



# Adoption of Conservation Agricultural Practices among Maize Farmers: An Alternative Livelihood to Mitigate Climate Change Impact in Bawku Municipality, Ghana

Alhassan Bawa<sup>1,\*</sup> and Abu T. Jambedu<sup>2</sup>

*1*Department of Sustainable Agriculture, Faculty of Agriculture and Natural Resources, Tamale Technical University, Tamale, Ghana

*2*Milar Institute for Transdisciplinary and Development Studies, Bolgatanga, Ghana

\*Corresponding author's E-mail address: [abawai1@yahoo.com](mailto:abawai1@yahoo.com)

**Abstract**—The plight of farmers in Northern Ghana are worsening by the impact of climate change. Warming and variability in rainfall pattern is causing floods and long dry spells of drought with resultant effects of reduced food crop and livestock production. Conservation Agriculture (CA) has therefore been introduced as a substitute to conventional agriculture for sustainable agricultural productivity. The objective of the study was to assess the rate of adoption of CA practices in the Bawku Municipality in the Upper East region of Ghana. The study was conducted in the Bawku Municipal area of Ghana. The research design used for the study was the mixed methods. The purposive sampling technique was used to select the Bawku Municipality as the major area where agricultural conservation practices occur in the Upper East region. The simple random sampling technique was used to select ten (10) communities in the Municipality, whilst the systematic random sampling was used to select forty (40) respondents from each community for the study. The target population for the study was maize farmers in the Bawku Municipality. In all, a total of 358 respondents were interviewed for the study. Data was taken on socio-cultural and socio-economic characteristics of respondents. Data analysis was done using the Statistical Package for Social Sciences (SPSS). Descriptive statistics, such as frequencies, percentages, and means were computed. Cross tabulations of variables were also computed and the chi-square tests used to establish relationships. The study revealed that age, sex, level of education, religion, household size, government policy, access to credit, source of income, farm size, and access to extension services were found to have significantly influenced adoption of CA practices. The results of the study indicated that majority of farmers were aware and had knowledge about CA practices. “No-tillage with cover crops, minimum tillage with cover crops, and crop rotation with cover crops” were the main practices of conservation agriculture in the study area. The survey also reveals that 81% of farmers adopted CA practices in full. It is recommended that the Ghanaian government should boost CA practices by instituting an annual national award scheme to award hardworking CA practitioners in Ghana.

**Keywords**—Conservation agricultural (CA) practice, Conventional tillage; Climate change mitigation, Adoption rate, Socio-economic characteristics

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## INTRODUCTION

The socio-economic conditions of farmers are worsening by the impact of climate change which is evident in all agro-ecological zones in Ghana. Average annual temperatures are projected to increase between 0.8 °C and 5.4 °C, while average annual rainfall totals are projected to decline between 1.1 % and 20.5 % for the years 2020 and 2080 respectively (Dalton et al., 2014). Global warming and variability in rainfall patterns are causing floods and long dry spells of drought with a resultant effect on food crop and livestock production. Anthropogenic activities such as crop farming, bush burning, deforestation, over-grazing and application of insecticides and chemical fertilizer on the agricultural land have exacerbated the impacts of climate

change on the environment. Adaptation is needed as a response strategy to adjust to actual or expected climate and its effects, to moderate harm or harness potential opportunities. The practice of conventional tillage by farmers, which is supposed to mitigate the effect of climate change, is also grappled with many more challenges such as low yield, soil fertility decline, bad root development and compaction of underlined layer. Low productivity systems in Africa are often attributed to conventional farming practices. However, research and development partners also view the technology as one of the solutions to the adverse effects of climate change (Gattinger et al., 2011). Conservation agriculture (CA) is one of the alternative sustainable agricultural production methods that could mitigate the impact of climate change. It is therefore likely

to be the major solution to food security, biodiversity, and water scarcity challenges worldwide (Gattinger et al., 2011).

