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Rate of adoption and Factors influencing the rate of conservation agriculture adoption in the Bawku Municipality, Ghana.

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Table of Contents

Abstract:

Conservation agriculture (CA) serves as an alternative to conventional farming practice. This study seeks to investigate the factors influencing the rate of conservation agriculture adoption.

The study was conducted in the Bawku Municipality of the Upper East Region of Ghana. Data was gathered through a cross-sectional farmer household field survey, using a structured questionnaire. Out of the 20 variables estimated, 11 of them were statistically significant and 9 insignificant. Conclusion: The factors that influence the rate of CA adoption in the Bawku Municipality are grouped into socio-economic, farm biophysical factors, institutional and exogenous factors. The research Recommend that, in planning for the farmer to adopt CA, farmers, NGOs, governments and all relevant stakeholders should make relevant use of the above categorisation of the factors to increase the rate of adoption

KEYWORDS: conservation agriculture, alternative production, food productivity. Rate of adoption.

1.0 Introduction:

The low productivity in Africa is attributed to conventional farming techniques Bjornlun et al. (2020). Traditional tillage practices degrade the quality of many vital natural resources, including soil, water, biodiversity, and the ecosystem services supplied by nature (Dumansky et al., 2014; Kassam et al., 2014; Bach et al., 2020; Nabel et al., 2021).

These degradations of the land resource base have caused crop yields and factor productivity to decline and have promoted the search for an alternative production system that is ecologically sustainable, as well as profitable to farmers (Kassam et al., 2014; Rodriguez et al. 2017).

For instance, soil erosion, water losses from run-off, and soil physical degradation will be minimized by reducing soil disturbance and maintaining soil cover (Pittelkow et al., 2015).

One of the production methods that could improve food productivity is conservation agriculture (CA). CA is one of the alternative sustainable agricultural production methods that could mitigate the impact of climate change.

There is evidence that the CA production system increases food productivity, soil fertility and enhances water retention capacity thereby enhancing food security and food availability for smallholder farmers (Steffen et al. 2015; Rodriguez et al. 2017; Fisher et al. 2018; Udimal et al. 2019; Gruhn et al. 2020). Others also view it as a solution to biodiversity and water scarcity challenges worldwide (Gattinger et al., 2011).

With some of the benefits discussed above, CA adoption is expected to be worldwide and evenly spread all over the continents and all countries, as seen in conventional farming practice, but the situation is different in other countries. There is a low rate of CA adoption in Africa (Kassam et al., 2019) and sub-Saharan Africa (Ouedraogo et al., 2019). The low rate of adoption was revealed

ISSN 2229-5518

in a comparative study conducted in Tamale (Ghana) and Kakamega (Kenya) to determine the rate of CA adoption. The results indicated that only 3% of the farmers in Tamale adopted all the recommended CA practices by FAO, as compared with a 37% rate of adoption in Kakamega (Kenya) (Adolwa et al., 2019). Despite several interventions or measures being taken to promote the adoption of CA in northern Ghana, upper west, upper east, savannah and northeast regions of Ghana (USAID ADVANCE & IFCC, 2017),

The main objective of this study is to investigate the rate of CA adoption, and the factors influencing the rate of CA adoption in the Bawku Municipality.

The probit regression model will be used to investigate the factors influencing the rate of CA adoption in the Bawku Municipality.

2.0 Literature Review

2.1 The theoretical framework of the study

The decision to adopt in agriculture has the advantage of helping both farmers and researchers to determine their profit maximization or the utility maximization of consumers. Shiferaw et al. (2014) indicate that the main theoretical foundation of agricultural innovation or technology adoption is the theory of consumer behaviour (behavioural theory), especially the random utility theory. A farmer adopting conservation agriculture (CA) has the option of being a net adopter or non-adopter. This involves decision making following the assumption that the utility that a farmer derives from adopting a conservation agricultural practice can be ordered. Setting a utility maximization objective implies a farmer chooses to adopt conservation agriculture which provides him or her with maximum utility. The assumption of completeness shows the net benefit or utility

(U) from each or a combination of them can be compared. The transitivity assumption states that, given a range of innovations and technologies, or a combination (y),

$$\text{If } U(y_1) \geq U(y_2) \text{ and } U(y_2) \geq U(y_3) \text{, then } U(y_1) \geq U(y_3) \qquad [2]$$

From the above, given that a smallholder farm has three different sets of agricultural production technology to adopt as represented by y1, y2 and y3. If a given set of technology y1>y2 and y2>y3 the farmer adopt y1 since it provides more satisfaction as compared to y2 and y3 and vice visa Again, given that y1 ≥y2 ≥ y3 the smallholder farmer will adopt any of these techniques because any of them provide the same satisfaction

2.2 Theoretical specification of the model

Binary Probit Model

To hypothesize the linear connection of the factors influencing the adoption or non-adoption of conservation agriculture practices, a binary probit regression will be utilized. In contrast to the Bayesian averaging model and duration analysis. The assessment of literature shows that logit and probit models are the most common choice models in economics for studying agricultural technology adoption.

