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Factors Promoting Utilisation of Climate-Smart Agricultural Practices in Northern Ghana

Seidu Nanundow [1], Hudu Zakaria [2], Osman Tahidu Damba [3] and Samuel Allottey [2]

[1] Department of Food Security and Climate Change, Faculty of Food and Consumer Sciences, University for Development Studies (UDS), Tamale, Ghana.

[2] Department of Agricultural Innovation Communication, Faculty of Food and Consumer Sciences, University for Development Studies (UDS), Tamale, Ghana

[3] Department of Agricultural and Food Economics, Faculty of Food and Consumer Sciences, University for Development Studies (UDS), Tamale, Ghana

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Abstract: This study examined the factors driving the adoption of Climate Smart Agricultural (CSA) practices in Northern Ghana. In nine selected communities, 318 smallholder farmers were interviewed, comprising 115 adopters and 203 non-adopters of CSA practices. Descriptive statistics were used to analyse the most common CSA practices in the area. Chi-square analysis and binary logistic regression were performed to examine which factors most likely influenced the use of the selected CSA practices. The study found that age, educational level, household size, access to extension and farmer-based organisations (FBO) membership of all smallholder farmers surveyed directly influenced smallholder farmers' utilisation of CSA practices. As revealed in the study, up to 90% of the smallholder farmers in the study area were aware of the various CSA practices being examined. The study also showed that smallholder farmers frequently used on-farm composting, with the Chi-square test showing that access to extension services, household size, and educational attainment all had an impact on smallholder farmers' usage of on-farm composting. The study recommends that the Ministry of Food and Agriculture (MoFA) intensify extension service delivery on CSA practices to promote their adoption by smallholder farmers in the face of climate variability and change.

Key Works: Climate Change, Climate Smart Agriculture, Utilisation, Greenhouse Gas and Smallholder.

I. Background

Africa has been identified as the continent most vulnerable to adverse effects of climate change because of its heavy reliance on natural resources and rain-fed agriculture. Smallholder farmers who depend largely on natural resources for their livelihoods are enduring significant repercussions from climate change, as noted by Batisani (2012). Due to existing climate-related pressures like drought, floods, erratic rainfall, and a lack of adaptive capability, African countries are particularly exposed and vulnerable to the adverse effects of climate change (FAO, 2021).

Several studies have explored the potential of CSA to enhance raid-fed agriculture in Africa. For example, a study by Karg *et al.* (2020) examined the effectiveness of soil and water conservation measures in improving crop yields and reducing erosion in raid-fed agriculture systems in Burkina Faso. The study found that farmers who adopted these practices could increase their crop yields by up to 54% while reducing erosion by up to 67%.

Another study by Kamara *et al*. (2019) investigated the potential of agroforestry in improving raid-fed agriculture systems in the Sahel region. The study found that integrating trees into raid-fed agriculture systems can improve soil fertility, provide shade for crops, and enhance biodiversity, leading to higher yields and improved resilience to climate change.

Overall, these studies suggest that CSA can be a practical approach to enhancing raid-fed agriculture in Africa. By adopting climate-resilient and environmentally sustainable practices, farmers can improve their yields and livelihoods while reducing their vulnerability to climate change.

However, the general lack of involvement of farmers and other implementing stakeholders in the developmental stages of CSA technologies has been blamed for the low adoption and scaling up of climate-smart agriculture and other sustainable agriculture practices. At a conference hosted by Ghana Climate Change, Agriculture and Food Security (CCAFS) Science Policy Platform to create a technical report on CSA, participants consisting of community leaders and farmers and agribusiness entrepreneurs bemoaned the lack of coordination among the institutions involved in the development and promotion of CSA and the absence of successful project implementation (Essegbey *et al.*, 2016).

In response, the Food and Agriculture Organization called for the involvement of farmers in the development of climate-smart technologies to consider indigenous knowledge in formulating sustainable agriculture practices in the face of climate change (FAO, 2021).

Involving farmers in the development of CSA practices is crucial for ensuring that the approach is tailored to the needs and priorities of local communities. Participatory approaches to CSA development can help to build trust and ownership among farmers, leading

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to more successful and sustainable outcomes. Several studies have highlighted the importance of involving farmers in the development of CSA. A study by Sova *et al*. (2017) examined the role of participatory research in developing CSA practices in Mali. The study found that involving farmers in the research process led to the identification of locally appropriate practices, such as intercropping and the use of organic fertilizers, that was more effective than externally imposed interventions. The study also highlighted the importance of building partnerships with local organisations to ensure the sustainability of CSA practices.

Also, a study by Vanlauwe *et al*. (2014) emphasised the importance of involving farmers in the testing and adaptation of CSA practices in Uganda. The study found that farmers could identify the most promising CSA practices, such as intercropping with legumes and using crop residues as mulch and were more likely to adopt these practices when involved in the research process.