Conservation Agriculture is defined as a set of agricultural technologies, which includes minimum soil disturbance, zero tillage, permanent soil cover, diversified crop rotations, and integrated weed management (Carter et al., 2009), aimed at reverting the many negative effects of conventional farming practices such as soil erosion, soil organic matter decline, water loss, soil physical degradation, and fuel use (Baker et al., 2002). The residue use as mulches also prevents soil erosion and rainfall infiltration which is common in sub-Saharan Africa. This degradation of the land resource base has caused crops yield and productivity to decline, hence the need to search for an alternative paradigm that is ecologically sustainable as well as profitable (Kassam et al., 2015). For instance, soil erosion, water losses from run-off, and soil physical degradation may be minimized by reducing soil disturbance and maintaining soil cover (Farooq and Siddique, 2014). Using organic materials as soil cover and including legumes in rotations may help to address the decline in soil organic matter and fertility (Kassam et al., 2015). Less soil disturbance results in less fuel use, resulting in lower carbon dioxide emissions, which is one of the gases responsible for global warming (Carter et al., 2009). Again, ICA helps to improve biodiversity in the natural and agro ecosystems (Carter et al., 2009) complemented by other good agronomic practices, such as the use of quality seeds, integrated pest management, and nutrient and water management. Furthermore, CA provides a base for sustainable agricultural production intensification. Also, yield levels in CA systems are comparatively high and even higher than traditional intensive tillage systems (Farooq and Siddique, 2014). Increasing the productivity of maize crops by using nitrogen fixation crops and biomass is a better alternative in increasing food security and food availability among smallholder farmers. CA is increasingly promoted as "a concept of crop production for a sustainable production level to achieve acceptable profit, while saving the resources along with conserving the environment" (Teklewold et al., 2013). In CA, modern and scientific agricultural technologies are applied to improve crop production by mitigating reductions in soil fertility, topsoil erosion and runoff; and improving moisture conservation and environmental footprints. I

In Ghana, farming communities have gradually shifted towards no-tillage systems for potential fossil-fuel savings, reduced erosion, and runoff, and to minimize soil organic matter loss. A large percentage of agricultural land is cropped following CA principles (Akowuah, 2010). Land preparation in the early 1980s for crop production in Ghana was mainly through the slash and burn method. As a result of low-pressure land, farmers could leave their farmlands for some years, after the soil has lost its fertility, to farm another fertile land while the abandoned land regains its fertility. This practice was considered as sustainable because of shifting cultivation (Boahen et al., 2007). However, as population growth, development and industrialization of the nation began to compete with agriculture over limited land; the practice of shifting

cultivation has therefore, gradually diminished (Boahen et al., 2007).

Adoption of conservation agricultural innovations has attracted the attention of agricultural scientists, because majority of the population in the less developed countries derived their livelihood from agricultural production (Feder et al., 1982). Government and other development partners such as NGOs and CBOs have therefore provided materials, technical and logistics support to help improve the adoption of CA practices. Sustained governmental policies and institutional support may play a key role in the promotion of ICA both in rain-fed and irrigated cropped lands, by providing incentives and required services to farmers to adopt CA practices and advance them over time (Kassam et al., 2015). The adoption of a new practice is basically an individual decision. The adoption process involves five stages as outlined by Rogers (2003). These stages include the following:

1. Awareness: The individual becomes aware of the existence of an innovation.
2. Interest: The individual develops interest and seeks further information.
3. Evaluation: The individual considers whether to adopt the new practice.
4. Trial: On a small-scale basis, the individual will try the new idea.
5. Adoption: The idea is used on a full-scale basis.

## MATERIALS AND METHODS

### *Research design*

The research design is the plan for collecting data to answer the research questions (Bell, 1993). It also includes the specific data analysis technique or methods that the researcher intends to use. Research design is the overall strategies and approaches used in the data collection. The research design used for the study was the mixed methods. That is, it combines quantitative and qualitative methods in data collection and analysis. The instruments that were used for data collection were questionnaires, interview guide and checklist for focus group discussion.

### *Sampling techniques and sample size*

Purposive sampling was used to select the Bawku Municipality as the major area where conservation agricultural practices occur in the Upper East region. The simple random sampling technique was also used to select ten (10) communities in the Municipality, whilst the systematic sampling technique was used to select forty (40) respondents from each community. The target population for the study was maize farmers in the Bawku Municipality. In all, a total of 358 farmers were interviewed. The Snedecor and Cochran (1989) sample size calculation formula was used to determine the sample size for the study:

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

Where, n = sample size,

N = sample frame

$\alpha$  = margin of error = 5% (0.05)

A total of four hundred (400) farmers were selected. However, after screening, 358 were used for the study.