The two popular models differ essentially in the distribution of the error terms. Udimal et al. (2017) in their study accessing the factors influencing the Agricultural Technology Adoption using the case of improving (Nerica) rice variety in Northern Ghana found that “Both logit and probit models are suitable for studying the adoption of Agricultural Technology. The choice of either model is left to the individual researcher and the assumptions made about the error term. Both models gave the same signs/direction of change; the difference was their coefficients. There were not many differences found in terms of altering the interpretation of the results. Whilst logit assumes a logistic distribution, probit assumes a normal distribution. The dependent variable in

ISSN 2229-5518

both cases may be binary or multinomial. For estimation, the dependent variable undergoes a natural logarithmic transformation. The independent variables or covariates are usually policy variables.

In practice and from the empirical review, the common covariates in the study of CA technology adoption are farm and farmer characteristics as noted earlier. Duration analysis, which is also less popular than logit and probit, has a long history in biometrics and statistical engineering (Burton et al., 2003). This seeks to capture the time between the availability of the technology to the time of adoption. This method is capable of handling diffusion and adoption together. Duration analysis can also be used to model entry and exit decisions as a process of choice of when to adopt and when to abandon Djokoto et al. (2016). Unlike logit and probit models that rely on one equation for estimation, duration analysis relies on two important concepts (equations), the hazard function and the survivor function that are related in a one-to-one relationship Djokoto et al. (2016). Since the current study seeks to study adoption rather than diffusion, the probit procedure was employed but nonetheless, the Logit model could have been used too.

The probit model with a normal constant distribution function (CDF) transformation functions assumes the existence of a latent unobserved variable Y_i^* This Y_i^* is considered as a tendency in favour of the event of interest. This Y_i^* is assumed to be linearly related to the observed characteristics.

Following Greene (2003) the probit model is therefore given as follows:

Let: $Y_i^* = X_i^* z + e_{1i}$

Where

Y_i^* is the dependent variable.

ISSN 2229-5518

X_i is a $(1 \times k)$ vector of independent variables

e_{1i} is the two sided error term with zero mean and constant variance.

In practice, Y_i^* is unobservable, what we observe is a dummy variable Y_i defined by

$Y_i = 1$ if $Y_i^* > 0$ (farmer i adopted conservation agriculture), and $Y_i = 0$ if otherwise.

Thus, in this formula

$$\begin{aligned} prob(Y_i = 1) &= prob(Y_i^* > -X_i^{'} z) \\ &= prob(e_{1i} > -X_i^{'} z) = 1 - F(-X_i^{'} z) \end{aligned} \quad (2)$$

Where F is the cumulative distribution function of e_{1i}

The likelihood function is thus,

$$L = \prod_{Y_i=0} F\left(-X_i^{'} z\right) \prod_{Y_i=1} \left[1 - F\left(-X_i^{'} z\right)\right] \quad (3)$$

Where $\Pi_{Y=0}$ and $\Pi_{Y=1}$ indicate multiplication over observations where $Y = 0$ and $Y = 1$ respectively. If we assumes that the cumulative distribution of e_{1i_i} is normal we have the probit model:

$$F\left(-X_i^{'} z' X_i\right) = \int_{-\infty}^{-X_i^{'} z_i / \sigma} \frac{1}{(2\pi)^{1/2}} \exp\left(-\frac{t^2}{2}\right) dt \quad (4)$$

Where t is a standardized normal variable, i.e., $t \sim N(0,1)$.

