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Effect of adoption of conservation agriculture on household food security of smallholder maize farmers in Ghana

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ABSTRACT

This cross-sectional study set out to examine the effect of conservation agriculture (CA) adoption on the food security of smallholder maize farmers in the Adansi Akrofuom District in the Ashanti Region of Ghana. Using the multistage sampling technique, 400 small-scale farmers who have been introduced to CA were selected. The findings of the study show that crop rotation, row planting, fertilizer application, improved seeds and cover cropping were the CA practices often implemented by the farmers. Age of the farmer, household size, years of education, religion, access to extension, frequency of group visits, and the area under CA cultivation were significant predictors of farmers' adoption of CA practices. Implementation of CA practices has a significant effect on household level of food security. There was an agreement among the farmers that access to credit is the greatest challenge they face in using CA practices. The paper proposes that efforts towards the continuous and high adoption of CA practices must be given more attention since they can affect farmers' household food security.

1. Introduction

The demand for food keeps growing globally, and with the unparalleled population growth, more food must be sustainably produced with little environmental impact from accessible land. With this in mind, more countries are adopting sustainable methods to help meet their agricultural demands while maintaining their lands for future use. Nevertheless, the increasing costs of energy and food, the impacts of climate change, the degradation of biodiversity and ecosystem services, and growing water scarcity, along with financial crises, are amplifying the difficulties associated with achieving agricultural sustainability (Kassam et al., 2009). In response, farmers and governments are seeking out alternative production approaches that can uphold soil productivity. The recognition of this necessity has led to the emergence of conservation agriculture (CA), touted as the optimal solution for fostering sustainable agricultural development in Africa (Andersson and D'Souza, 2014; Baudron et al., 2012).

Conservation Agriculture (CA) is an ecosystem method to agriculture that aims to conserve and improve the resilience of agricultural systems and natural resources while enhancing productivity (González-Sánchez, 2016). According to FAO (2015), CA is characterized as an agricultural methodology aimed at diminishing soil erosion, maintaining soil fertility, enhancing water management, and decreasing production expenses, thereby rendering inputs and services more accessible for smallholder farmers. It is based on three key principles: crop rotation and permanent soil cover, minimal soil disturbance, and diversification (Bisht, 2016). It involves practices such as zero or minimum tillage (Derpsch et al., 2014; FAO, 2015), crop residue management, cover crops, integrated pest management (IPM), agroforestry and agroecology, crop rotation, use of organic cover to maintain soil quality (Bisht 2016). Nonetheless, variations of these foundational CA components have been employed by farmers long before the terminology was coined (Giller et al., 2015).

CA is profitable and sustainable, with the potential to address agri-environmental challenges and improve farmer prosperity (González-Sánchez, 2016). It is also an effective strategy for sustainable agriculture, offering the opportunity to reverse resource degradation and enhance productivity (Singh and Meena, 2012). Other benefits include increased productivity through enhanced and sustained yields, bolstering soil carbon sequestration; and the enhancement of farmers'

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resilience to future changes through improved water and soil organic matter preservation (FAO, 2014).

Food security is a complex concept that encompasses various dimensions (Siegel, 2021). It was initially formulated around half a century ago, during the backdrop of worldwide food crises in the 1970s (Peng and Berry, 2019). Berry et al. (2015) argue that food security framework encompasses the availability of sufficient food for an cative and a healthy life for all individuals at all times. Siegel (2021) defines it as consistent access to safe, nutritious and sufficient food that meets dietary preferences and needs for a healthy and an active life. This includes the availability, access, utilization of food, and stability, encompassing the continuity in the accessibility, use, and availability of food (United Nations High-Level Task Force (UN-HLTF), 2011).

Ghana is considered an agriculturally dependent country. Like other countries in Sub-Saharan Africa (SSA), Ghana needs an increase in the adoption of CA to boost the agricultural sector and reduce food insecurity. A viable approach to restoring depleted soils and counteracting the impacts of unpredictable rainfall involves the adoption of conservation agricultural practices within highly managed cropping systems (Chichongue et al., 2020). In Ghana, both governmental and non-governmental organizations are doing their best to promote CA among smallholder farmers across various regions. The effects of land degradation and climate change, among others, continue to be a menace to agricultural production and food security (FAO, 2014). As Africa's population continues to grow and the demand for food rises, the traditional cultivation methods embraced by smallholder farmers are proving to be increasingly unsustainable (Chichongue et al., 2020).

Conversely, CA has shown positive impacts on crop yields, labour efficiency, farm revenues, and weed management (González-Sánchez, 2022; Singh and Meena, 2012; FAO, 2014). However, although efforts such as planting for food and jobs, modernizing agriculture in Ghana (MAG), and others made by stakeholders and the government to support farmers in intensifying CA adoption, there is still more to do to bring these interventions to fruition. In the past, alterations in climatic conditions have increased the vulnerability of rural households to poverty, problems of land degradation, and desertification, thereby making investments in agriculture expensive, risky, and less profitable. Consequently, the present predicament confronting agricultural policy-makers, researchers, and extension personnel in Ghana revolves around crafting strategies, developing and sharing technologies, and disseminating information capable of imparting enhanced resilience to the agricultural production system amidst evolving climatic circumstances. With global food production and agricultural yields dwindling against fast population growth, food security has become a major problem for most countries. Issahaku and Abdulai (2020) and Partey et al. (2018) have highlighted the efficacy of implementing climate-smart agriculture (CSA) practices to tackle the challenges posed by climate change within farming systems. However, Bawa (2019) proposes that embracing contemporary and cultural agricultural practices like CA could potentially serve as the solution to elevate agricultural production, augment food security, and enhance the livelihoods of farmers.

Studies on CA (Van Hulst and Posthumus, 2016; Ngwira et al., 2014; Anuga et al., 2019) have focused on elements affecting their acceptance among small-scale farmers. In a study conducted in Zambia, Ng'ombe et al. (2014) discovered that access to loans, marital status, labour availability, and age exerted positive influences on CA adoption, while ownership of livestock, off-farm income, and access to extension services had negative effects on CA adoption. Additionally, Arslan et al. (2013) argued that farmers implemented CA as a prerequisite for obtaining subsidized input packages. Additional factors influencing the implementation of CA comprised household size, rainfall intensity, engagement with extension services, and availability of labour (Arslan et al., 2013). Tshuma et al. (2012), Jumbe and Nyambose (2016), and Mango et al. (2017) assessed the relationship between CA and food security, but the study areas were mostly focused on SSA countries other than Ghana. Consequently, it becomes evident that the effects of agricultural practices are location-specific (Scheba, 2017), necessitating a comprehensive understanding for the development of relevant policy insights (Anuga and Gordon, 2016). Although there are numerous studies conducted in this area, these studies merely made mention of its influence on food security. Scant information exists regarding the factors that influence CA adoption and its influence on the food security of smallholder maize farmers within Ghanaian communities.