#### *Data collection and analysis*

Both quantitative and qualitative data were collected from primary source for the study. Data was taken from 358 maize farmers through a farm and market survey using interview guide and checklist. Key informants (including stakeholders, nucleus farmers, extension officers, district director of Agriculture and officials of CSIR-SARI at Manga and Garu Presby Agricultural Station) were also

interviewed using questionnaire. Secondary data was also gathered from literature, MoFa and CSIR – SARI documents. Both qualitative and quantitative tools of analysis were employed in data analysis. Prior to the analysis, the data was coded. Analysis was done using the Statistical Package for Social Sciences (SPSS). Descriptive statistics, such as frequencies, percentages and means were computed. Cross tabulations of variables were also computed, and the chi-square tests used to establish relationships.

#### RESULTS

Table 1. Distribution of respondents by gender, age and level of education

Gender	Frequency	Percentage (%)
Male	213	59.50
Female	145	40.50
Total	358	100.00
Age (years)	Frequency	Percentage (%)
20 – 39	250	69.83
40 – 59	71	19.83
60 and above	37	10.34
Total	358	100.00
Level of education	Frequency	Percentage (%)
No formal education	167	46.65
Basic education	173	48.33
Secondary education	9	2.51
Tertiary education	9	2.51
Total		100.00

*Source: Field Survey, 2020*

Table 2. Distribution of respondents by marital status, religion, access to extension services and access to government policy

Marital status	Frequency	Percentage (%)
Unmarried	126	35.50
Married	191	53.35
Divorced	27	7.54
Widow(er)	2	0.56
Separated	12	3.35
Total	358	100.00
Religion	Frequency	Percentage (%)
Christian	90	25.14
Islam	200	55.87
Traditionalist	68	18.99
Total	358	100.00
Access to extension services	Frequency	Percentage (%)
Yes	166	46.37
No	192	53.63
Total	358	100.00
Access to government policy	Frequency	Percentage (%)
Yes	295	74.02
No	93	29.90
Total	358	100.00

*Source: Source: Field Survey, 2020*

Table 3. Distribution of respondents by socio-cultural characteristics and adoption of CA practices

Socio-cultural characteristics	Adoption of CA practices
Gender	
Male	59.50
Female	40.50
$X^2 = 0.362$ ; df = 1; $P > 0.05$ ; Non-significant	
Age	
20 – 39	69.83
40 – 59	19.83
60 and above	10.34
$X^2 = 4.260$ ; df = 2; $**P < 0.01$ ; Significant	
Level of education	
No formal education	46.65
Basic education	48.33
Secondary education	2.51
Tertiary education	2.51
$X^2 = 2.068$ ; df = 3; $**P < 0.01$ ; Significant	
Religion	
Christian	25.14
Islam	55.87
Traditionalist	18.99
$X^2 = 0.137$ ; df = 2; $P > 0.05$ ; Non-significant	

$X^2$  = chi-square; df = degrees of freedom

Table 4. Distribution of respondents by source of household income, farm size, household size and access to credit

Source of household income	Frequency	Percentage (%)
Farming	270	75.42
Farming + rearing of animals	13	3.63
Farming + rearing of animals + off- farm activities	75	20.95
Total	358	100.00
Farm size (acres)	Frequency	Percentage (%)
1 – 5	275	76.82
6 – 10	74	20.67
10 and above	9	2.51
Total	358	100.00
Household size	Frequency	Percentage (%)
1 – 5	229	63.97
6 - 10	111	31.00
11 and above	18	5.03
Total	358	100.00
Access to Credit	Frequency	Percentage (%)
Yes	147	41.06
No	211	58.94
Total	358	100.00

Source: Field Survey, 2020

Table 5. Distribution of respondents by socio-economic characteristics and adoption of CA practice

Socio-economic characteristics		Adoption of CA practices
Household size		
1 – 5		63.97
6 – 10		31.00
11 and above		5.03
$\chi^2 = 2.242$ ; df = 2; *P < 0.5; Significant		
Access to credit		
Yes		41.06
No		58.94
$\chi^2 = 1.068$ ; df = 1; **P < 0.01; Significant		
Farm size (acres)		
1 – 5		76.82
6 – 10		20.67
10 and above		2.51
$\chi^2 = 4.260$ ; df = 2; **P < 0.01; Significant		
Source of household income		
Farming		75.42
Farming + rearing of animals		3.63
Farming + rearing of animals + off- farm activities		20.95
$\chi^2 = 10.362$ , df = 3, ***P < 0.001 Significant		