2.3 Literature on the adopted model

Diverse approaches have been used in the literature to model factors influencing adopters' decisions on agricultural technologies, among which dichotomous choice models (Logit, Probit, and Tobit) and multiple response models (Multinomial Logit or Multivariate Probit) are widely used. A dichotomous regression model (Probit or Logit) is usually used when the data in question is quantitative and explains only the probability of adoption or non-adoption (Madala, 2005). Contrary to the logit or probit model, multinomial response models (probit or logit) deal with three or more alternative responses under the assumption of Independent Irrelevant Alternative (IIA), that is, the relative probability of someone choosing between two options is independent of any additional alternatives in the choice set (Train, 2003). The Tobit model is employed when the data set for the dependent variable is censored, and there are continuous effects of the explanatory variables on the dependent variable. The Tobit model is usually used to estimate the joint effects of factors influencing the probability and intensity of adoption (Adesina, 1996; Waithaka, Thornton, Shepherd, & Ndiwa, 2007) cited in Djokoto et al. (2016). Considerable literature exists in explaining factors influencing adoption decisions of IMV using different econometric techniques, some of which are mentioned above. Danso-Abbeam et al. (2017) used the logit model and posited that farmers' age, farming experience, and household labour, among others, significantly explain the adoption of improved maize seed varieties in Southern Zambia. Educational attainment also plays a vital role in enhancing production through farm technology adoption by increasing the capacity of farmers to access market information easily. Gebresilassie and Bekele (2015) used the Tobit regression model to study the determinants of allocation of farmland to improved wheat varieties in Northern Ethiopia. The study found that farmers with higher years of formal education have a higher probability of allocating a significant proportion of their farmlands to an improved variety of wheat seeds. This is because educated households are better skilled and can quickly synthesize production technologies and market information.

Other relevant variables that have been documented by many studies to have significant effects on the adoption of agrarian technology are on-farm and off-farm income, Diiro (2013). Diiro

(2013) analyzed the impact of off-farm income on agricultural technology adoption intensity and productivity among rural maize farmers in Uganda. The empirical results revealed that income from off-farm activities induces the adoption of improved maize varieties. However, farm households without off-farm income were more productive than households with off-farm income. Similar results on the influence of off-farm activities on-farm technology adoption were reported by Mmbando and Baiyegunhi (2016), while previous income from rice farming was found to positively and significantly influence the adoption of improved rice varieties among farm households in rural Nigeria (Awotide et al., 2016). Many pieces of literature have reported that the adoption of farm technology, including IMV, has been positively influenced by many pieces of literature. For instance, Afolami et al. (2015) indicated that household ownership of assets such as radio, television and mobile phones are significant sources of information for new farm technology and hence the likelihood of increasing the level of adoption. A study by Awotide et al. (2014) in South-Western Nigeria found a negative and significant relationship between total farm size and the adoption of an improved cassava variety. Similar results were reported by Teklewold et al. (2013) and Kassie et al. (2013). Awotide et al. (2016) also examined factors influencing the adoption of improved rice varieties (IRV) in rural Nigeria using the Tobit regression model, where the dependent variable (intensity of adoption) was defined as the proportion of farmland allocated to improved rice varieties. Their empirical results identified factors such as membership of a Farmer-based Organization (FBO), the level of training, and distance to the seed input shop as positively and significantly affecting the intensity of IVR. Regarding the effects of extension services on agricultural technology, a study by Ugwumba and Okechukwu (2014) and Ojo and Ogunyemi (2014) found a positive and significant influence of extension services on an improved variety of cassava among Nigerian farmers. A similar study suggested that the credit-constrained conditions of farmers explain both the probability and the intensity of adoption of sustainable farming practices (Teklewold et al., 2013).

Methodology

3.0 Introduction

Research methodology is described as the techniques employed by the researcher to collect and analyse data (Leedy and Ormrod, 2013).

3.1 Philosophical Perspective

A Positivist quantitative research philosophy was used for the study.

Bryman (2006) identifies a paradigm as a cluster of beliefs and dictates that, for scientists in a particular discipline, influence what should be studied, how research should be done, and how results should be interpreted. Bryman indicated that researchers could make use of models of reality that quantify flows of relationships and embody a view of social reality as an external, objective reality.

3.2 Study Area

The study was conducted in the Bawku municipality. The Bawku municipal has a total land area of 247.23720 km2 and it is located approximately between latitudes 11o 111 and 100o 401 North and longitudes 0o 181 W and 0o 61 E in the northeastern corner of the region. The Bawku Municipality has its administrative capital at Bawku. It is one of the 16 MMDAs in the Upper East Region of Ghana. The Municipality has a total population of 98,254 and a farming population of 68,600 MOFA (2019). The dependency ratio in the municipality is 87.4; the child dependency ratio is 40.3, while the old-age dependency ratio is 6.3. The sex ratio is 92.1. The urban population is 63.6 per cent of the total population, while the rural population constitutes 36.4 per cent.

It shares boundaries with Pusiga District to the North, Binduri District to the South, Garu-Tempane District to the East and Bawku West to the West (GSS, 2016).

soil.