To close this information gap, we conducted this study in the Adansi Akrofuom District to investigate the variables influencing CA adoption and the consequences of CA adoption on the food security status of smallholder maize farmers. The overarching research goal stated above will be addressed through the following specific objectives: (i) assess the level of CA adoption by maize farmers; (ii) determine the socio-economic variables that influence the use of CA by maize farmers; (iii) ascertain the food security situation among maize farmers; (iv) determine the influence of level of CA adoption on food security; and (v) identify the challenges encountered by farmers who embrace CA practices.

The unique contribution of this study lies in its comprehensive examination of conservation agriculture (CA) adoption among small-scale maize farmers and its effect on household food security in the specific context of the Adansi Akrofuom district in the Ashanti region of Ghana. By focusing on this particular geographic area, the study provides localized insights that are essential for understanding the dynamics of CA adoption and its implications for food security within the district. One of the study's key contributions is the identification of significant predictors of CA adoption among farmers in the Adansi Akrofuom district. Furthermore, the study's findings regarding the positive relationship between food security and CA adoption offer valuable insights into the potential benefits of sustainable agricultural practices for enhancing household food availability, utilization, access, and stability. By identifying the CA practices that have positive effects on food security, as well as those that may have challenges or unintended consequences, the study provides valuable guidance for optimizing CA implementation strategies to maximize their benefits while minimizing potential drawbacks.

2. Materials and methods

2.1. Study area

The Adansi Akrofuom district (Fig. 1) in the Ashanti region is the focus of the study. Located in the southern sector of the Ashanti Region, the Akrofuom District shares its borders with the Adansi Asokwa, Adansi South, and Obuasi East Districts to the north. Additionally, it shares a boundary with the Upper Denkyira Municipal in the Central Region. Covering a land expanse of 899 square kilometers, around 24% (334.5 square kilometers) of this area comprises designated forest reserves. According to the Population and Housing Census conducted in 2021, the overall populace of Adansi Akrofuom stands at 49,291 individuals. The climatic conditions within the district are generally favourable, featuring mean monthly temperatures that fluctuate between 26 °C and 29 °C. February and March emerge as the warmest months of the year. The district's abundant forest reserves contribute to a well-distributed pattern of rainfall, characterized by two distinct rainy seasons that peak around May–June and October. Annual rainfall averages fall within the range of 160 mm–180 mm, accompanied by an average of 150 rainy days each year. The Akrofuom District falls within the rainforest zone and is distinguished by its moist semi-deciduous forest type, characterized by dense vegetation and lush growth (https://ghanadistricts.com/Home/District/226).

2.2. Research design, study population and sample size

This research used a descriptive cross-sectional research design to

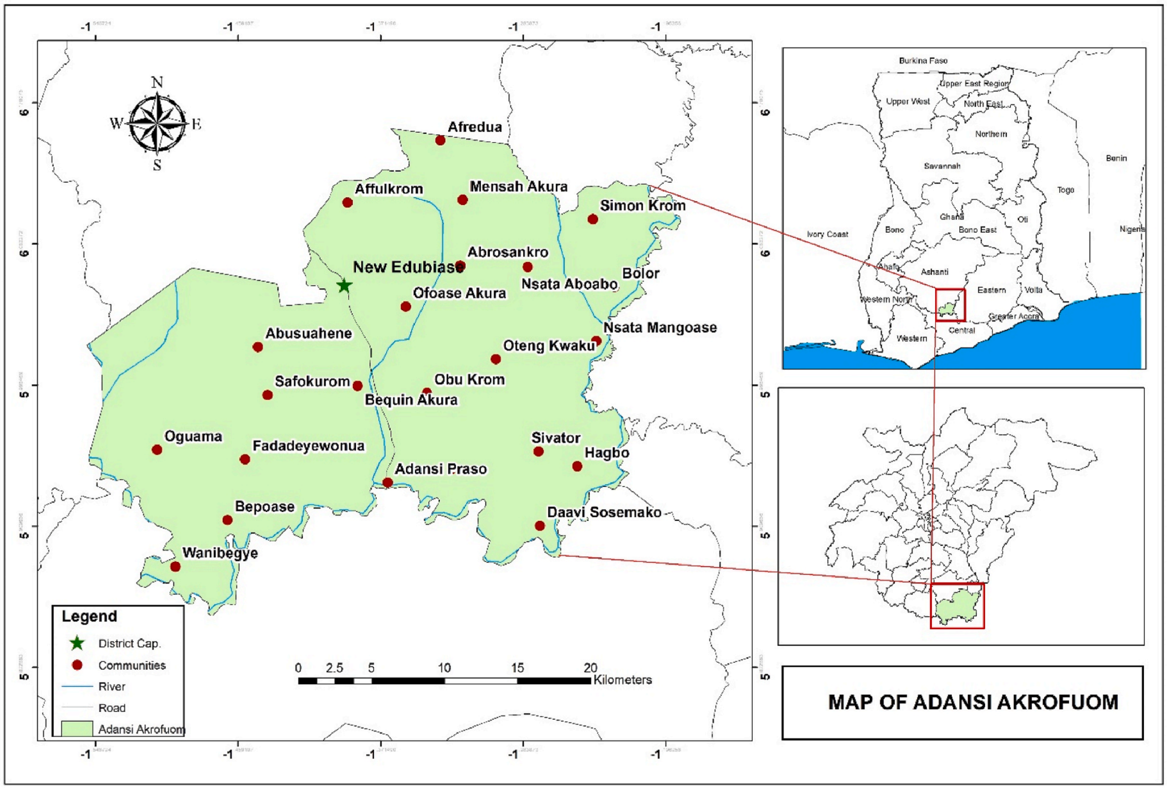

Fig. 1. Map of Adansi Akrofuom.

gather quantitative data. The target population for this study included smallholder[1] maize farmers who had been trained on CA by the Ministry of Food and Agriculture in the Adansi Akrofuom district. A total of 4880 smallholder farmers in the Adansi Akrofuom district have been trained on CA practices. Since the population is known, Yamane's (1967) formula was adopted to estimate the sample size. The equation is presented as follows: $n = N/[1 + N(e)^2]$, Where n = sample size, N = population size (4880), e = desired significance level (5%). Therefore, the calculated sample size was 370. However, it was increased to 400.