Similarly, a study by Baudron *et al*. (2017) emphasised the importance of involving farmers in the development of CSA practices in Malawi. The study found that participatory approaches, such as farmer field schools and participatory varietal selection, led to higher adoption rates of CSA practices, such as intercropping and agroforestry, and greater yields and soil fertility improvements.

These studies suggest that involving farmers in the development of CSA practices can lead to more effective and sustainable outcomes. By building partnerships with local organisations and using participatory approaches, researchers and development practitioners can ensure that CSA practices are tailored to the needs and priorities of local communities.

Northern Ghana depends mainly on cultivating food crops and animal rearing for the livelihoods and sustenance of its people amidst mounting challenges (GSS, 2020). According to MOFA (2022), poor soils, poor infrastructure, limited market access, and absence of access to new and improved agricultural inputs are among the problems threatening improved livelihoods in northern Ghana and harming food security. However, agriculture still holds many prospects for the area in eradicating the endemic poverty and chronic food insecurity amongst the majority of the inhabitants, mainly smallholder farmers. However, the fragile nature of northern Ghana in terms of vegetation, climate and ecology exposes agricultural production in the area to climate variability and changes. In view of this, it is important to employ agricultural strategies to enhance food production by reducing vulnerability and resilience to climate change while minimising its carbon footprint.

This can be achieved through the adoption of CSA practices. However, Agrawal (2008) has long observed that as climate change continues to worsen northern Ghana farmers' vulnerability, the success of the uptake of CSA techniques in the area would rely on the level of organisational and farmer awareness and network building among stakeholders. Also, Abegunde *et al*. (2020) reviewed a decade's CSA-related scientific material between 2010 and 2020. The main conclusions were that there are differences between macro-areas in the pattern and degree of adoption of CSA methods and the reaction to climate change. Significant drivers of CSA adoption include resources, institutional tools, climatic and ecological environments, and farmer attributes like experience and access to extension services. Dethier and Effenberger (2012) also believe that while extension services and research and development are essential, establishing strong institutions is crucial for technology-driven agricultural development. Similarly, Imran *et al*. (2019), among many other researchers, looked at how the implementation of CSA would affect farmers' incomes. They concluded that CSA increases agricultural output and farm revenue on a sustainable basis, improves the efficiency of how nutrients and water are used, makes crops more tolerant to climatic shocks, and reduces Greenhouse Gas (GHG) emissions to a minimum level. Anuga *et al*. (2019) concluded that institutional, economic, environmental, and sociocultural factors were the most critical factors influencing CSA utilisation.

Even with the positive effects of CSA practices on farmers and their long impact on reducing climate change vulnerability among farmers while reducing the agricultural carbon footprint, the practice is rare in northern Ghana. This situation is of research concern because both government and non-governmental organisations have implemented programmes and projects to promote the adoption of CSA among farmers in the area. A recent study by Agbenyo *et al.* (2022) which examined income and economic impacts through the adoption of CSA practices, found a positive coefficient between the adoption of CSA and the income accruing to farmers.

Through the Ghana Ministry of Food and Agriculture, programmes such as the Ghana Agriculture Sector Investment Programme (GASIP) through sponsorship from the International Fund for Agricultural Development (IFAD) had implemented projects in northern Ghana to promote and build the capacity of smallholder farmers on climate-smart agricultural techniques (GASIP 2022). The Ministry of Food and Agriculture is implementing the project, and its main objective is to aid in the reduction of poverty in rural Ghana (Ambler, 2020). Some activities comprise the Climate Change Resilience sub-component of GASIP: advancing CSA by extension and raising value chain players' understanding of climate change resilience (IFAD, 2019).

The project has introduced CSA practices to farmers, built their capacity to uptake those practices, and helped establish small-scale irrigation schemes. Nine (9) agrarian communities have so far benefited from the project’s training programmes and provision of improved crop varieties as well as highlight-quality fertilizers, crop protection products and small-scale irrigation schemes to ensure uptake and utilisation of CSA in the area. This paper, therefore, examines the factors influencing the utilisation and uptake of CSA among farmers in the areas where these projects were implemented. This is to investigate the factors affecting the adoption of CSA practices from academic perspectives beyond the usual project evaluation studies.