The soils in the municipality are generally of the Savannah ochrosol type. Detailed soil classification reveals three different soil series. These are: the Varempare series, Tafali series, Gule and Brenyasi series. "The soils in the Bawku Municipality, as typified by research results at Manga, show low nutrient properties compared with the standards. This renders the fertility of the soils low and normally requires the application of organic manure, chemical fertilizer, and other soil management practices to support agricultural production, "GSS (2016).

3.3 Research Design

A research design is a grand plan for particular research that shows how one intends to conduct the research (Nsingo, 2005). Yin (1994) also described research design as the logic that links the data to be collected and the conclusions to be drawn to the research questions. This implies that research design refers to the overall strategies and approaches used in data collection, analysis and interpretation of facts to avoid a situation in which the evidence does not address the research questions and hence maximizes the validity, reliability and credibility of the research findings.

The research design adopted for the study was survey design.

3.5 Number of samples

The Representative sample size was determined and used for the study to ensure that it was large enough to minimize the sample variance and ensure that the expected value of the sampling distribution of the sample estimates equated to the population parameters. The target population for the study was farmers in the Bawku Municipality.

In all, a total of 400 household farmers were interviewed.

The Snedecor and Cochran (1989) sample size formula was used to determine the sample size for the study,

$n=N/(1+N(\alpha^{(2)}))$

Where, n=Sample size,

N=Sample Frame=68,600, MOFA (2019)

α=Margin of Error=5% or 0.05

And confidence level of 95%

$n=68,600/(1+68,600\,[(0.05)]^{2})=399.994=400$

3.6 Sampling technique/procedure

Multi-stage sampling techniques were employed for the study. In the first stage, purposive sampling was used to select one (1) municipality in the major conservation practice areas of the region (Upper East). The second stage (2) involves the use of a simple random sampling technique to select ten (10) communities in the municipality. The third (3) stage was the selection of forty (40) respondents from each community using the simple random sampling technique.

In all, a total of 400 farmers, regardless of the acreage, were used for the study.

3.4 Data gathering

Data for the study was both primary and secondary and was made up of quantitative data. The data was gathered through a cross-sectional field survey using a structured questionnaire. A total of 400 respondents, maize farmers, were interviewed but after cleaning 358, for the study.

3.7 Data examination

The study employed quantitative techniques in the analysis. Stata software was used to run a regression statistical analysis of the respondents' scores on all the statements in each of the sections of the questionnaire. The test of significance was primarily performed at the probability level of 10%.

The main objective of the study was to identify the factors influencing the adoption or non-adoption of CA in the Bawku Municipality and analyze them with the aid of a binary probit regression model. The model was used to postulate the relationship between the factors influencing the adoption or non-adoption of CA.

3.8 Empirical specification of the binary probit model

$$\begin{aligned} Adoption = {} & \beta_0 + \beta_1 Age + \beta_2 Gen + \beta_3 Educ + \beta_4 HHsize + \beta_5 Marst + \beta_6 Pyield + \beta_7 Fsize \\ & + \beta_8 Croptyp + \beta_9 Foutput + \beta_{10} HHincome + \beta_{11} Accland + \beta_{12} Flabour \\ & + \beta_{13} Govpolicy + \beta_{14} Offarm + \beta_{15} Training + \beta_{16} Accre + \beta_{17} Accirr \\ & + \beta_{18} AccExt + \beta_{19} AccInfo + \beta_{20} MFBO + \varepsilon \end{aligned}$$

Table 3.1 Determinants of adoption of conservation agriculture

Variable	**Definition of variables**	**Measurement of variables**	***A-priori***
Farmers socio-economic			

ISSN 2229-5518

Characteristics			
Sex	Sex of household head	Dummy, 1 if male, 0 if otherwise	+/-
Age	Number of years	Continues	-
Household size	Number of people eating from the same bowl in the house	Continues	+/-
Marital Status	Famers marital Status	Dummy	+
Education	Level of schooling	Years	+/-
Potential yield	Number of bags per acre	50 kg bag	+
Farm Biophysical			
Cropping system	Type of cropping system	Dummy	
Farm size	number of acres	Continues	+
Farm output	Number of bags per acre	50 kg bag	+
Institutional			
Family labour	Number of family labour	Continues	+
Income	Amount in GHC	Continues	+
Land tenure	Ownership of land	Dummy	+
Access to credit	Access to credit by farmer	Dummy	+
Off-farm activities	Activities farmer engage outside farming	Dummy	+/-
Training	Training is given to farmers concerning CA	Dummy	+
Gov't policy on CA	Gov't policyon CA	Dummy	+/-
Exogenous factors			
Irrigation Usage	access to irrigation	Dummy	+/-
FBO	membership to FBO	Dummy	-/+
Access to information	Ease of obtaining information	Dummy	+
Extension services	Access to agricultural	Dummy	+/-
Other factors	Any other relevant factors not captured	Dummy	+/-

Results And Discussions

4.0 Introduction

This chapter presents the results and findings of the study. Ogah (2013) contended that discussion of results/ findings in a study is aimed at doing two things: first to show how the findings of the current study fit into existing knowledge, and secondly, to articulate the implication of the findings to life. The study was conducted with the main objective of investigating the factors influencing CA adoption or non-adoption in the Bawku Municipality.