2.3. Sampling procedure

Smallholder maize farmers were selected using the multi-stage sampling approach. The sampling process involved the methodical selection of a sample from a larger population to form the basis for estimating the study outcomes (Nayak and Singh, 2015). The first stage involved purposively selecting the Adansi Akrofuom district as the study area. This decision was based on the fact that approximately 85% of the farmers in this district have been exposed to conservation agriculture (CA) practices. Purposive sampling allowed researchers to focus their efforts on an area where CA adoption was relatively high, ensuring the relevance of the study to the target population. In the second stage, 12 communities were selected from the Adansi Akrofuom district. To achieve this, a simple random sampling method was employed. Simple random sampling involves selecting samples from a population in such a way that each member of the population has an equal chance of being chosen. By using this method, researchers ensured that the selected communities were representative of the district. Once the communities were selected, the final stage involved sampling maize farmers from these communities. Again, a simple random sampling method was used to choose the maize farmers from the 12 selected communities. This sampling technique ensured that each maize farmer in the communities had an equal chance of being included in the study, thereby reducing selection bias and enhancing the representativeness of the sample. The communities selected and the corresponding number of respondents are; Grumesa-30, Kofigyame-40, Kramokrom-25, Asiedukrom-35, Bekawpa-29, Nyamebekyere-41, Carowner-38, Dunkwawfuom-22, Akoakor-45, Mprakyire-35, Nkoranza-40 and Sikaman-20.

2.4. Research instrument and data collection

Primary data was collected using a structured interview schedule. The selected communities were contacted through the extension agents. The respondents were asked for their verbal consent before the actual data collection exercise. The reliability of the questions was assessed utilizing Cronbach's alpha test aided by IBM SPSS software version 21.0. The resulting value of 0.72 suggests that the questionnaire demonstrated reliability. To validate the data collection tool, a pilot test was carried out by administering the questionnaire to ten maize growers. The pilot test functioned as a preliminary run to detect any possible problems or uncertainties in the questionnaire, enabling essential modifications to be made before the official data collection phase. Data collection occurred between June and August 2022.

Due to the high number of respondents, the researchers enlisted the help of three enumerators to aid in data collection. These enumerators were extension officers who had direct interactions with the farmers. While working with them as enumerators can offer certain advantages, such as their expertise and rapport with farmers, it could also come with some disadvantages. We mitigated these possible limitations and biases through careful training, supervision, and transparency in the data collection process to help enhance the reliability and validity of the study findings.

[1] The FAO (2015) characterization of smallholder farmers, which defines them as individuals engaged in farming activities on plots of land spanning 2 ha or smaller, and who depend solely on the labour of their own family members was adopted.

2.5. Data analysis

The data acquired from the field underwent editing, coding, and entry for analysis. All these were accomplished through the utilization of IBM SPSS software version 21.0. Both descriptive (mean, frequency, standard deviation, percentage) and inferential statistics (ordered logit regression model, Kendall's coefficient of concordance) were used.

To assess the level of CA adoption by maize farmers, we asked the maize farmers to indicate from a list of CA practices their frequency of use on a Likert scale ranging from one (never) to five (always). Based on their responses, we adapted and modified a grading system used by Sarea et al. (2017), Ankuyi et al. (2023) and Anaglo et al. (2014) to group the maize farmers into three (3) levels i.e., low, moderate and high. Thus, maize farmers whose record of CA practice shows a value of ≤40% are considered low CA adopters. Farmers whose record of CA practice shows a value ranging between >40% - and ≤70% are categorized as moderate CA adopters, while those with >70% are classified as high CA adopters. Table 1 shows the CA practices that the study focused on.

To determine the socio-economic variables that influence the use of CA by maize farmers, we used the ordered logit regression model. The ordered logit regression model is a statistical technique used to analyse the relationship between one or more independent variables (predictors) and an ordinal dependent variable (outcome) that has more than two ordered categories (Badu-Gyan and Owusu, 2017; Tham-Agyekum et al., 2021). In the context of determining the socio-economic variables that influence the use of CA by maize farmers, the ordered logit regression model was appropriate because CA adoption which was the dependent variable fell into ordered categories such as "low adoption," "moderate adoption," and "high adoption." The independent variables hypothesized to influence the level of CA adoption by maize farmers are presented in Table 2.

The ordered logit regression model assumes that the relationship between the explained and the explanatory variables is linear in the log-odds. It also assumes the proportional odds assumption, which means that the effect of the independent variables on the log-odds of being in a higher category of CA adoption is constant across all levels of the dependent variable (Badu-Gyan and Owusu, 2017). To determine the effect of CA adoption on the food security of maize farmers, we used the ordered logit model. In this case, food security was the dependent variable and it was measured in levels. The household food insecurity access scale (HFIAS) was used. Based on the scale, the farmers were characterized into four (4) food security levels i.e., severely food insecure, mildly food insecure, moderately food insecure and food secure. Descriptive statistics such as frequency, percentage, standard deviation and mean were used. Independent variables such as level of CA adoption and socio-economic variables were used.

Table 1
CA practices used in the study.

CA Practices	Meaning
Crop Rotation	it involves planting different crops in a sequential order on the same piece of land over time
Mulching	it involves covering the soil surface with organic or synthetic materials such as crop residues, straw, plastic film, or compost
Zero Tillage	it refers to planting crops without prior soil tillage or minimal soil disturbance
Cover Cropping	it involves planting non-harvested crops during fallow periods or between cash crop growing seasons
Intercropping	it refers to growing two or more crop species together in the same field during the same growing season
Row Planting	it involves planting crops in parallel rows with spaces between rows for crop management activities such as irrigation, fertilization, and weed control
Use of Improved Seeds	it involves planting high-quality, genetically improved crop varieties or hybrids that exhibit desirable traits such as high yield potential, disease resistance, drought tolerance, and improved nutritional quality
Fertilizer Application	it involves supplementing soil nutrients with synthetic or organic fertilizers to optimize crop growth and yield
Integrated Pest Management	it is a holistic approach to pest control that combines cultural, biological, mechanical, and chemical control methods to minimize pest damage while minimizing negative impacts on human health and the environment

Table 2
Description of explanatory variables.

Variable	Unit of measurement	A priori expectations
Age	Continuous-years	+
Years of Adopting CA Practices	Continuous-years	+
Farm Size	Continuous-hectares	+
Area Under CA Cultivation	Continuous-hectares	+
Years Spent in School	Continuous-years	+
Household Size	Continuous-number	+
Sex	Dummy: female-0, male-1	+/−
Marital Status	Dummy: married-1, others-0	+/−
Religion	Dummy: Christian-1, other-0	+/−
Land Ownership	Dummy: own land-1, others-0	+/−
Access to Credit	Dummy: yes-1, no-0	+/−
Primary Occupation	Dummy: farming-1, otherwise-0	+/−
Access to Extension Services	Dummy: yes-1. Otherwise-0	+/−
Membership in CA Farmer Group	Dummy: yes-1, no-0	+/−

We used Kendall's Coefficient of Concordance to rank the challenges faced by farmers in adopting CA. Kendall's Wa is the determinant indicating in terms of percentage the level of agreement from the most pressing constraint to the least. First of all, each maize farmer was asked to rank the challenges faced in adopting CA according to their perceived severity. The Kendall's W was calculated based on the ranks assigned by each maize farmer to the challenges. It measured the extent to which the rankings provided by different farmers agree with each other. A value of 1 indicates perfect agreement (all farmers rank the challenges in the same order), while a value of 0 indicates no agreement (the rankings are completely random). A higher value of W indicates a higher level of agreement among farmers in their rankings of the challenges. This implies greater consensus among farmers regarding which challenges are the most significant in adopting CA.