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II. Research Methodology

The Study Area

The study was done in Northern Ghana, which has a land area of 97702 km2 and is located between 8° and 11° north latitudes. According to GSS (2020), Northern Ghana is situated in the Sudan Savannah and Guinea Savannah, which are sub-humid to semi-arid and receive 400 to 1200 mm of precipitation annually. The Guinea-Savannah zone makes up around 90% of the territory in Northern Ghana, and the Sudan-Savannah zone makes up the remaining 10% (GSS, 2020). These areas experience unimodal rainfall with an average rainfall of 1100mm (FAO, 2005). These regions have a long dry season of almost seven months (October to April), followed by a single cycle of rainfall of about five months (May to September), sufficient for agricultural productivity. During these five months of the cropping season, the zones occasionally record sporadic floods or droughts. A minimum temperature of 22°C is experienced yearly, ranging from 33 to 35°C. In the rainy season, humidity is at its maximum and is only moderately high in the dry season (FAO, 2005). Crop farming activities are only permitted once a year due to the rainfall pattern.

The soils of Ghana's Sudan and Guinea savannah regions are recognised to be the lowest, with low levels of some crucial nutrients like calcium, phosphorus, nitrogen, and potassium. In these regions, various crops are grown, including maize, rice, sorghum, yam, cassava, cowpea, groundnut, and tree crops such as mango, cashew including shea and dawadawa, which are wild commercial trees (FAO, 2009). For farmers to get a good yield of their crops, particularly cereals, the soil must be amended with both macro and micro soil nutrients. Rain-fed agriculture is the region's dominant farming system. Irrigation covers a minuscule portion of the region's arable land. Farmers in the area are unemployed for the seven months of the dry season, which causes food and income insecurity (MOFA, 2020).

Sampling Procedure and Sample Size

Multi-stage sampling technique was used in this study. In the first stage, the district and communities of the study were purposively selected. Districts and communities which have benefited from the GASIP CSA project were targeted for inclusion in the study. In the next stage, stratified sampling procedure was used to select respondents based on their involvement in the project or otherwise. Respondents were grouped based on communities and their involvement and non-involvement in the GASIP CSA project. A sampling fraction of ½ was used for each stratum. Simple random sampling was used in the third stage to select respondents for the household interviews. The random number method was used to assign every individual a number.

A total of 641 households were identified in the 9 selected communities, 231 farm households being adopters of CSA while 410 households were non-adopters of CSA (MoFA, 2022). According to Louangrath (2013), the Yamane 1965 formula for sample size should be used for research like this where the study population is known or finite. In the formula, n = N/(1+N(e)2 where (n is sample size, N represent Sample frame and e representing margin of error). The sample size calculated was 246, this is based on Yamane's 1965 formula for determining sample size. However, for more accuracy a total of 318 farmers, were interviewed, 115 adopters and 203 non-adopters.

Table 3.1: Sampling Frame

Communities	CSA Farmers	Sample	Non-CSA Farmers	Sample	Total Sample
Dulzugu	20	10	122	61	71
Dalun-Kukuo	20	10	13	6	16
Gingani	20	10	20	10	20
Kprum	40	20	19	9	29
Cheshegu	35	17	57	28	45
Gbullun-Nyoring	36	18	10	5	23
Voggu-Kushibo	20	10	20	10	20
Zangballin	20	10	123	61	71
Zugu	20	10	26	13	23
Total	231	115	410	203	**318**

Source: MoFA, (2022).

The selection of participants for the focus group discussions was made with a blend of farmers in the project and farmers who were not in the project. However separate meetings were also held for the adopters and non-adopters because Sim (1998) states that, the more homogeneous the membership of the group, in terms of social background, level of education, knowledge, and experience, the more confident individual group members are likely to be in voicing their views. Nine (9) focus group discussions (FGD) were held

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in all the selected communities. Each focus group comprised 10 farmers. The groups were also segregated based on sex. This is because when both genders are present, women are much less inclined to talk, and more men would take the lead in the conversation (Morgan, 1997).

Data Collection and Sources

Both primary and secondary data sources were relied on to obtain information from the respondents. Primary data for this study was collected directly from smallholder farmers in the selected communities in the district using questionnaires and focus group discussions. Data for the study was gathered from smallholder farmers through face-to-face interviews using semi-structured questionnaires. The questionnaire obtained information about the respondents' perspectives on the types of CSA practices accessible in the study area, as well as their awareness, uptake, and years of use of the CSAs. Secondary data were sourced from books, articles, conference papers, dissertations and web reports.

Method of Data Analysis

Semi-structured questionnaires that had been administered were scrutinised to find and remove faults by ensuring that the questions answered were correct and complete. Data input and analysis were done using the Statistical Package for Social Sciences (SPSS), which also provided test statistics and descriptive analysis. All graphs were created using Microsoft Excel. After data is acquired, appropriate tools and techniques should be employed for classification and analysis, according to Panneerselvam (2004) and Yelfaanibe (2011). To report and interpret this study’s findings, descriptive and inferential tools and techniques were employed. Whether a given phenomenon is simple or complicated, descriptive tools and procedures of inquiry describe the nature of the phenomenon. However, the requirement for methods of determining a condition means that it is more than a complex one (Osuala, 2005).