4.1 The adoption rate

The majority of the farmers 292 (81.72%) of the farmers adopted CA with non-adopters being 66 (18.28%) implies a high rate of adoption in the study area as represented in (Table 4.1).

This finding contradicts the findings of Kassam et al. (2015) and Adolwa et al. (2019) who found the CA adoption rate to be below.

Table 4.1: The adoption rate

Conservation Agriculture	Frequency	Percentage
Adopters	292	81.72
Non – adopters	66	18.28
Total	358	100.00

Source: Computed from Household Survey Data,2020

Furthermore, various practices of CA components adoption rate were investigated and the results are reported in a table in 4.2. The results showed that the main practices of CA in the study area were no-tillage with cover crops (9.22%), minimum tillage with cover crops (69.55%), crop rotation with cover crops (18.16%) and crop residues/ biomass retention (3.07%) been the list adopted.

Table 4.2 various components of CA and their rate of adoption in the Study Area

CA Practice	Frequency	Percentage (%)
No-tillage with cover crops	33	9.22
Minimum tillage with cover crops	249	69.55
Crop rotation with cover crops	65	18.16
Residue/Biomass retention	11	3.07
Total	358	100.00

Source: Computed from Household Survey Data, 2020.

Although the above mention was the main CA practice in the study area, Composting/compose preparation was also identified as another CA method often used by farmers in the study area.

The findings further reveal that all the sample farmers (358) representing 100% agreed that CA methods like No-tillage, minimum tillage, crop rotation, crop residues retention and other soil management practices like composting, animal dung/ animal manure application, was used as an alternative to the above CA practices in the study area and they are as old as Agricultural production itself. The finding agrees with the position of Fernandes et al. (1981) and Hobbs (2008) who share the view that conservation tillage (CT) is an old age practice that was borne out of the American dust bowl of the 1930s.

Again, the above finding is similar to the finding of Zulu-Mbata et al. (2016) who found that 8.8% of smallholder rural households practised CA in the 2013/14 agricultural season, with 3.7%

adopting the full CA package (minimum tillage, maize-legume rotation and residue retention) and the remainder adopting partial CA (minimum tillage with either maize-legume rotation or residue retention).

4.2 Estimates of the Probit Regression Results for the Adoption of CA

The estimated results of the factors influencing conservation agricultural adoption from the Probit regression model are presented in table 4.3.

The log-likelihood value of -22.2909 and the Wald Chi-square of 85.56 indicates that the likelihood ratio statistics are highly significant ($P < 0.001$) suggesting the model is a good fit and has strong explanatory power. The pseudo R^2 of 0.8708 showed that the explanatory variable explained about 87.1% of the variation in choice of conservational agricultural practices. This means that the empirical Probit regression model is highly significant in explaining the choice of conservational agricultural practices by maize farmers in the study.

Table 4.3: Probit estimates of determinants of adoption of conservation agricultural practices

Variable	Coefficient	Robust Std. error	P-value
AGE	-0.0477***	0.01063	0.000
GENDER	1.5383***	0.4667	0.001
EDUCATION	0.1119*	0.0617	0.070
HOUSEHOLD SIZE	0.2071**	0.0887	0.020
MARITAL STATUS	0.8351**	0.4173	0.045
FARM SIZE	0.7689***	0.2133	0.000
HOUSEHOLD INCOME	-0.1283NS	0.1532	0.402
ACCESS TO	1.2600***	0.4376	0.004
INFORMATION	-0.4193NS	0.6417	0.513
ACCESS TO LAND	-0.4370NS	0.4743	0.357
TRAINING	1.2180**	0.5094	0.017
CROPPING TYPE	0.6954 NS	0.4801	0.147
ACCESS TO IRRIGATION	1.6081***	0.5676	0.005
CREDIT	0.1054 NS	0.3384	0.755
	2.5318***	0.5960	0.000