As a limitation, the study relied on self-reported information from farmers, including their adoption of CA practices and food security status. There may be a risk of respondents providing socially desirable responses or inaccuracies due to recall bias. The research employed a cross-sectional approach, offering a momentary glimpse of the conditions at a particular juncture. Longitudinal data would offer a more comprehensive view of the dynamics of CA adoption and its long-term impact on food security. The study focused on CA adoption and food security but did not delve into other potential socioeconomic factors, such as income levels, access to healthcare, or education, which can also impact food security. Findings from this study may be specific to the Adansi Akrofuom district and may not be directly applicable to other regions or districts with different climate conditions, agricultural practices, or socioeconomic contexts.

3. Results and discussion

3.1. Farmers' demographic characteristics

The results of the farmers' demographic characteristics are presented in Table 3. Of the 400 farmers interviewed, 53.0% of them were males. This suggests that just over half of the farmers were males, and in Ghanaian contexts, farming is predominantly carried out by men (Tham-Agyekum et al., 2023; Fiawoo et al., 2024). This result follows the

Table 3
Demographic attributes of the farmers.

Discrete variables	Frequency (N)	Percent (%)
Sex of the Respondents		
Male	188	53.0
Female	212	47.0
Marital status of the Respondent		
Married	329	82.3
Others	71	17.7
Religion of the Respondent		
Christianity	354	88.4
Others	46	11.6
Land Tenure System		
Owner	194	48.5
Others	206	51.5
Primary Occupation		
Farming	283	70.8
Others	117	29.2
Membership in CA farmer group		
No	11	2.8
Yes	389	97.2
Access to credit facilities		
No	395	98.8
Yes	5	1.2
Access to Extension Service		
No	5	1.2
Yes	395	98.8
Continuous Variables	Mean (Std. Dev.)	Min (Max)
Age (years)	44.17 (9.16)	23 (86)
Household Size	4.67 (1.92)	2 (7)
Farm Experience (years)	21.00 (8.51)	1 (50)
Years of Education (years)	11.20 (4.89)	0 (15)
Total Farm Size (hectares)	1.92 (0.82)	1 (12)
Total area under conservation agriculture (hectares)	1.58 (0.44)	1 (5)

Source: Field Data, 2022.

same trend as a study conducted by Christen et al. (2016) which showed that males formed the majority of farmers.

For marital status, the results show that 82.3% of the farmers were married whilst 6.5% have never married. The marital status of farmers can significantly influence farming practices and outcomes, as it can affect access to both financial resources and labour. Married farmers often benefit from greater access to labour resources, as they can enlist the help of their children and spouses in farming activities. Additionally, they may have increased access to financial resources due to shared household assets and income (Ankuyi et al., 2023).

The finding that 88.4% of respondents identified as Christians while only 4.8% identified as Muslims reflects the religious composition of the surveyed population. This distribution suggests a predominant Christian presence among the respondents, with a significantly smaller representation of Muslims. The finding that 48.5% of farmers were landowners, while the remaining 51.5% represented other land tenure systems (communal land tenure system, share cropping, rent etc.), highlights the diverse landscape of land ownership and tenure arrangements within the surveyed population. Different farmers may have access to land through different arrangements, each with its rights, responsibilities, and implications for agricultural production and livelihoods. The result shows that 70.8% of the respondent had farming to be their primary occupation. This high percentage suggests that the sample primarily consisted of individuals directly involved in agriculture, which could have implications for the generalizability of the findings to other populations with different primary occupations.

Most of the farmers (97.2%) are members of the CA farmer group. This high level of membership could influence the responses, as individuals affiliated with farmer groups may have different perspectives and experiences compared to those who are not part of such groups. Farmer groups play a vital role as distribution hubs for disseminating information and technology to farmers (Fiawoo et al., 2024). For instance, Debela et al. (2018) suggest that farmers' cooperatives have improved the productivity and income of smallholder farmers.

Despite the high percentage of group membership, 98.8% of farmers lacked access to credit. This observation is expected given that most farmer groups in Ghana are formed with specific project goals and commercial aims, rather than prioritizing access to credit (Fiawoo et al., 2024). Again, the majority of the respondents (98.8%) indicated that they have extension access. Farmers are inclined to claim access to extension services and to report increased interaction levels with these services if they are familiar with and have a positive rapport with the enumerators who are extension officers. This may result in an overestimation of the true extent of extension access within the wider farming community. To mitigate this risk, extension officers were prohibited from collecting data from the communities they serve.

Table 3 shows that the farmers' average age was 44 years. The average age of 44 years old implies that farmers in the study are middle-aged with relatively enough energy for production activities. This finding aligns with Salau and Salman (2017), suggesting that farmers fell within the productive age range of 40–45 years. The mean household size was 4.67. This suggests that, on average, farmers maintain a household size of five individuals. For farm experience, a mean score of 21 years with a minimum of 1 year and a maximum of 50 years was recorded for the study. This agrees with Asante et al. (2013) who reported that the mean farm experience of farmers is 21 years. The farmers spent an average of 11 years in school. This result indicates that the smallholder farmers are somehow literate enough to accept CA practices or improved agricultural technologies as noted by Singh et al. (2016). The total farm size used for maize farming was 1.92 ha. This confirms that most of the farmers in the district are small-scale farmers, which agrees with Goodman (2017). Most of the farmers on average have 1.58 ha of land under conservation agriculture.

3.2. Adoption of CA practices by respondents

The findings presented in Table 4 provide valuable insights into the frequency of adoption of conservation agriculture (CA) practices among smallholder maize farmers. Practices such as crop rotation (mean = 4.47), row planting (mean = 3.92), improved seeds (mean = 3.81), cover cropping (mean = 3.57), and fertilizer application (mean = 3.86) demonstrate relatively high mean scores, indicating widespread adoption among farmers. This implies that farmers incorporate these practices into their agricultural routines and acknowledge their beneficial effects on productivity and soil health. Maize farmers appear to embrace CA practices due to their distinct approach, which emphasizes principles such as minimal soil disturbance, crop diversification, and soil cover. This underscores the importance of promoting CA as a holistic and integrated approach to farming that offers multiple benefits beyond conventional practices (Scheba, 2017).

While some practices are frequently adopted by farmers, others, such as mulching (mean = 3.09), zero tillage (mean = 3.47), intercropping (mean = 3.35), and integrated pest management (mean = 3.26), show lower mean scores, indicating less consistent adoption. These differences in adoption levels may stem from various factors, including farmers' knowledge, resources, access to support services, and perceptions of the benefits and challenges associated with each practice (Scheba, 2017).

The findings corroborate earlier studies that have reported similar patterns of adoption among smallholder farmers. Chichongue et al. (2020) noted that farmers do not fully adopt all components of CA, reflecting the variability in adoption levels observed in this study. Scheba (2017) rather observed challenges with crop rotation and zero-tillage adoption, citing factors such as limited capacity and weed management difficulties. Meijer et al. (2014) highlighted the role of access to information, learning opportunities, training, and extension services in shaping farmers' adoption decisions.

