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Attitudes and Practices on the Adoption of Conservation Agriculture among Smallholder Farmers in Bahi District

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ABSTRACT

Conservation Agriculture (CA) has gained prominence worldwide, with its principles including minimum soil disturbance, maintaining soil cover and crop rotation. However, in some areas, the adoption is still low. Therefore, this study explored smallholder farmers' attitudes and practices on the adoption of CA at Msisi, Babayu, Zanka and Mundemu wards in Bahi district. The study sample size was 379 respondents, obtained using stratified and simple random sampling techniques. Also, the purposive sampling technique was used to select agricultural field officers, ward executive officers and village chairpersons as key informants. A structured survey through questionnaires was used to collect data from smallholder farmers, and in-depth interviews through checklist were used to collect data from key informants. A cross-tabulation with a Chi-square test (at the 5% level of significance) was used to test the relationship between sex and education level of respondents to the adoption of CA. Quantitative data were analysed using IBM-SPSS statistics version 25 computer programme in which descriptive statistics (mean, minimum, maximum, frequency and percentage) were analysed. Also, thematic analysis was used for qualitative data. The study found that respondents had neutral attitude, indicated by mean scores between 2.5 to 3.4. The study further revealed that only 17.4% of the respondents practice CA whereby minimum soil disturbance and maintaining soil cover are commonly used. Maize, millet and groundnut claimed to perform better under CA. Moreover, the study highlights pests, wild bird attacks, and erratic rainfall patterns as major challenges smallholder farmers encountered during CA implementation. The study recommends that local government through agricultural extension officers and agricultural field officers in collaboration with non-government organization should continue with the provision of knowledge about CA benefits to farmers to encourage its implementation.

1. Introduction

Conservation Agriculture (CA) is a sustainable farming practice designed to improve soil health and increase agricultural productivity. It is based on three key principles: minimal soil disturbance which enhances soil structure; maintaining soil cover to prevent erosion, suppress weeds and reduce moisture loss; and practising crop rotation to improve nutrient availability, increase resilience and reduce pests and diseases. Globally, CA has gained prominence as a strategy to enhance food security, mitigate climate change, and promote environmental sustainability. Kassam et al. (2022) reported that the global area under CA increased from 180.4 million hectares (12.5% of global cropland) to 205.4 million hectares (14.7%) in recent years. While the focus of the 8th World Congress on CA has set for itself to increase a global cropland area under CA to 700 Mha (50%) by 2050 to respond to global challenges, mitigate advancing climate change and land degradation (WCCA-declaration, 2021). Studies indicate that CA can significantly boost crop yields and soil fertility while reducing water and labour requirements (FAO, 2019).

In Asia, CA adoption has been growing, particularly in countries like India and China. These countries face challenges such as soil degradation and water scarcity, which CA practices can address. Specifically, CA in India has shown promise in improving productivity and soil health in various states (Jat *et al.*, 2020; Jat et al., 2021; Kumar, 2025).

However, adoption rates vary, and smallholder farmers often encounter barriers such as limited access to resources and information.

In South Asia, Das et al. (2022) found that perceived economic benefits, access to information, and institutional support were key determinants in the adoption of Conservation Agriculture (CA) practices. However, the lack of financial incentives and knowledge gaps remained major barriers. Based on studies examining the impact of CA on climate resilience and crop productivity, improvements in soil moisture retention and increased crop yields were reported (Abdallah et al., 2021; Mishra et al., 2024 ; Kumar, 2025). Despite these benefits, the lack of knowledge, high upfront costs and limited access to machinery and technical support hindered the adoption. On the other hand, education level and access to extension services were positively associated with CA adoption, as they help raise awareness, disseminate knowledge, provide technical support and advice, encourage innovation and local adaptation and link farmers to necessary resources (Dharmasiri and Jayarathne, 2021; Datta and Behera, 2022 ; Tuti et al., 2022).