Using STATA, the Chi-square analysis was performed to test the level of association between adoption and selected socio-demographic and institutional factors found in literature as determinants of adoption of CSA practices among smallholder farmers. These factors included gender, educational status, household size, FBO membership, access to market, and access to extension services. The 95% confidence interval was used to determine the level of significance, which is expressed as:

$$\chi^2 = \sum\frac{(O_1-E_1)^2}{E_1}) \quad \ldots\ldots\ldots \quad (1).$$

where Oi is the observed value, Ei is the expected value, and c is the degree of freedom.

A binary logistic regression was conducted to determine which of the variables influenced the adoption of the chosen CSA practices. These variables were chosen based on hypotheses and prior empirical discoveries in literature. This is expressed as:

$$Y = B_0 + B_1X_1 + \ldots + B_KX_K \quad \ldots\ldots\ldots \quad (2)$$

where each X_i is a predictor

B_i is the regression coefficient.

III. Results and Discussion

Existing Climate-Smart Agriculture Practices Utilised by Smallholder Farmers

This section of the results lists the smallholder farmers' current methods for practicing climate-smart agriculture. As shown in Table 1 below, between 60 % and 100 % of the smallholder farmers in the research area are aware of the various CSA techniques. These results resonate with previous studies suggesting that smallholder farmers in dryland farming systems employ a host of practices to manage climate risks and sustain livelihood and food security (Fagariba *et al*., 2018 & Rahut *et a*l., 2021). Also, the most (over 65.0%) utilised CSA practices in the study area were on-farm composting, crop rotation, mulching, improved crop varieties, use of minimum tillage, improved livestock, and land bunding. Additionally, Figure 1 further compares the level of awareness and utilisation of CSA practices. The result revealed a less than 65.0% utilisation of some of the CSA practices by smallholder farmers. These CSA practices utilised were agroforestry (55.0%), small-scale irrigation (63.0%), rainwater harvesting (58.0%), crop-livestock integration (50.0%) and residue retention (48.0%). The result is similar to the findings made by Fagariba *et al*. (2018) when they reported that planting early maturing varieties of crops, agroforestry and woodlot schemes, water management and water harvesting, earth bunding, crop residue mulching, and zero tillage/minimum tillage as standard CSA practices among respondents in the Sissala West district of the Upper West region. Residue retention was utilised by only 48% of the smallholder farmers who indicated during FGDs that bye laws are not enforced on animal grazing and bush burning hence making it difficult to leave crop residue after harvest. Again, they stated that in the wake of non-enforcement of these bye laws the alternative is to fence their fields which is expensive for them. Also, only 50% of the respondents use crop-livestock integration which the smallholder farmers indicated that aside from the cost involved in using the practice, they have also been advised that animals contribute to greenhouse gas emissions which affects agriculture considerably.

Generally, the various CSA practices were adequately promoted by institutions such as MoFA, and NGOs through community radio and other media. The high utilisation level among smallholder farmers is supported by studies such as Kangogo, Dentoni and

Bijman, 2021; Andersson and D'Souza, 2014; Birner and Resnick, 2010), who all reported a high level of adoption of CSA practices among farmers. All these studies further revealed that a high level of CSA practices leads to enhanced food security, improved soil fertility, carbon sequestration and improvement of farmers' livelihoods. For instance, if utilized by smallholder farmers, improved crop varieties would increase crop yield and further reduce post-harvest losses. Since food insecurity is a significant concern to policymakers and farmers, utilisation of these CSA practices would significantly reduce the incidence of food insecurity among rural households.

Table 1: Climate-smart Agriculture practices utilised by Smallholder Farmers

Practices	Aware practice (%)	Currently using practice (%)	Willingness to introduce (%)
Agroforestry	63	55	29
On-farm Composting	96	*79*	65
Crop Rotation	100	*77*	30
Mulching	99	67	33
Intercropping	100	64	36
Improved Crop Varieties	99	*83*	33
Use of Minimum Tillage	93	68	43
Small Scale Irrigation	85	63	39
Improved Livestock	99	*68*	47
Rain Water Harvesting	95	58	30
Land Bunding	96	*67*	64
Crop-Livestock Integration	95	50	44
Residue Retention	64	48	12