Table 4
Adoption of CA practices.

CA Practices	Never (F/%)	Rarely (F/%)	Sometimes (F/%)	Often (F/%)	Always (F/%)	Mean	Std. Dev.
Crop Rotation	–	3 (0.8)	96 (24.0)	11 (2.8)	290 (72.4)	4.47	0.881
Mulching	60 (15.0)	86 (21.5)	74 (18.5)	120 (30.0)	60 (15.0)	3.09	1.308
Zero Tillage	43 (10.8)	9 (2.3)	195 (48.8)	23 (5.6)	130 (32.5)	3.47	1.262
Cover Cropping	38 (9.4)	60 (15.0)	47 (11.8)	147 (36.8)	108 (27.0)	3.57	1.288
Intercropping	73 (18.3)	1 (0.3)	177 (44.3)	10 (2.6)	139 (34.8)	3.35	1.424
Row planting	43 (10.8)	18 (4.5)	72 (18.0)	61 (15.2)	206 (51.5)	3.92	1.357
Improved seeds	56 (14.0)	6 (1.4)	99 (24.8)	36 (9.0)	203 (50.8)	3.81	1.430
Fertilizer	39 (9.8)	23 (5.7)	86 (21.5)	58 (14.5)	194 (48.5)	3.86	1.339
Integrated Pest Management	43 (10.8)	8 (2.0)	239 (59.8)	22 (5.5)	88 (22.0)	3.26	1.149

Source: Field Data, 2022.

3.3. Level of practice of CA by maize farmers

The findings presented in Table 5 shed light on the levels of adoption of CA by smallholder maize farmers. The fact that 74% of farmers are practicing CA at a moderate level indicates a notable level of engagement with these sustainable agricultural techniques. This moderate level of adoption suggests that many farmers have integrated at least some aspects of CA into their farming practices, demonstrating a willingness to explore and implement more environmentally friendly and sustainable approaches to agriculture. Moreover, the data reveal that 23.8% of farmers are practicing CA at a high level, which is a promising sign of significant adoption among a substantial portion of the farming population. These farmers likely exhibit a deeper commitment to CA principles and may be reaping the benefits of improved soil health, enhanced crop resilience, and higher yields associated with more advanced CA practices. However, a small percentage of farmers (2.2%) are practicing CA at a low level. While this proportion is relatively small, it still highlights a subset of farmers who may require additional support, training, or resources to fully embrace CA principles and overcome barriers to adoption.

3.4. Determinants of CA practices adoption among crop farmers

Table 6 displays the outcomes of an ordered logit model employed to examine the factors influencing the adoption of CA practices among crop farmers. The statistical tests indicate the model's significance (LR $chi^2(19) = 19.16$, p-value = 0.000). With a pseudo-R^2 value of 0.433, it can be inferred that the independent variables in the model collectively account for approximately 43.3% of the variance in CA practices adoption.

Among the variables analyzed, the significant factors influencing the adoption of Conservation Agriculture (CA) practices among smallholder maize farmers are age, household size, education level, religion, access to extension services, and area under CA cultivation.

The coefficient for sex in the regression analysis is −0.935, and it is statistically significant at 1%. This negative coefficient indicates that there is a significant negative relationship between the sex of farmers and the likelihood of adopting Conservation Agriculture (CA) practices among smallholder maize farmers. Specifically, male farmers are less likely to adopt CA practices compared to their female counterparts. One possible explanation for this gender disparity in CA adoption could be related to access to information, resources, and extension services. Women often face greater constraints in accessing agricultural extension services, credit, and land tenure rights compared to men (Atsbeha and Gebre, 2021). As a result, they may be more open to exploring alternative farming practices like CA as a means of improving productivity, conserving natural resources, and enhancing resilience to climate change.

Table 5
Level of practice of CA.

Levels	Frequency (N)	Percent (%)
Low (≤40%)	8	2.2%
Moderate (≥40% - ≤70%)	297	74.0%
High (≥70%)	95	23.8%
Total	400	100.0%

Source: Field Data, 2022.

Table 6
Determinants of CA practice adoption.

Variables	Coeff.	Std. Err.	Odds Ratio
Level of practice of CA = 1 (Low)	2.317**	2.443	2.343
Level of practice of CA = 2 (Moderate)	8.180***	2.513	1.001
Sex	−0.935***	0.377	2.013
Household size	−0.148**	0.102	4.048
Age	0.069***	0.025	2.007
Marital status	0.577	0.367	3.116
Farm experience	−0.033	0.024	0.971
Years of education	0.019*	0.026	0.763
Religion	−1.325	0.853	1.120
Primary occupation	0.070	0.325	1.829
Land tenure	−0.296	0.293	2.313
Access to credit	−1.043	1.409	0.859
Access to extension service	4.739***	1.260	3.200
CA farmer group	−0.001	0.028	1.972
Farm size	0.217	0.298	0.966
Area under cultivation	0.047**	0.032	3.043
Observations	400		
LR $chi^2(14)$	19.16		
Pseudo R^2	0.433		
Prob > chi^2	0.000		
Log-likelihood	−117.932		

Source: Field Data, 2022.
NB: 1% = ***, 5% = **, 10% = *.

Household size exhibited a negative coefficient (−0.148) and is statistically significant at 5%, indicating that larger household sizes were associated with decreased odds of adopting CA practices. This suggests that farmers with smaller households may find it easier to implement and manage CA techniques due to potentially lower labour demands and resource constraints. One potential reason for this negative association could be the allocation of resources within larger households. With more family members to support, farmers might prioritize conventional farming methods that are perceived as providing more immediate or stable yields. CA practices might require a transition period and initial investments that larger households find challenging. Chichongue et al. (2020), Ngoma et al. (2021), and Tufa et al. (2023) contradicted this study, indicating that household size had a notable and positive impact on the adoption of conservation agriculture practices.

Age demonstrated a positive coefficient (0.069) and is statistically significant at 1%, indicating that older farmers were more likely to adopt CA practices. This finding suggests that older farmers may have accumulated more experience and knowledge over time, making them more receptive to adopting sustainable farming practices like CA. Moreover, their accumulated years of farming experience often translate into a deeper comprehension of agricultural methods, including the advantages of CA, contributing to higher adoption rates (Tham-Agyekum et al., 2023). The results align with those of Abdulai et al. (2021), Ngoma et al. (2021), and Tufa et al. (2023), who reported that age significantly influences farmers' decisions to adopt CA.