ACCESS TO EXTENSION	1.0467NS	0.8283	0.206
CONTACT	0.8286*	0.4606	0.072
GOV'T POLICY	-0.1139NS	0.4879	0.815
POTENTIAL BENEFIT OF	0.1011 NS	0.4782	0.832
CA	0.0204 NS	0.0941	0.829
MEMBERSHIP TO FBO	-5.4676**	2.5470	0.032
OFF-FARM ACTIVITIES	358	* Significance at 10%	
FAMILY LABOUR	85.56	** Significance at 5%	
OUTPUT/YIELD	0.001	*** Significance at 1%	
Constant	0.8708		
Observations	-22.290935		
Wald Chi-square			
Prob > chi2			
Pseudo R2			
Log pseudolikelihood			

Out of the 20 variables estimated, 11 of them were statistically significant and 9 insignificant. The insignificant variables include household income, access to land, training, access to irrigation, access to extension contact/services, a potential benefit of CA/profit orientation, off-farm activities, family labour and output/yield with the rest being significant. The significant levels range from 1%, 5% and 10%.

These variables/factors were further grouped into socio-economic factors, farm biophysical, institutional factors and other factors.

4.2.1 Socio-economic factors influencing the rate of adoption or non-adoption of CA in the Bawku Municipality.

Six socio-economic variables were included in the probit model to estimate the probit regressions results for the adoption of conservation agriculture. Out of the 6 socio-economic variables estimates, 5 of them were statistically significant as shown in table 4.3 above.

Age

Advancing/increasing in age reduces the probability of adopting conservational agricultural practices and is statistically significant at 5%. This implies that for every unit increase in age leads to a decrease in the rate of CA adoption. Age is statistically significant at 1% as indicated in the Table 4.3 probit regression model above. This finding agrees with the study of (Mauceri et al., 2005) cited in Udimal et al. (2017; 2019) and Teklewold and Kohlin (2011) who reported that older farmers are risk-averse to technology adoption. However, the results are contrary to the findings of Islam et al. (2012), who observed that older farmers are experienced and readily adopt new technologies.

Gender

Gender influences the probability of the adoption of CA and it is statistically significant at 1% as shown in the probit table 4.3 above. The possible explanation could be that males are traditionally seen as the ones in control of the family land and are at the centre stage of decision-making regarding farming and its associated activities.

Education

Education positively influences the probability of adoption of conservation agricultural practices. This implies that for every unit increase in the number of years of education brings about a resultant increase in the adoption of CA by 11.2%. Education is statistically significant at 10% as shown in the probit table 4.3 above. The finding supports (Tiwari et al., 2008; Miheretu & Abegaz, 2017) who observed that education positively and significantly affect the adoption of agricultural technology. However, Udimal et al. (2017) found education to have negatively and insignificantly influenced farmer adoption of Nerica rice technology.

Household size

The results showed that household size increases the probability of adopting the conservational agricultural practice. This implies that every unit in Household size brings about a resultant increase in CA adoption. Household size is statistically significant at 5% as shown in the probit table 4.3 above. This finding is consistent with that of Danso-Abbeam et al. (2017), who found that household size is significantly and positively related to the adoption of improved maize variety in the northern region of Ghana. Also, the finding agrees with Ouma et al. (2002) cited in Udinal (2017) and Sodjinou et al. (2015) who indicated that the cost of labour is a hindrance to technology adoption and therefore, an increase in household size could reduce the high cost associated with labour and hence increase adoption.

Marital Status

The marital status of a farmer positively impacts the adoption of conservation agricultural practices and is statistically significant at 5% in table 4.3. This implies that married household heads are more willing to adopt conservation agriculture than their unmarried counterparts. The result shows that a unit increase in marital status will increase household labour, and farmers with more household labour are willing to adopt CA as compared to their colleagues with less labour. This result agrees with the finding of Udimal et al. (2017) who also found the coefficient of family labour to be positive signs about the adoption of Nerica rice, and explain that farmers with family labour are more likely to adopt Nerica rice than those without family labours because Nerica rice requires timely planting, prompt weeding and harvesting and all these activities are labour demanding, as a result, farmers who are assured of labour are more likely to adopt than those that are not sure of their chances of getting labour.

Output

Crop yield was postulated to positively influence the likelihood of farmers adopting conservation agriculture. The more yield farmers expected to get, the more they are willing to invest in innovation. Hence the higher the likelihood of farmers adopting conservation agriculture. Though the finding met the positive postulation of potential yield influencing adoption of conservation. However, the finding was not statistically significant as shown in table 4.3.