$\chi^2 =$  chi-square; df = degrees of freedom

Table 6. Distribution of respondents by knowledge and perception about CA practices, and specific CA practices already adopted in the area

Farmers have heard about conservation agriculture	Frequency	Percentage (%)
Agreed	292	81.72
Disagreed	66	18.28
Total	358	100.00
CA practices	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: Field Survey, 2020

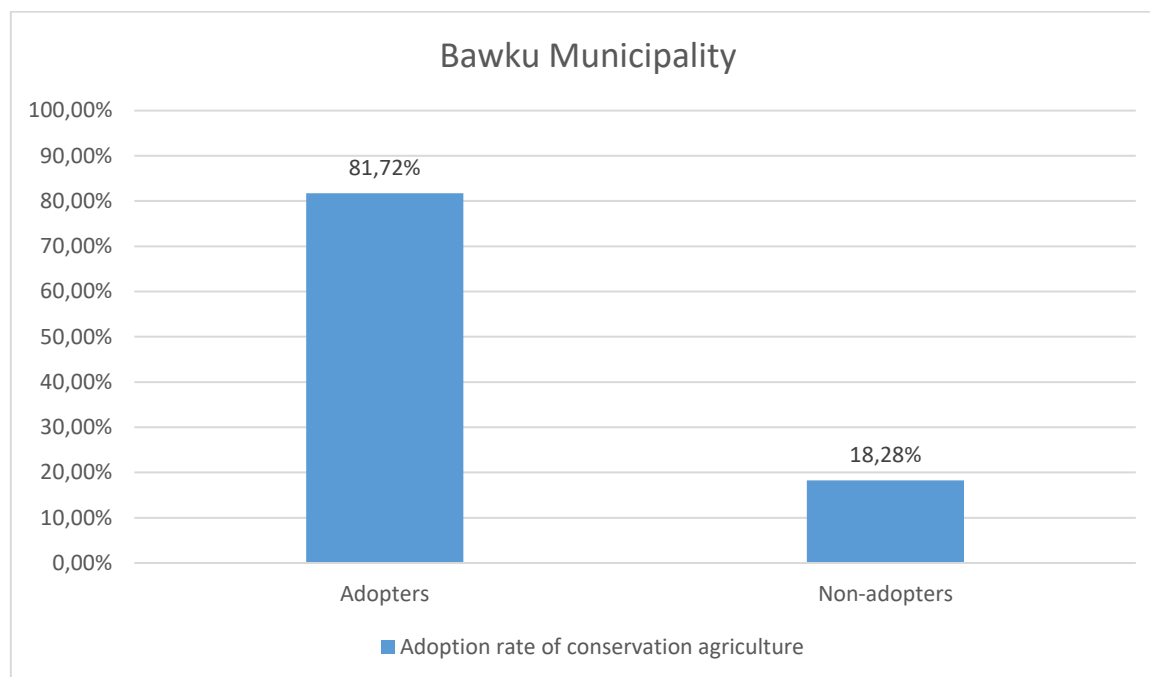


Fig. 1. Adoption of conservation agricultural (CA) practices among respondents in the Bawku municipal area

#### *Socio-cultural characteristics of respondents and adoption of CA practices*

The study reveals a significant correlation between socio-cultural characteristics of respondents and adoption of conservation agricultural (CA) practices. The socio-cultural characteristics include gender, age, religious affiliation, level of education, marital status, access to extension services and access to government policies. The chi-square test results show that at 5% confidence level, there was a significant ( $X^2 = 4.260$ ;  $df = 2$ ;  $P < 0.01$ ) difference between distribution of respondents by level of adoption of CA practices with respect to their ages (Table 3). However, the chi-square results did not show any significant ( $X^2 = 0.362$ ;  $df = 1$ ;  $P > 0.05$ ) difference between distribution of respondents by level of adoption of CA practices with respect to their gender.

#### *Socio-economic characteristics of respondents* *Source of household income*

The study reveals that household's income comes from farming, rearing of animals and off-farm activities. Out of the total sample, 270 respondents (75.42%) earn their income from farming only, whilst 13 respondents, representing 3.63%, earn their income from both farming and rearing of animals (Table 4). The remaining 20.95% of respondents earn their income from farming, rearing of animals and other off-farm activities (Table 4).