Source: Field Survey Data, 2022

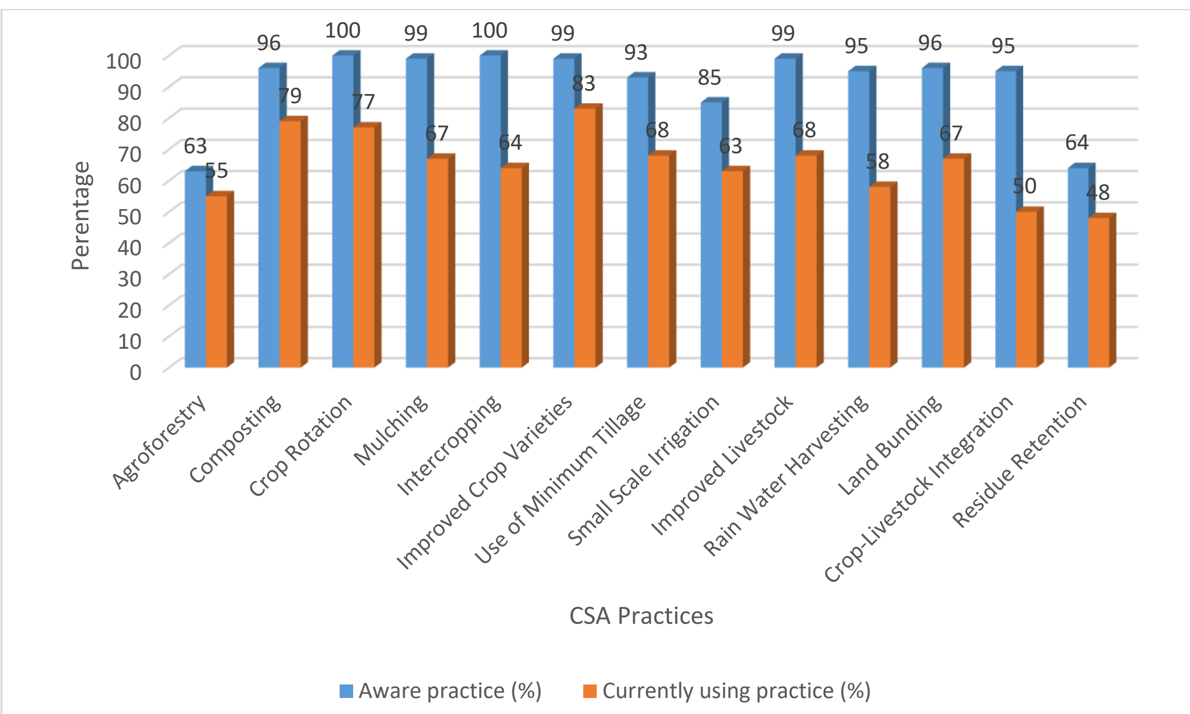

Figure 1: CSA Practices Awareness and Current Utilisation

Source: Field Survey Data, 2022.

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Factors Likely to Influence Uptake of CSA Practice of On-Farm Composting

Results of the study shown in Table 2 revealed that on-farm composting was widely utilised among smallholder farmers. Also, the Chi-square test revealed that educational level ($\chi2$ = 11.110, p = 0.025), household size ($\chi2$ = 56.539, p = 0.000) and access to extension ($\chi2$ =3.220, p = 0.073) all affected smallholder farmers' utilisation of on-farm composting.

The logistic regression model, which was conducted to assess the determinants of adoption of CSA practices, shown in Table 3, was found to be significant, with the selected explanatory variables jointly accounting for 62.9% (Nagelkerke R Square = 0.629) of the variation in the utilisation of on-farm composting as a CSA practice. This suggests that approximately 62.9% of the variation in the utilisation of on-farm composting is explained by the model.

Also, the educational level of smallholder farmers was found to have a positive influence on smallholder farmers' utilisation of on-farm compositing with a coefficient of 0.2760. This implies that educated smallholder farmers are more likely to utilise on-farm composting as a CSA practice than non-educated smallholder farmers if everything else remains the same. Furthermore, access to extension among smallholder farmers was found to have a positive influence on smallholder farmers' utilisation of on-farm compositing with a coefficient of 3.220. This implies that smallholder farmers with access to extension services are more likely to utilise on-farm composting as CSA practices compared to smallholder farmers without access to extension services if everything remains the same. On-farm composting has been a long tradition among farmers to increase soil fertility. The high level of on-farm composting utilisation could be attributed to loss of soil fertility combined with adverse effects of climate change and vulnerability and the high cost of inorganic fertilizers as a result of the reduction of government subsidies on the product. In this study, educational level and access to extension all influenced smallholder farmers' utilisation of on-farm composting, which is supported by Akram *et al.* (2019); they reported that vegetable farmers accessing extension services are always encouraged to use compost on their farms as means of boosting yield. Also, the findings support the work of Abegunde *et al.* (2020), who found that farmers' characteristics, such as farmers' experience and access to extension services, are significant determinants of CSA adoption.