Years of education also showed a positive coefficient (0.019) and is statistically significant at 10%, suggesting that higher levels of education were associated with increased odds of CA adoption. This implies that farmers with higher education levels may be more inclined to seek out and adopt innovative agricultural practices that promise benefits such as improved yields and sustainability. Farmers with higher levels of education frequently enjoy improved access to agricultural knowledge and resources, which likely contributes to their increased adoption (Tufa et al., 2023) of CA practices. This access can provide them with more information about modern agricultural practices, including CA, and the benefits it offers for sustainable farming. Education can enhance critical thinking and problem-solving skills. Farmers with higher education levels may be better equipped to analyse the potential advantages of CA practices, such as improved soil health and reduced environmental impact, and apply these concepts to their farming. The results align with Abdulai et al. (2021) who asserted that education plays a significant role in farmers' decisions to adopt CA. Higher levels of education enhance the ability and efficiency in processing CA-related information (Kotu et al., 2017).

Access to extension services emerged as a significant predictor with a notably high positive coefficient (4.739). This implies that farmers who have access to extension services are substantially more likely to adopt CA practices compared to those without access. Extension services play a crucial role in disseminating information, providing training, and facilitating the adoption of new agricultural technologies and practices. With access to extension services, farmers can receive guidance and technical support on soil conservation, crop rotation, minimal soil disturbance, and other CA principles from extension agents which can whip up their interest in adopting CA practices. Extension agents may offer practical demonstrations and training, enabling farmers to gain firsthand experience with CA practices (Tufa et al., 2023).

Lastly, the area under cultivation demonstrated a positive coefficient (0.047), indicating that farmers with larger cultivated areas were more likely to adopt CA practices. This suggests that farm size may play a role in CA adoption, with larger farms potentially benefiting more from the implementation of sustainable practices like CA. This could be because large-scale farming operations often have a greater interest in long-term sustainability and soil health due to their dependence on consistent crop production. Crop rotation, a key component of CA, can be more easily implemented with larger areas available for diversification.

3.5. Maize farmers' level of food security

The data on household food security over the past four weeks reveals varying degrees of concern and experiences among respondents (Table 7). While a majority (91.5%) reported never worrying about access to food, a notable portion expressed occasional concerns (1.2%). The majority's lack of worry suggests a level of stability and access to resources that enables consistent access to food. However, the presence of those expressing occasional concerns signifies that even in relatively stable circumstances, there are still instances where access to food becomes a source of worry. Similarly, a majority (77.4%) reported never experiencing food insecurity, yet a significant proportion encountered frequent (7.8%) or occasional (7.8%) food insecurity. The finding highlights the importance of recognizing the varying degrees and dynamics of food insecurity and the need for targeted interventions to address the multifaceted challenges associated with ensuring food security for all. Additionally, a substantial number of respondents frequently (44.5%) or occasionally (11.5%) had to resort to eating restricted food due to lack of resources, while a notable percentage reported frequently (10.3%) consuming less than required due to food scarcity. This indicates that a substantial proportion of individuals are forced to compromise on the quality or variety of their diet. This could

Table 7
Household food security of respondents.

Statements	Frequency (N)	Percent (%)
In the past four (4) weeks:		
Did you or any household member worry about access to food?		
Frequently	23	5.8
Occasionally	5	1.2
Rarely	6	1.5
Never	366	91.5
Did you or any household member experience food insecurity?		
Frequently	31	7.8
Occasionally	31	7.8
Rarely	28	7.0
Never	310	77.4
Did you or any household member have to eat restricted food because of a lack of resources?		
Frequently	178	44.5
Occasionally	46	11.5
Rarely	70	17.5
Never	106	26.5
Did you or any household member eat less than is required due to a lack of food?		
Frequently	41	10.3
Occasionally	34	8.4
Rarely	56	14.0
Never	269	67.3
Did you or any household member skip meals due to a lack of food?		
Frequently	15	3.8
Occasionally	41	10.2
Rarely	57	14.2
Never	287	71.8
Did you or any household member go to bed hungry due to a lack of food?		
Frequently	55	13.8
Occasionally	23	5.8
Rarely	1	0.2
Never	321	80.2
Did you or any household member go an entire day or night without eating anything due to a lack of food?		
Frequently	18	4.5
Occasionally	–	–
Rarely	9	2.3
Never	373	93.2

Source: Field Data, 2022.
NB: Frequently (over ten times in the last four weeks).
Occasionally (three to ten times over the previous four weeks).
Rarely (a couple of times over the previous four weeks).

involve consuming inexpensive, less nutritious foods or relying on food items that are easily accessible but may not contribute to a balanced diet. The prevalence of eating restricted food and consuming less than required due to food scarcity has implications for the health and well-being of individuals affected. Poor nutrition resulting from limited access to diverse and nutritious foods can increase the risk of malnutrition, micronutrient deficiencies, and chronic health conditions such as obesity, diabetes, and cardiovascular diseases. Furthermore, a proportion of respondents frequently (3.8%) or occasionally (10.2%) skipped meals due to lack of food, with a significant number frequently (13.8%) going to bed hungry. The results highlight the extent to which food insecurity affects individuals' ability to maintain regular eating patterns. Skipping meals can have serious consequences for health and well-being, leading to hunger, malnutrition, and decreased energy levels. Going to bed hungry can negatively impact sleep quality, overall health, and cognitive function. Though fewer respondents frequently (4.5%) went an entire day or night without eating, it's evident that food insecurity remains a significant concern among a portion of the respondents, necessitating further attention to address these challenges and ensure improved household food security.

3.6. Maize farmers' household food insecurity access scale (HFIAS) level

Table 8 presents the distribution of respondents according to their level of HFIAS, indicating that the majority of respondents (79.3%) are classified as food secure, while smaller proportions fall into categories of

Table 8
Level of respondents HFIAS.

Levels	Frequency (N)	Percent (%)
Food Secure	317	79.3
Slightly Food Insecure	43	10.8
Moderately Food Insecure	26	6.5
Severely Food Insecure	14	3.5
Total	400	100.0

Source: Field Data, 2022.

slight food insecurity (10.8%), moderate food insecurity (6.5%), and severe food insecurity (3.5%). This distribution highlights the varying degrees of food insecurity experienced by the respondents, with a substantial portion facing challenges ranging from mild to severe. These findings highlight the importance of addressing food insecurity comprehensively, with targeted interventions aimed at supporting individuals and households across different levels of food insecurity to ensure access to sufficient, safe, and nutritious food for all. Achieving food security goals necessitates the simultaneous fulfilment of all four dimensions (pillars), including food access, to ensure the successful livelihoods of farmers (UN-HLTF, 2011).

3.7. Influence of CA practices acceptance on farmers' food security

Table 9 displays the results of the ordered logit analysis examining the influence of CA adoption on food security. The statistical tests for the model demonstrate the model's statistical significance (LR $chi^2(23) = 81.84$, p-value = 0.000). With a pseudo-R^2 value of 0.647, it is indicated that the independent variables in the model collectively account for roughly 64.7% of the variance in household food security. The subsequent variables are statistically significant at a 10% significance level or higher:

Sex is significant at 10%. In the case of male farmers, the odds of achieving food security increase by a factor of 1.900. This suggests that male farmers have a higher likelihood of being food secure compared to their female counterparts. The finding suggests that the gender of the farmer plays a crucial role in household food security (Joshi and Joshi, 2016). Correspondingly, Mango et al. (2014) argue that men have greater access to on-farm labour compared to women, resulting in improved food security. According to Aragie and Genanu (2017) and Abdullah (2015), women face a higher susceptibility to food insecurity due to their restricted access to livelihood assets.

