most cassava processors are females. Females generally tend to plan for unforeseen circumstances compared to the males. It is in contrast with Alam *et al.*, 2016; Deressa *et al.*, 2011, which stated that Male-headed households often have a higher likelihood of adopting agricultural innovations and thus more adapted better to climate change.

CONCLUSION AND RECOMMENDATIONS

Different adaptation strategies are adopted by processors in combating the negative effects of climate variability in order to maintain and/or to improve their livelihood. The study indicated that 48%, 45%, 34%, 23% and 19% monitors weather by indigenous means, diversify into other non-processing activities, change processing time, store produce, diversify into processing of other products respectively.

Multivariate probit model was employed to determine the factors influencing processors choice of adaptation strategies related to climate change. The result of the model revealed that processors Diversify more into other processing products, Diversify into non-processing activities, Monitor weather change by indigenous knowledge, Increase the quantity of cassava purchased the following season, change processing time and store cassava products. While processors decisions to adapt diversify more into other processing products and forecasting weather change by indigenous knowledge; changing processing time and products diversification; changing processing time and secondary activity diversification; store produce and change processing time are carried out in a substitute way storing of produce and secondary activity diversification; storing of produce and monitoring weather change are adopted in a complementary fashion.

Multivariate probit model result also iterates that family size, secondary income, access to extension contact, years of processing experience, educational level, length of residence in the community, and marital status are crucial features shaping processors decisions to adopt adaptation strategies. The study also pointed out the dominance of the female gender in the cassava processing activity with more yearning to store produce as a measure of combating climate change. This study therefore recommends improved education and awareness of climate change adaptation options in form of formal and extension education be disseminated to cassava processors in the study area.

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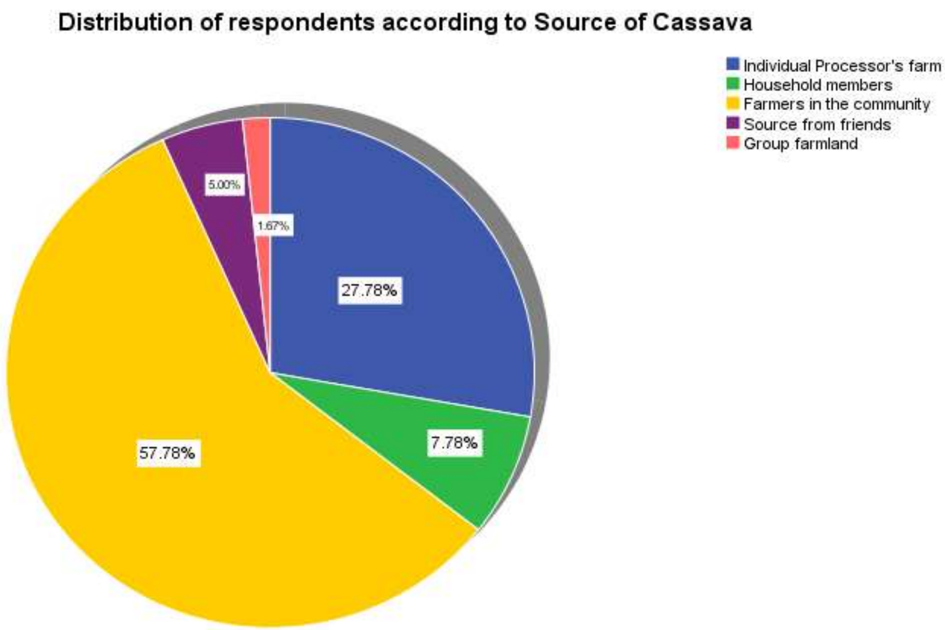

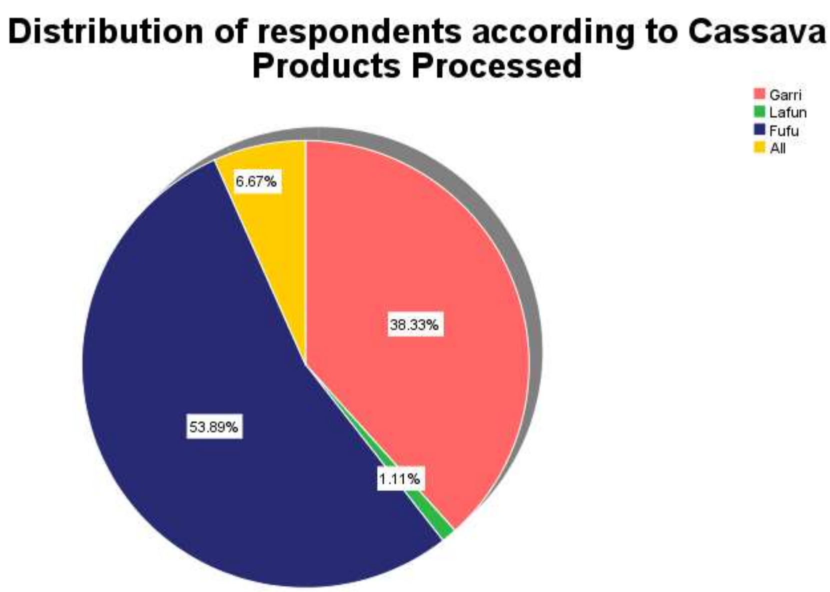

APPENDIX

Figure 1 Distribution of Respondents According to Source of Cassava

Figure 2 Distribution of Respondents According to Cassava Processed Product

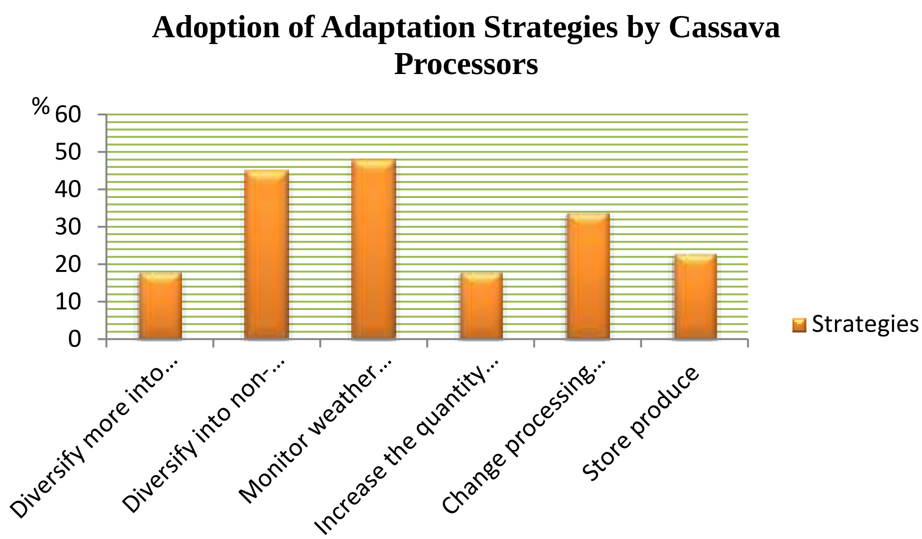

Figure 3 Shows the Distribution of Respondents According to Adaptation Strategies Ad