#### *Socio-economic characteristics of respondents and adoption of CA practices*

The study reveals a significant correlation between socio-economic characteristics of respondents and adoption of

conservation agricultural (CA) practices. The socio-economic characteristics include household size, access to credit, farm size and source of household income. The chi-square test results show that at 5% confidence level, there was a significant ( $P < 0.5$ ) difference between distribution of respondents by level of adoption of CA practices with respect to their farm size, access to credit, household size and source of household income (Table 5).

#### *Knowledge and perception of respondents about CA*

The knowledge and perception of respondents about conservation agricultural practices is very essential in examining the factors that influences its adoption. Out of the total sample, 292 respondents (81.72%) agreed having heard about conservation agriculture, whilst 18.28% disagreed (Table 6).

The results in Table 6 showed that majority of respondents (69.55%) were of the view that the most specific CA practice that is already adopted in the area was 'minimum tillage with cover crops'. This was followed by 'crop rotation with cover crops' (18.16%) and 'No-tillage with cover crops' (9.22%). However, the least specific adopted (3.07%) CA practice was 'residue/biomass retention'.

In a focus group discussion, the respondents expressed the following opinion:

*[Some of the main CA practices in the Bawku municipal area include No-tillage, minimum tillage, crop rotation, crop residues retention and other soil management practices like compost application, animal manure application, and tree planting. 'These CA practices are as old as Agricultural production itself', the respondents concluded. According to the respondents, the practices of*

*conservation agriculture reduces soil erosion, increases soil fertility, increases soil organic matter and improves agricultural productivity].*

#### *Specific CA practices already adopted in the area*

## DISCUSSIONS

### *Socio-cultural characteristics of respondents*

The study revealed that majority of the farmers were males. The implication is that farming is a male dominated profession in the Bawku municipality. This finding supports the observation made by GSS (2016) that 95.0% of farmers in the Bawku municipality are males with the remaining 5.0% being females. Males are traditionally seen as the ones that control the family lands and are at the centre-stage of decision-making regarding farming and its associated activities, while their female counterparts do not take an active decision regarding technology adoption (CIMMYT, 1993). This is reinforced by the cultural system which requires women to remain at home while men attend seminars, and yet do not always discuss/ teach the women what they have learnt (Mazvimavi and Twomlow 2009). The researchers also reported that women do not have access to the key productive resources of land, labour and capital, and that they are also underprivileged in terms of education and knowledge.

Farmers within the age bracket of 20 – 39 years were in the majority. Farmers within this age group are in their active age. Amir (2006) and Akudugu et al. (2012) also reported that younger household heads are more dynamic with regards to the adoption of innovations. In Karatu district, many youths (20–25 years) and some adults (36–60 years) were ready to adopt conservation agriculture technologies. Youths were eager because they are more business-minded. However, lack of capital has prevented many from adopting. Some youths did not have their own land, or they have only a small area obtained from their parents; hence they were not motivated to invest in agriculture (Shetto and Owenya, 2007). Akudugu et al. (2012) reported that older farmers tend to be risk-averse and may avoid innovations to avoid the risk associated with the initiative. The researchers furthermore observed that older people are relatively more conservative and hence, resistance to change. Mazvimavi and Twomlow (2009) also reported that older farmers with high farming experience are more likely to practice all CA technologies. This is because, they are expected to use their farming experience to decide, whether, to adopt a new technology.

The study also revealed high illiteracy rate among majority of maize farmers. High illiteracy rate is likely to reduce adoption of conservation agricultural practices. This is because education helps to improve the farmer's ability to easily determine which agricultural activity to undertake in a particular area. Level of education and training influences adoption decisions because of the assumed link between education and knowledge.

### *Adoption of conservation agriculture*

The survey reveals that majority of respondents (81.72%) adopted conservation agricultural practice whilst 18.28% did not (Fig. 1).

Religious membership in a social grouping, such as faith based organization in social linkages influence access to information. The study showed that Islam is the major religious grouping in the Bawku municipal area. This implies that information relating to CA adoption should be targeted at the mosques, so it could descend to majority of the farmers. Mignouna et al. (2011) reported that farmers within a social group learn from each other the benefits and usage of a new technology. They found membership in a social grouping, such as a faith-based society, to have a positive and significant influence on the tendency to adopt improved pigeon pea varieties. In addition, Uaiene et al. (2009) suggests that social network effects are important for individual decisions, and that, in the context of agricultural innovations, farmers share information and learn from each other.