Table 9
Influence of CA practices acceptance on household food security.

Variables	Coeff.	Std. Err.	Odds Ratio
Sex	1.036*	0.544	1.900
Age	0.061	0.050	1.220
Household Size	0.532***	182.354	0.903
Marital status	−0.748	0.663	1.130
Farming Experience	−0.061	0.049	1.250
Years of Education	0.063	0.052	1.210
Religion	−0.485	0.797	0.910
Primary occupation	1.418**	0.604	2.350
Land Tenure	2.529***	0.569	1.450
Access to Credit	−0.934	2.246	2.420
Membership in CA Farmer Group	0.136	1.507	1.090
Access to extension	−0.210	0.318	1.660
Farm Size	−0.074	0.055	1.340
Area Under CA Cultivation	−0.019	0.063	0.900
Crop Rotation	0.057	0.279	2.210
Mulching	0.492**	0.203	2.420
Zero Tillage	0.468**	0.218	2.150
Cover Cropping	−0.473**	0.216	2.190
Intercropping	0.128	0.193	0.660
Row Planting	0.367*	0.208	1.770
Use of Improved Seeds	0.076	0.213	3.350
Timely Fertilizer Application	0.307	0.245	1.250
Integrated Pest Management	0.114	0.254	0.750

Number of Obs = 400; LR $chi^2(23) = 81.84$; Log-likelihood = −1137.864; Prob > chi^2 = 0.0000; Pseudo R^2 = 0.647

Source: Field Data, 2022.
NB: 1% = ***, 5% = **, 10% = *.

Household size is significant at 1%. The odds ratio supporting food security rises by 0.903 with each additional household member, indicating a positive correlation between household size and the probability of achieving food security. In practical terms, this suggests that larger households are more inclined to achieve food security than smaller ones. The result aligns with Faustine (2016). In contrast, Mango et al. (2014) observed that larger households exacerbate food insecurity by creating food pressure. Conversely, Aragie and Genanu (2017) as well as Kuwornu et al. (2012) contend that households with a less engaged labour force tend to exhibit a higher dependency ratio, elevating the risk of food insecurity. Larger households typically have more potential labour available for farming and income-generating activities. This can be an advantage in terms of producing or earning enough to meet their food needs. If all other factors are equal, having more household members who can contribute to food production or income generation can increase food security. In some cases, larger households may benefit from economies of scale. This means that they can purchase food and other resources in larger quantities, potentially at lower per-unit costs, which can contribute to improved food security. In larger households, tasks can be divided among family members, allowing for specialization in various activities. For example, some members may focus on farming, while others work in non-agricultural sectors. This diversification of income sources can enhance overall household food security.

Primary occupation is significant at 5%. Among respondents whose primary occupation is farming, the odds of achieving food security increase by a factor of 2.350. This signifies that those who rely on farming as their primary occupation are twice as likely to attain food security compared to individuals whose primary occupation is not farming. Consistent with this research, Mannaf and Uddin (2012) and Sani and Kemaw (2019) have both highlighted agricultural income from farming as a crucial determinant influencing food security. Farming as a primary occupation can contribute to food security through various mechanisms. Farmers often can grow a significant portion of their food needs, reducing their reliance on external food sources. Additionally, income generated from farming activities can be used to purchase food or invest in food production (Sani and Kemaw, 2019).

Land tenure is significant at 1%. For farmers who possess land, the odds of achieving food security rise by a factor of 1.450. This suggests that land-owning farmers are more inclined to achieve food security compared to those without land ownership. This points to a positive correlation between owning land and attaining food security. Land ownership provides farmers with a valuable resource for food production. They can cultivate crops or raise livestock on their land, which can contribute to food self-sufficiency. Landownership can serve as an asset that farmers can leverage to access credit and invest in agricultural inputs and practices that enhance food production. Possessing land increases opportunities for domestic production, thereby enhancing nutritional intake (Kumar et al., 2012). Land access is deemed a vital tactic for alleviating rural poverty and guaranteeing food security in Nepal (Joshi and Joshi, 2016) and Ghana (Kuwornu et al., 2012).

Mulching, a CA practice is significant at 5%. The outcome of the odds ratio supporting being food secure increases by 2.420 for farmers who practice mulching. It implies that farmers who practice mulching are 2 times more likely to be food secure compared to those who do not practice mulching. Mulching is an agricultural practice where a layer of organic or inorganic material is placed on the soil surface around plants. This practice offers several benefits that can contribute to food security: Mulching helps retain soil moisture, which is crucial for plant growth, particularly in regions with irregular rainfall and mulch can suppress weed growth, reducing competition for water and nutrients. Zhang et al. (2022) found that employing mulching techniques typically enhances soil nutrient levels, thereby increasing crop yield. This directly contributes to improved food security.

Zero tillage, a CA practice is significant at 5%. The outcome of the odds ratio supporting being food secure increases by 2.150 for farmers who practice zero tillage. It implies that farmers who practice zero tillage are twice as likely to be food secure in contrast to those who do not practice zero tillage. Zero tillage, also known as no-till farming, is an agricultural practice where crops are grown without disturbing the soil through ploughing or tilling (Keil et al., 2017). This practice has several potential benefits that can contribute to food security: Zero tillage helps reduce soil erosion, which can protect arable land and maintain soil fertility; Zero tillage can improve water retention in the soil, which is particularly valuable in areas with limited rainfall and Zero tillage can reduce labour and fuel costs associated with traditional tillage, potentially increasing farm income. Keil et al. (2017) further stated that zero-tillage stands as a well-established technology capable of augmenting agricultural productivity and thereby contributing to food security in contemporary farming, all the while reducing production expenses.

Cover cropping, a CA practice is significant at 5%. The outcome of the odds ratio supporting being food secure decreases by 2.190 for farmers who practice cover cropping. It implies that farmers who practice cover cropping are 2 times less prone to achieve food security than individuals who do not practice cover cropping. Land used for cover cropping might not be utilized for maize production, potentially reducing the food available for immediate consumption. Cover cropping is primarily aimed at soil improvement, erosion control, and weed suppression. While it indirectly benefits food production, its main objective is not food security. Improvements in soil health due to cover cropping may take time to translate into increased food production, and in the short term, it might not directly impact food security. Leguminous cover crops such as alfalfa, vetches, and clover contribute to soil fertility by naturally fixing nitrogen and increasing organic matter levels (Lüscher et al., 2014). Conversely, non-legume cover crops like spinach, canola, and flax aid in regulating soil nitrate levels, supporting crop growth, and improving overall soil health (White et al., 2016; Finney et al., 2016).