Household income

Household income plays a role in financing the uptake of innovation. Serman and Filson (1999) and Mwangi & Kariuki (2015) argued that high farm income improves the capacity to adopt agricultural innovations as they have the necessary capital to start the innovation. However, the results indicated that household income was not significant in explaining the factors influencing the adoption of conservation agriculture in this study area as shown in Table 4.3 above.

4.2.2 Farm biophysical factors influencing the rate of adoption or non-adoption of CAP in Bawku Municipality

Farm size

Farm size was one of the biophysical factors that were used in the probit model to investigate the adoption of CA in table 4.3. Farm size positively influences the adoption of conservation agriculture and is statistically significant at 1%. This implies that farmers with larger farms are more willing to adopt conservation agriculture than those with smaller farms. Alternatively, a unit increase in farm size brings a resultant influence in farmers decision to adopt CA by 99%.

The effect of farm size on CA adoption appear ambiguous. A study from South Africa showed that farmer adoption of CA is negatively correlated with farm size (Ntshangase et al., 2018), while a study from Zimbabwe showed that farm size had a positive effect on CA adoption (Kunzekweguta et al., 2017)cited in (Rodenburg et al., 2020). Lalani et al. (2016) found no evidence of an adoption unfairness towards the better-off and larger scale farms in Mozambique; they observed CA be beneficial for the extreme risk-aversive poor farmers. This appears to be confirmed by Brussow et al. (2017) who observed the strongest crop income effects from mulching in the group of marginalized farmers and a decrease in this effect with increasing levels of farm output.

Cropping system

Again, the results in the probit model in Table 4.3 shows that farmers who practice mixed farming were more willing to adopt conservation agriculture than their counterparts in mono/single cropping. The inferences drawn from the above finding is that smallholder farmers are risk-averts and will not want to experiment on new agricultural technologies which outcomes are not certain on their small pieces of land because their entire livelihood depends on the farm for their survival. This finding supports the call for agricultural technology adaption rather than adoption (Long et al., 2003) cited in (Millar, 2018) and (Rodenburg et al. 2020b).

Potential Benefit

Profit orientation in the form of potential benefit both in a form soil and environmental benefit of adopting CA were postulated to positively influence the adoption of CA technology. The more benefit farmers expect to drive from adopting a particular agriculture technology, the more they are willing to invest in that technology/innovation. Hence, the higher the likelihood of farmers adopting conservation agriculture. Though the finding met the positive postulation of potential benefit influencing adoption of conservation. However, the finding was not statistically significant as shown in the probit regression in Table 4.3 above. However, Ouédraogo et al. (2019) found potential benefit or profit orientation to be statistically significant in adopting Nerica rice technology as compared to those who just want to break even.

Access to Irrigation

Access to irrigation was found to be positively and statistically insignificant in CA adoption in the study area as shown in table 4.3 above. This finding is supported by Mumin (2017) and Chuchird et al. (2017). However, Kudadze et al. (2019) in their found that water unavailability is not a major challenge to most irrigation farmers.

4.2.3 Institutional Factors Affecting the Adoption of Conservation Agriculture

Seven (7) institutional variables were included in the probit model to estimate the probit regressions results for the adoption of conservation agriculture. Out of the 7 institutional variables estimates, 2 of them were found to significantly influence the adoption of conservation agriculture as shown in the probit regression Table 4.3 above.

Access to credit

Access to credit was one of the institutional factors that have a positive coefficient and are highly statistically significant at 1% as shown in Table 4.3 above. This implies that a unit increase in access to credit brings about a resultant increase in CA adoption. The finding is consistent with Danso-Abbeam et al. (2017 and Udimal et al. (2017) who found that having access to credit positively and significantly affected farmers' decisions to Agricultural technology. Also, Fisher and Carr (2015) found a positive but no significant relationship between access to credit and CA adoption. However, the finding is contrary to that of Nyanga (2012), whose finding indicated that access to credit reduced the likelihood of CA adoption in their study.

Government Policy

The government policy has a positive effect on the adoption of conservation agriculture as shown in Table 4.3 above. This finding is consistent with Kassam et al. (2014), who explained that government interventions aimed at encouraging the adoption of conservation agricultural practices among farmers can be justified by the frequent divergence between the narrow interests of profitoriented individuals and the broader interests of society. Government policies in the form of Subsidies may make fertilizer inputs more affordable and thereby add to increased adoption, but such solutions are unlikely to be untenable in the longer term (Ward et al., 2016) and may also indirectly de-incentivize the use of organic soil amendments (Khataza et al., 2017). High dependence on government grants, rather than direct farm proceeds as an income source, may also demotivate smallholders to adopt innovations like CA (Muzangwa et al., 2017) cited in (Rodenburg et al. 2020).