The smallholder farmers generally attributed their utilisation of on-farm composting to the high cost of inorganic fertilizers. In a FGD, they argued that for the past three years government has reduced subsidy on inorganic fertilizers making the product expensive and sometimes unavailable which makes them shift their focus to producing their own organic fertilizers.

Table 2: Chi-Square test Analysis of factors likely to influence utilisation of on-farm composting

Attributes	**Degree of Freedom**	**Chi-Square test**	
		$\chi2$	**Sig**
Sex	1	2.380	0.123
Age	4	2.540	0.637
Educational level	4	11.110	*0.025*
Household size	15	56.539	*0.000*
Access to market	1	0.254	0.614
Access to extension	1	3.220	*0.073*
FBO membership	1	0.471	0.492

Source: Field Survey Data, 2022

Table 3: Factors influencing utilisation of on-farm composting as a CSA practice

Attributes	**On-Farm Composting**			
	B	**SE**	**Z**	**P>|z|**
Sex	0.5450	0.3355	1.62	0.104
Age	-0.0370	0.1906	-0.19	0.846
Educational level	0.2760	0.1110	2.48	***0.013****
Household size	0.0227	0.0460	0.49	0.621
Access to market	0.1259	0.3372	0.37	0.709
Access to extension	0.7903	0.4659	1.70	*0.090*
FBO membership	-0.6082	0.5033	-1.21	0.227

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Pseudo R^2	0.0534
Log-likelihood	-152.95835
Prob > chi2	0.0536
Nagelkerke R Square	0.629

Source: Field Survey Data, 2022

Factors Influencing Utilisation of Improved Crop Varieties

The results in Table 4 below revealed that improved crop varieties were widely utilised among smallholder farmers. However, the Chi-square test showed that access to extension ($\chi2 = 6.816$, $p = 0.009$) affected smallholder farmers' utilisation of improved crop varieties. Also, the extent of utilisation, age of smallholder farmers, household size and access to extension all influence smallholder farmers' utilisation of improved crop varieties.

The logistic regression model that included these variables explained around 50.5% of the variances. Furthermore, the age of smallholder farmers was found to have a positive influence on smallholder farmers' utilisation of improved crop varieties with a coefficient of 0.3847. This implies that older smallholder farmers are more likely to utilise improved crop varieties as CSA practices compared to young smallholder farmers if everything remains the same. Also, household size was found to negatively influence smallholder farmers' utilisation of improved crop varieties with a coefficient of 0.1375. This implies that smallholder farmers with smaller household sizes are more likely to utilise improved crop varieties as CSA practices compared to smallholder farmers with large household sizes if everything remains the same. Smallholder farmers with smaller household size utilise improved crop varieties because of the perceived increase in yield. They usually cultivate fewer acreages due to the unavailability of family labour and want to maximise yield from the small farm.

Finally, access to extension among smallholder farmers was found to have a positive influence on smallholder farmers' utilisation of improved crop varieties, with a coefficient of 1.142. This implies that smallholder farmers with access to an extension are more likely to utilise improved crop varieties as CSA practices compared to smallholder farmers without access to an extension if everything remains the same. During focus group discussions, the farmers stated that they use improved crop varieties to adapt to climate change and variability. It was summarised in one of the focus group meetings by participants as follows:

"*We receive early maturing seeds and drought tolerant varieties from our Agric. Officer to be able to get good yields because the cropping pattern is changing*".

Generally, farmers are encouraged to adopt improved crop varieties to increase yield. Also, most of the improved crop varieties are bred to withstand drought, and some are early maturing; these features are desirable in the face of the erratic rainfall pattern being experienced in the study area. The usage of improved crop varieties is influenced by age, household size and access to extension. This finding is in line with Belay *et al.* (2017), who reported that farmers with access to extension services and large households use improved crop varieties for improved yield and well-being. Moreover, farmers utilised improved crop varieties because of the demand for a particular crop variety.

Table 4: Chi-Square test Analysis of factors likely to influence utilisation of improved crop varieties

Attributes	**Degree of Freedom**	**Improved Crop Varieties**	
		$\chi2$	**Sig**
Sex	1	.014	0.906
Age	4	1.412	0.842
Educational level	4	6.812	0.146
Household size	15	20.837	0.142
Access to market	1	2.068	0.150
Access to extension	1	6.816	0.009
FBO membership	1	1.221	0.269

Source: Field Survey Data, (2022).

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Table 5: Factors influencing utilisation of improved crop varieties

Attributes	Improved crop varieties			
	B	**SE**	**Z**	**P>|z|**
Sex	-0.0293	0.3837	-0.08	0.939
Age	0.3847	0.2036	1.89	0.059*
Educational level	0.1277	0.1220	1.05	0.295
Household size	-0.1375	0.0506	-2.72	0.007**
Access to market	0.4650	0.3510	1.32	0.32
Access to extension	1.142	0.5820	1.96	0.050*
FBO membership	-0.3876	0.6120	-0.63	0.527
Pseudo R^2	0.0714			
Log-likelihood	-133.05416			
Prob > chi2	0.0047			
Nagelkerke R Square	0.505			

Source: Field Survey Data, (2022).