The survey reveals that majority of farmers have access to and benefited from government policies. Government policies are likely to influence farmers' decisions to adopt or not to adopt conservation agriculture practices. The results corroborate the observation made by Arslan et al. (2012) who reported that Government policies in the form of subsidies, fertilizer, inputs, and machines for CA farmers help farmers to adopt CA. However, Djokoto et al. (2016) observed that government subsidies may serve as a disincentive to the use of organic soil amendments. Danso-Abbeam et al. (2017) also reported that a high dependence on government grants and other benefits, rather than direct farm proceeds as an income source, may also demotivate smallholders to adopt innovations like CA.

### *Socio-economic characteristics of respondents*

It was revealed from the study that majority of the farmers were in small households. The results further showed that majority of respondents were smallholder farmers with no access to credit. It is regularly hypothesized that owners of larger scale farms are more willing to invest in new technologies such as direct seed drills. Sodjinou et al. (2015) explain that large households serve as potential labour for farming. They further argue that large families enable household members to earn additional income from non-farm activities. Though large households signify the availability of labour, it also has some financial implication in terms of feeding, healthcare, education, and clothing. Many households' size can therefore constitute an economic burden. Sodjinou et al. (2015) also reported that access to credit increases the likelihood of a household adopting hybrid maize in their study area. They further observed that access to credit is a major constraint faced by households. However, access to funds/credit is likely to increase the rate of adoption of CA. Due to poverty and limited access to credit, most small-scale farmers in the country are unable to

afford basic production technologies such as fertilizers and other agrochemicals resulting in low crop yields (Birner and Resnick, 2010).

#### *Socio-economy-cultural characteristics of respondents and adoption of CA practices*

The study reveals a significant correlation between socio-cultural characteristics of farmers and adoption of conservation agricultural (CA) practices. The socio-cultural characteristics include gender, age, religion, level of education, marital status, access to extension services and access to government policies. The chi-square test showed that at 5% confidence level, there was a significant ( $X^2 = 4.260$ ;  $df = 2$ ;  $**P < 0.01$ ) difference between distribution of farmers by level of adoption of CA practices with respect to their ages. This implies that adoption of CA practices is dependent on age of farmers. This result corroborates with the observation made by Okoye (1998) who reported positive significant correlation between age and adoption of conservation agriculture. Clay et al. (1998) however, reported negative correlation between age and adoption of CA practice. However, the chi-square results did not show any significant ( $X^2 = 0.362$ ;  $df = 1$ ;  $P > 0.05$ ) difference between distribution of farmers by level of adoption of CA practices with respect to their gender. This implies that adoption of CA practices is not dependent on gender of farmers. The results also showed that at 5% confidence level, there was a significant ( $X^2 = 2.068$ ;  $df = 3$ ;  $**P < 0.01$ ) difference between distribution of farmers by level of adoption of CA practices with respect to their level of education. This implies that adoption of CA practices is dependent on level of education of farmers. This finding, however, contravenes the report of Saltiel et al. (1994) who found education to be an insignificant factor in technology adoption.

The study also reveals a significant correlation between socio-economic characteristics of farmers and adoption of conservation agricultural (CA) practices. The socio-economic characteristics include household size, access to credit, farm size and source of household income. The chi-square test showed that at 5% confidence level, there was a significant ( $P < 0.5$ ) difference between distribution of farmers by level of adoption of CA practices with respect to their farm size, access to credit, household size and source of household income. The implication is that adoption of CA practices is dependent on household size, access to credit, farm size and source of income of farmers.

The survey shows that majority of the farmers in the study area already have some knowledge and perception about the conservation agricultural practice. Farmers' perception about the performance of the technologies significantly influences their decision to adopt them. This finding is in consonance with the observation made by Karugia et al. (2004) who reported that it was important to involve farmers in the evaluation of new technologies before introducing it to them, so they can assess its suitability to their circumstances.

The results show that majority of farmers were of the view that the most specific CA practice that is already adopted in the area was 'minimum tillage with cover crops'. This was followed by 'crop rotation with cover crops' and 'no-tillage with cover crops'. However, the least specific adopted CA practice was 'residue/biomass retention'. This finding contradicts the observation of Kassam et al. (2015) who found CA adoption rate to be low. The finding, however, agrees with the position of Fernandes et al. (1981) 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. However, conservation tillage was re-packaged by researchers and promoted as if it was a new technology.