Row planting, a CA practice is significant at 10%. The outcome of the odds ratio supporting being food secure increases by 1.770 for farmers who practice row planting. It implies that farmers who practice row planting are 2 times more likely to be food-secured compared to those who do not practice row planting. Row planting allows for optimal spacing between plants, reducing competition for resources such as sunlight, water, and nutrients. This can result in increased yields per unit area compared to other planting methods. Higher yields mean more food produced from the same amount of land, potentially enhancing food security. Planting crops in rows with the correct spacing between them is anticipated to enhance productivity by optimizing light interception, resource utilization efficiency, tillering capacity and photosynthetic potential (Mihretie et al., 2021). As stated by the Agricultural Transformation Agency (2013), farmers who use row planting techniques have seen increases in yields. Furthermore, Ayal et al. (2018) contends that row planting consistently leads to higher yields, with an average increase of 70% from 12.6 quintals/ha to 20.9 quintals/ha in Ethiopia.

3.8. Challenges faced by farmers in adopting CA practices

Table 10 presents the challenges faced by farmers in adopting CA practices, with the mean rank indicating the perceived severity of each constraint. The primary challenge identified is the lack of access to or insufficient credit, with a mean rank of 3.25, followed closely by the high cost of farm inputs at 3.85. Incompatibility with social norms and values ranks third at 4.58, while inadequate capital and scarcity of cultivable land/problem of land tenure follow closely behind. Other significant challenges include limited access to technical information, extension services, and skilled labour. The findings suggest that addressing financial constraints, input costs, and social factors is crucial for promoting the adoption of CA practices among farmers, highlighting the need for targeted interventions and support mechanisms to overcome these barriers effectively. Factors such as land tenure arrangements, labour demands (particularly during cropping cycles), small farm sizes, inadequate access to credit/capital facilities and low educational attainment have all been cited as reasons for the low adoption of CA in Africa (Baudron et al., 2012). Furthermore, Pittelkow et al. (2015) contended that short-term yield reductions are often encountered with CA, despite its long-term ecological advantages. Scheba (2017) acknowledges the cost of inputs as the primary deterrent to the adoption of CA. Smallholder agriculture faces a web of interconnected challenges, encompassing issues like diminished soil fertility, recurrent dry spells, drought, and unsustainable management methods (Dalton et al., 2017).

Table 10
Challenges farmers face in adopting CA practices.

Constraints	Mean Rank	Ranking
No access to/or insufficient credit	3.25	1st
High cost of farm input	3.85	2nd
Incompatibility to social norms and values	4.58	3rd
Inadequate capital	4.67	4th
Scarcity of cultivable land/Problem of land tenure	5.04	5th
No access to technical information	5.09	6th
Limited access to extension service	5.43	7th
Low availability of skilled labour	6.11	8th
Long length of time required to see results	6.99	9th
N: 400; Kendall's Wa: 0.569; Chi-Square: 540.84; Df: 8; Asymp. Sig.: 0.000		

Source: Field Data, 2022.

This research enhances the theoretical comprehension of CA adoption among smallholder farmers, contributing to the existing knowledge regarding the determinants of CA adoption, its extent, and its implications for food security. The study offers valuable insights into the role of social and economic factors, including access to credit, education, and extension services, in shaping the adoption of CA practices. These findings can inform and enrich theories related to rural development and agricultural practices. The research enhances understanding of the relationship between CA adoption and food security. It can contribute to the development and refinement of theories related to food security in agricultural communities, particularly those practicing CA which is is often considered a sustainable farming practice. The study's findings may contribute to sustainability theories by exploring how CA adoption can lead to improved soil health, reduced environmental degradation, and enhanced food production sustainability.

The study offers practical insights for policymakers in Ghana and beyond. It highlights the importance of policies that promote access to credit, affordable agricultural inputs and extension services to encourage CA adoption. Extension agencies can use the study's findings to tailor their outreach efforts. Understanding the factors that influence CA adoption can help extension agents provide targeted support and training to farmers in the district. Local leaders and community-based organizations can use the study's insights to engage with farmers, raise awareness about the benefits of CA, and encourage its adoption within communities. Researchers and agricultural development organizations can use the study's findings as a basis for further research on CA adoption and its impact in different regions and contexts.

4. Conclusions

The study presents significant insights into the adoption of CA practices among small-scale maize farmers and their effect on household food security in the Adansi Akrofuom district in the Ashanti region of Ghana. The findings reveal a growing interest and engagement in CA within the district. Identified factors such as farmer sex, age, education, household size, access to extension services, and cultivated area under CA emerge as significant predictors of CA adoption. Moreover, the study highlights a positive relationship between CA adoption and food security among farmers, indicating a potential avenue for enhancing agricultural productivity and resource management. There are varied effects of specific CA practices on food security, with practices like mulching, zero tillage, and row planting showing positive effects while others, such as cover cropping, exhibit negative effects. Challenges such as limited access to credit pose significant barriers to wider CA adoption, emphasising the need for financial support mechanisms to facilitate investment in CA techniques.

Based on the significant insights from the study on the adoption of CA practices and their effect on household food security in the Adansi Akrofuom district, we suggest the following recommendations: Collaboration with local agricultural extension agencies and NGOs to design and implement extension programmes specifically tailored to the needs of small-scale maize farmers in the district using participatory approaches and local knowledge can help address their unique challenges and opportunities. Based on the findings indicating a growing interest and engagement in CA within the district, awareness campaigns and training programmes to further educate farmers about the principles and benefits of CA can be organized by the Ministry of Food and Agriculture. Demonstrations and field days can be organized to showcase successful CA practices and their positive outcomes for agricultural productivity and sustainability. Based on the findings highlighting factors influencing the adoption of CA among small-scale maize farmers in the Adansi Akrofuom district, agricultural extension services could be tailored to the specific needs and preferences of maize farmers, considering factors such as age, education level, and household size. The study highlights the positive relationship between the adoption of CA and food security. Therefore, we should encourage farmers to adopt integrated farming systems that integrate CA practices with livestock rearing, soil health management, water conservation, agroforestry, diverse crop species, and other complementary activities. Supportive policies and market mechanisms that advocate, recognize, and reward maize farmers practicing CA for their contributions to food security, environmental conservation, and climate change adaptation.

Availability of data and materials

Data will be provided upon reasonable request.

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Kaakyire Opoku-Acheampong: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Data curation, Conceptualization. **Enoch Kwame Tham-Agyekum:** Writing – review & editing, Visualization, Supervision, Investigation, Formal analysis. **Fred Ankuyi:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Ernest Laryea Okorley:** Writing – original draft, Formal analysis, Writing – original draft, Formal analysis. **John-Eudes Andivi Bakang:** Writing – review & editing, Data curation. **Fred Nimoh:** Writing – review & editing, Supervision.

Declaration of competing interest

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Data availability

Data will be made available on request.

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