Labour

The prior expectation of examining the impact of labour (family or hired) in the adoption of conservation agriculture is met. The results highlighted a positive but no significant correlation between labour and conservation agriculture as shown in Table 4.3 above. The finding is consistent with Ouma et al. (2002). Udimal et al. (2017). They found a positive but no significant relation between labour and agriculture technology adoption.

Off-farm activities

The results further revealed that the presence of off-farm activities has no significant relationship with the adoption of conservation agriculture as shown in Table 4.3 above. This result is in line with the findings of Smit and Smithers (1992); Knowler and Bradshaw (2007); Udimal et al. (2017) who also found an insignificant relationship between off-farm activities and adoption of conservation agriculture.

Access to land/ Land tenure

Land tenure was postulated to influence CA adoption. The results revealed that land tenure was not a significant factor and negatively influenced the adoption of CA as shown in Table 4.3. Bewket (2007), explained that land users must have secured property ownership rights of the lands they cultivate if they are to invest in conservation work in anticipation of long-term benefits. This supports the argument that farmers who own the land they cultivate take good and proper care of the land than those farmers who leased land. The results, however, revealed that land tenure was not a significant factor influencing the adoption of conservation agriculture in the study area. This finding is in line with the findings of Nowak, (1987) and De Harrera and Sain (1999). Clay et al. (1998); Neill and Lee (1999) found a positive correlation between land tenure and the adoption of conservation agriculture. However, Smit and Smithers (1992) and Fuglie (1999) observed that land tenure negatively affects the adoption of conservation agriculture.

Training

Ketema and Bauer (2002), explained that farmers' knowledge gained through training enables them to be equipped with the technical know-how required for constructing conservation structures and it makes them far-sighted to look for long-term benefits through sustainable practices rather than immediate benefits obtained at the expense of soil quality. However, the results of this study found no statistically significant relationship between training and the adoption of conservation agriculture as in Table 4.3 above. The finding agrees with that of Ketema and Bauer (2002) and Udimal et al. (2017) who found the training to be insignificant to technology adoption in their study area.

Extension contact

Access to extension contact was postulated to positively influence CA adoption. Though the results in table 4.3 indicated that the coefficient of the variable access to extension services was positive but it was not statistically significant. Ouédraogo et al. (2019) found that Farmers with extension contact improved their adoption of drought-tolerant improved variety and microdosing practices by 6% and 8% through contact with extension services as compared to those without extension contacts in their study area in Mali.

4.2.4 Exogenous Factors Affecting the Adoption of Conservation Agriculture

Access to information

The variable access to information was one of the Exogenous Factors that was used to determine CA adoption. The results in Table 4.3 shows that access to information is positively and highly significantly related to the adoption of CA. The results imply that farmers who have easy access to information are more likely to adopt conservation agricultural practices than their counterparts who do not have access to information. A unit increase in access to information brings about a resultant increase in CA adoption. This result is consistent with innovation diffusion theory (Rogers, 2003) which postulates that information access is central in the process of innovation adoption. Long (1989); Long & Van-der Poeg (1994) and Long (2003) cited in (Millar, 2018 p. 33) also found access to information to influence agricultural technology adoption. They are of the view that "farmers as a network of social actors who share innovation and information with their kin, neighbours, peers(friends), relative and colleagues farmers. Farmers as 'social actors cannot afford to be isolated in their social actions as a result of their quest for knowledge and innovations"

Membership of farmer-based organization (FBO)

Other exogenous factors that were used in the probit regression in table 4.3 above to investigate CA adoption were membership to the farmer-based organisation. The results indicate the farmer-based organization is statistically significant at 10% and has a positive influence on the adoption of conservation agriculture. This meets a priori expectation of the model. FBO is a Variable in CA adoption studies because it enables farmers to exchange services such as extension services and information sharing regarding farm activities. FBOs were found to be the major source of information for farmers in the study area. The finding is consistent with Mmbando and Baiyegunhi (2016); Danso-Abbeam et al. (2017) who also found membership to FBO critical to agricultural technology and innovation sharing.

Conclusion:

The majority of the farmers 292 (81.72%) in the Bawku municipality adopted CA with non-adopters being 66 (18.28%). That implies, there are good prospects for CA as an alternative to conventional farming in the Bawku municipality. The factors that influence the adoption of CA in the Bawku municipality are categorised in socio-economic, farm biophysical factor, institutional and exogenous Factors

Recommendation:

In planning for a farmer to adopt CA, colleagues farmer, NGOs, governments and all relevant stakeholders should be conversant with the above categorisation of factors to enable them to attain good adoption results.

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