#### CONCLUSIONS

The study was conducted to examine the adoption rate of conservation agricultural (CA) practices. From the findings, the following conclusions were deduced:

Majority of farmers (81%) were aware and had knowledge about CA practices. The conservation agricultural practices reduce soil erosion, increases soil fertility, increases soil organic matter, and improves agricultural productivity. Majority of farmers (81%) adopted CA practices in full. It is recommended that the Ghanaian government should boost CA practices by instituting an annual nation award scheme to award hardworking CA practitioners in Ghana. The impact of climate change is worsening the plight of farmers in the Bawku municipal area of northern Ghana. Global warming and variability in rainfall pattern is causing floods and long dry spells of drought with resultant effects of reduced food crop and livestock production. CA has therefore been identified as a substitute to conventional agriculture for sustainable agricultural productivity, and to mitigate the effect of climate change. This study discovered that majority of farmers have knowledge about CA and have therefore, adopted the CA practices. The study also discovered that the practices of conservation agriculture reduce soil erosion, increases soil fertility, increases soil organic matter and improves agricultural productivity.

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#### REFERENCES

- Akowuah, P. 2010. IFarmers IExperience Iand IPactice Iof INo-tillage ISystem: ITowards the Adoption Iof IConservation IAggricultural IProduction in Atwima-Nwabiagya District of Ashanti IRegion, IGHana. IJournal Iof IDevelopments Iin Sustainable Agriculture I5:I191-202.



- Akudugu, I.A.M., Guo, E. and Dadzie, K.S. 2012. Adoption of Modern Agricultural Production technologies by Farm Household in Ghana: What factors influence their decision. *Journal of Biology, Agriculture and Healthcare* ISSN 12224-3208 (Paper) ISSN 12225-093X (online) Vol. 2, No. 13, 12012).
- Arslan, A., McCarthy, N., Lipper, L., Asfaw, S. and Cattaneo, A. 2014. Adoption and intensity of adoption of conservation farming practices in Zambia. *Agriculture, Ecosystems and Environment* 1187: 72–86. <https://doi.org/10.3368/le.90.1.26>.
- Amir, I.T.H. 2006. How to define farmers capacity. *Agricultural Economic Journal* 236 (3): 261 – 272.
- Baker CJ, Saxton KE, and Ritchie WR. 2002. No-tillage Seeding: Science and Practice. 2nd Edition. Oxford, UK: CAB International.
- Bell J. 1993. *Doing your Research Project: A guide for first time researchers in education and social science*, Open University Press, UK.
- Birner, R. and Resnick, D. 2010. The Political Economy of Policies for Smallholder Agriculture World Development 138 (10): 1442–1452. <https://doi.org/10.1016/j.worlddev.2010.06.001>.
- Boahen, P., Dartey, B.A., Dogbe, G.D., Boadi, E.A., Triomphe, B., Daamgard-Larsen, S. and Ashburner, J. 2007. Conservation Agriculture as Practised in Ghana. Nairobi. African Conservation Tillage Network, Centre de Coopération Internationale de Recherche Agronomique Pour Le Développement, Food and Agriculture Organization of the United Nations., 11–71. Bolliger.
- Carter, I.M.R., Noronha, C., Peters, R.D. and Kimpinski, J. 2009. Influence of conservation tillage and crop rotation on the resilience of an intensive long-term potato cropping system: Restoration of soil biological properties after the potato phase. *Agriculture, Ecosystems and Environment* 133: 132–39. <https://doi.org/10.1016/j.agee.2009.04.017>.
- CIMMYT. 1993. *The Adoption of Agriculture Technology: A guide for survey design*. Mexico. 188pp.
- Clay, D., Reardon, T. and Kangasniemi, J. 1998. Sustainable intensification in the highland tropics: Rwandan farmers' investments in land conservation and soil fertility. *Economic Development and Cultural Change* 45 (2): 351–378.
- Dalton, I.T.J., Yahaya, I. and Naab, J. 2014. "Perceptions and performance of conservation agriculture practices in northwestern Ghana", *Agriculture, Ecosystems Environment*, Vol. 187 No. 2014, pp. 165-71.
- Danso-Abbeam, G., Bosiako, A.J., Ehiakpor, S.D. and Mabe, N.F. 2017. Adoption of improved maize variety among farm households in the northern region of Ghana. *Cogent Economics & Finance* 5: 1416896. <https://doi.org/10.1080/23322039.2017.1416896>.
- Djokoto, G.I.L., Owusu, V. and Awunyo-Vitor, I.D. 2016. Adoption of Organic Agriculture: Evidence from Cocoa Farming in Ghana. *Cogent Food and Agriculture* 2: 1242181.
- Farooq, M. and Siddique, K.H.M. 2014. *Conservation Agriculture*. Springer International, Switzerland.
- Feder, G., Just, I.R. and Zilberman, D. 1982. Adoption of Agricultural Innovation in Developing Countries: A Survey, the World Bank Staff Working Paper No. 542, Washington D.C., USA. VF2006228528.33.10.1086/451461.
- Fernandes, I.E.C.M., Oktingati, A. and Maghembe, J. 1981. The Chagga home gardens: A multi-storeyed agroforestry cropping system on Mt. Kilimanjaro (Northern Tanzania). *Agro-Forestry Systems* 12: 73–86.
- Gattinger, A., Jawtusch, J., Müller, A. and Mäder, P. 2011. No-Till Agriculture: A Climate-Smart Solution? *Misereor: Aachen, Germany*, 2011; pp. 1–24.
- GSS. 2016. Ghana Statistical Service (GSS) website: [Iwww.statsghana.gov.gh](http://www.statsghana.gov.gh).
- Karugia, S., Baltenweck, I., Waithaka, M., Miano, M., Nyikal, R. and Romney, D. 2004. Perception of Technology and its Impact on Technology Uptake: The Case of Fodder Legume in Central Kenya Highlands. The Role of Social Scientists. Proceedings of the Inaugural Symposium, 6 to 8 December 2004, Grand Regency Hotel, Nairobi, Kenya.
- Kassam, A., Friedrich, T., Derpsch, R. and Kienzle, J. 2015. Overview of the Worldwide Spread of Conservation Agriculture, *Field Actions Science Reports* [Online], Vol.8 2015, Online since 26 September 2015, Retrieved on 13 April 2019. URL: <http://journals.openedition.org/factsreports/3966>.
- Mazvimavi, K. and Twomlow, S. 2009. Socio-economic and institutional factors influencing adoption of conservation farming by vulnerable households in Zimbabwe. *Agricultural Systems* 10: 20 – 29.
- Mignouna, B., Manyong, M., Rusike, J., Mutabazi, S. and Senkondo, M. 2011. Determinants of Adopting Imazapyr-Resistant Maize Technology and its Impact on Household Income in Western Kenya: *AgBioforum* 14(3): 158-163. Hall, B. and Khan, B. (2002) Adoption of new technology. *New Economy Handbook*.
- Okoye, C. 1998. Comparative analysis of factors in the adoption of traditional and recommended soil erosion