Factors Influencing Utilisation of Crop-Livestock Integration

The study in Table 6 below revealed that crop-livestock integration was among the least utilised CSA practice among smallholder farmers. However, the Chi-square test revealed that none of the variables influenced smallholder farmers' utilisation of crop-livestock integration as a CSA practice. The logistic regression model was able to explain 60.1% of the variances. Additionally, only FBO membership negatively influenced smallholder farmers' utilisation of crop-livestock integration with a coefficient of 1.067. This implies that smallholder farmers who are not members of FBO are more likely to utilise crop-livestock integration as CSA practices compared to smallholder farmers who are members of FBO if everything remains the same. FBO members according to discussions from the focus groups sometimes follow more standardized or specialized farming practices promoted by their sponsored organizations, which in most cases do not emphasize crop-livestock integration to the same extent. Again, FBO members in most cases have access to alternative CSA practices and they turn to adopt those that are more suitable to them. Additionally, FBO membership according to the farmers in some cases involve social or economic conditionalities that shape the types of practices adopted, potentially limiting some farmers' inclination or flexibility to integrate crop and livestock components comprehensively.

In this study, FBO membership was only the variable that influenced smallholder farmers' decision to utilise crop-livestock integration. According to Reddy (2016), farmers utilised or adopted crop-livestock integration to reduce the cost of chemical fertilizer usage on their farms since the animal dropping would serve as a fertilizer for the farm. Also, the animal dropping is purported to improve soil nutrition, limit soil nutrient leaching and promote higher yields. Furthermore, the current government initiative of rearing food and jobs only targets farmers in groups. Hence, FBO membership utilisation of crop-livestock integration is not surprising for influencing this study since members of FBOs always stand the chance of benefiting from projects and interventions such as climate-related interventions.

Table 6: Chi-Square test Analysis of Factors likely to influence utilisation of crop-livestock integration

Attributes	Degree of Freedom	Chi-Square test	
		$\chi 2$	**Sig**
Sex	1	0.151	0.697
Age	4	1.397	0.845
Educational level	4	2.964	0.564
Household size	15	8.510	0.902
Access to market	1	1.110	0.292
Access to extension	1	0.003	0.955

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FBO membership	1	0.069	0.792

Source: Field Survey Data, 2022

Table 7: Factors likely to influence utilisation of crop-livestock integration

Attributes	Crop-livestock integration			
	B	**SE**	**Z**	**P>|z|**
Sex	-0.1088	0.2890	-0.38	0.707
Age	0.1954	0.1540	1.27	0.205
Educational level	0.0086	0.0893	0.10	0.923
Household size	-0.0365	0.0386	-0.94	0.345
Access to market	0.2521	0.2786	0.90	0.366
Access to extension	0.2913	0.3405	0.86	0.392
FBO membership	-1.067	0.3697	-2.89	0.004***
Pseudo R^2	0.0410			
Log-likelihood	-211.35936			
Prob > chi2	0.0116			
Nagelkerke R Square	0.601			

Source: Field Survey Data, (2022).

Factors Likely to Influence Utilisation of Residue Retention

The results in Table 8 below revealed that crop residue retention was least utilised among smallholder farmers. However, the Chi-square test showed that educational level ($\chi2 = 9.561$, $p = 0.049$), access to extension ($\chi2 = 6.063$, $p = 0.014$) and FBO membership ($\chi2 = 9.517$, $p = 0.002$) all affected smallholder farmers' utilisation of residue retention. Moreover, the extent of utilisation, age of smallholder farmers, educational level, access to extension, and FBO membership all influenced farmers' utilisation of residue retention. Combining these factors in a logistic regression model could explain 50.8% of the variances.

Moreover, the age of smallholder farmers was found to have a positive influence on smallholder farmers' utilisation of crop residue retention with a coefficient of 0.2865. This implies that a one-year increase in the age of a farmer will influence their likelihood of utilising crop residue retention as a CSA practice compared to young smallholder farmers, all things being equal. Also, the educational level of smallholder farmers was found to have a positive influence on smallholder farmers' utilisation of crop residue retention with a coefficient of 0.2558. This implies that farmers with a high level of education are more likely to utilise crop residue retention as a CSA practice than non-educated smallholder farmers, all things being equal. According to Fagariba *et al*. (2018), soil and land management practices such as crop residue mulching and zero tillage improve the microclimate, boost soil fertility, and reduce the high intensity of direct sunlight on the crops and soil nutrients. This could be the reason why educated smallholder farmers use the practice.