control practices in Nigeria. *Soil and Tillage Research* 45: 251–263.

Rogers IEM. I2003. *Diffusion of Innovations* (5th ed.). London: Free Press.

Shetto, R. and Owenya, M.I2007. *Conservation Agriculture as Practised in Tanzania: Ithree Case Studies*. Nairobi. African Conservation Tillage Network, Centre de Coopération Internationale Ide Recherche Agronomique pour Ile Développement, IFood Iand IAgriculture Organization Iof Ithe IUnited INations, IRome, IItaly. I146pp.

Saltiel, J., Bauder, J.W. and Palakovich, S. 1994. Adoption of sustainable agricultural practices: diffusion, farm structure and profitability. *Rural Sociology* 59 (2): 333–349.

Snedecor GW, Cochran WG. 1989. *Statistical Methods*. 8th Edition, Iowa State University Press, Ames.

Sodjinou, IE., Glin, IC.L., Nicolay, G., ITovignan, IL. and IHinvi, IJ. 2015. ISocioeconomic determinants Iof Iorganic Icotton Iadoption Iin IBenin, West Africa. *Agricultural and Food Economics* 3 I(12): I1-22.

Teklewold, H., Kassie, M. and IShiferaw, B. 2013. Adoption of multiple sustainable agricultural Ipractices Iin rural IEthiopia. *Journal ofIAgricultural Economics* I64 (3):I597– 623. I<https://doi.org/10.1111/1477-9552.1201>.

Uaiene, R., Arndt, C. and Masters, W. 2009. *Determinants of Agricultural Technology Adoption in Mozambique*. Discussion papers No. 67E.