Additionally, household size was found to have a negative influence on smallholder farmers' utilisation of crop residue retention with a coefficient of 0.1342. This implies that smallholder farmers with smaller household sizes are more likely to utilise crop residue retention as CSA practices compared to smallholder farmers with large household sizes. Small-size farm families at the smallholder level usually have small farm sizes. So, it can therefore be argued that on one hand, smaller farm sizes can easily be protected from grazing livestock and wild bushfires after harvest as against larger households with larger farms. On the other hand, smaller farm families might also lack the required labour to protect their crop residue from grazing livestock and/or wild bushfires.

Finally, access to extension among smallholder farmers was found to have a positive influence on smallholder farmers' utilisation of crop residue retention with a coefficient of 1.107. This implies that smallholder farmers with access to an extension are more likely to utilise crop residue retention as CSA practice compared to smallholder farmers without access to an extension if everything remains the same. Despite the benefits of residue retention in mitigating the adverse effects of climate change and climate vulnerability, the low utilisation of crop residue retention could be attributed to farmers' inability to protect their farms, after harvest, from grazing livestock and wild bushfires. During FGDs, smallholder farmers bemoaned their difficulty in leaving residues on their field thereby losing out in getting the benefits associated with it to their crops. It was stated in the meetings by the respondents as follows:

"Here cattle will graze all the stalks if you leave them on the field or bushfire will

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burn all. Cattle owners are not restricted to where to graze and they burn the bush haphazardly to get green grasses. It is really a concern and we wish the authorities do something about it".

The low level of usage of crop residue retention has been found in many studies to be attributed to the perennial bushfires and uncontrolled grazing by livestock in the study area. This is because the practice of crop residue retention requires protecting leftovers after harvest to be decomposed on the field and thereby releasing their nutrient back into the soil for subsequent planting (Branca *et al*., 2020). This confirms the findings of Harvey *et al*. (2014), who found that weak regulatory frameworks and poor tenure rights and land use and management frameworks can hinder the propensity of farmers to adopt various CSA practices. Low crop residue usage could result in low crop yield in the study area. Hence, to boost crop yield, there is a need to promote the effective use of crop residues on farmland rather than allowing animals to feed on it. This required strong local laws and regulatory framework regarding wild bushfires control, effective land tenure systems and proper land use management systems with clear demarcation for crops and livestock farming.

Table 8: Chi-Square test Analysis of factors likely to influence utilisation of residue retention

Attributes	**Degree of Freedom**	**Chi-Square test**	
		$\chi 2$	**Sig**
Sex	1	0.057	0.811
Age	4	0.698	0.952
Educational level	4	9.561	*0.049*
Household size	15	15.049	0.448
Access to market	1	0.195	0.659
Access to extension	1	6.063	*0.014*
FBO membership	1	9.517	*0.002*

Source: Field Survey Data, 2022

Table 9: Factors likely to influence utilisation of residue retention

Attributes	**Residue retention**			
	B	**SE**	**Z**	**P>|z|**
Sex	-0.0071	0.3011	-0.02	0.981
Age	0.2865	0.1664	1.72	0.085*
Educational level	0.2558	0.0921	2.78	0.005***
Household size	-0.1342	0.0429	-3.13	0.002***
Access to market	0.0571	0.2954	0.19	0.847
Access to extension	1.107	0.3482	0.001	0.001***
FBO membership	0.3036	0.3759	0.419	0.419
Pseudo R^2	0.1142			
Log-likelihood	-195.11305			
Prob > chi2	0.0000			
Nagelkerke R Square	0.508			

Source: Field Survey Data, (2022).

IV. Conclusion and Recommendation

In analysing the existing climate-smart agriculture practices utilised by smallholder farmers in the area, the study concluded that majority of the smallholder farmers were using various CSA practices. The study established that most smallholder farmers utilised on-farm composting, crop rotation, mulching, improved crop varieties and minimum tillage. However, only some of the smallholder

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farmers utilised crop residue retention. Generally, several factors influence smallholder farmers' utilisation of CSA practices among smallholder farmers. However, this study concluded that age, educational level, household size, access to extension and FBO membership all directly influenced smallholder farmers' utilisation of CSA practices.

This study recommends that the district assemblies, in collaboration with their departments of agriculture, should embark on an educational campaign to promote the adoption of CSA practices among smallholder farmers as a climate change mitigation and adaptive strategy.

Also, the district assemblies, in collaboration with the traditional authorities, should ensure the institutionalization of enforceable laws and regulatory frameworks regarding wild bushfires control, effective land tenure systems and proper land use management systems with clear demarcation for crops and livestock farming.

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