In Africa, the majority of farmers are smallholders who face considerable hurdles due to climate variability and land degradation. Conservation Agriculture (CA) presents a promising solution to these issues, with demonstrated benefits in improving soil health and crop yields. For example, research conducted in Kenya and Zimbabwe highlights CA's role in enhancing productivity and resilience to climatic stresses (Kassam et al., 2018). However, widespread adoption remains limited due to factors such as inadequate technical knowledge and financial constraints. In Southern Africa, particularly in Malawi, Zambia and Zimbabwe, studies have reported varied adoption patterns. In Malawi, high non-adoption rates were attributed to labour intensity and pest challenges, whereas Zimbabwe and Zambia showed more stable adoption. Nonetheless, knowledge gaps and limited access to resources remained key barriers (Tufa et al., 2023). In West Africa, particularly in Ghana and Nigeria, farmers acknowledged the benefits of CA. However, adoption was hindered by high input costs, limited technical knowledge and support, insufficient capital, and weak extension services (Jellason et al., 2020; Opoku-Acheampong et al., 2024). In East Africa, Mpande (2021) reported that adoption of CA in Kenya and Tanzania had a positive and statistically significant impact on farmers perceived adaptation to climate change and resilience to drought. Similarly, Entz et al. (2022) reported that CA practices in Ethiopia, Kenya, and Tanzania improved qualitative soil characteristics such as soil structure, soil air and water and crop growth, colour and root system.

In Tanzania, smallholder farmers face significant challenges related to soil health degradation, declining crop yields, and unstable rainfall patterns, all of which hinder agricultural development and growth (URT, 2015). Conservation Agriculture (CA) is actively promoted as part of the country's agricultural development strategy. Government initiatives and non-governmental organizations are working to introduce CA practices to smallholder farmers as a workable solution for improving food security, enhancing soil health, increasing agricultural productivity, and promoting climate resilience. Research indicates that CA can be effective in enhancing yields and sustainability in Tanzanian agriculture (Mkonda and He, 2017; Sankhulani, 2021). However, the adoption of CA is uneven, with varying levels of success depending on local conditions and farmer perceptions. The variations in CA impact were claimed due to limited access to input resources, knowledge gaps, limited access to extension services and lack of training and technical knowledge (Mkonda andHe, 2017; Ngoma et al., 2021). Additionally, socio-economic factors such as income level, gender, age, farmer education, access to credit, perceived economic benefits and social networks were reported to influence significantly the adoption of CA practices (Ramírez et al., 2022; Mbaga, 2024a).

In the Dodoma region, CA was initiated to improve agricultural productivity in a semi-arid environment. Studies in the region suggest that CA can play a crucial role in addressing local challenges such as soil degradation and erratic rainfall (Kahimba et al., 2014; Mbaga, 2024b). Despite its potential benefits, the adoption of CA among smallholder farmers remains low, particularly in Bahi district, where only 20% of farmers have embraced CA practices despite receiving training and extension services under a project by World Vision. This was a development-oriented and livelihood-focused agricultural project that aimed to improve food security and livelihoods of smallholder farmers by promoting sustainable farming practices through conservation agriculture (World Vision, 2021). While other studies explored CA in relation to gender (Msuya et al., 2022); financial performance analysis between conservation agriculture and conventional agriculture (Mbaga et al., 2024b);

adoption and impact of conservation agriculture (Mpande, 2021; Sankhulani, 2021; Selya et al., 2023); and effects of CA on ecosystem services (Muniale, 2020). There remains a gap in understanding farmers' attitudes and practices regarding CA adoption, particularly in Bahi district. The study's insights will be crucial for policymakers and development practitioners who are working to promote CA in Tanzania to design more effective policies and programs that support the widespread adoption of CA practices to enhance agricultural productivity and environmental sustainability, particularly in a semi-arid region. This study specifically explored the attitudes and practices regarding the adoption of conservation agriculture among smallholder farmers in Bahi district.

2. Materials and Methods

2.1. Study Area and Research Design

The study was conducted at Msisi, Babayu, Zanka and Mundemu which are administrative wards found in Bahi district located in the western part of the Dodoma region. In these wards, agriculture is a major economic activity faced with soil degradation, declining crop yields, and erratic rainfall patterns. The selected wards are the only wards where CA training was conducted but the adoption of CA practices among smallholder farmers remained low (World Vision, 2021). The study employed a cross-sectional research design in which data were collected within a single point in time. The design allowed collection of data from the majority of smallholder farmers across the selected wards in Bahi district at a single point in time, making it a cost-effective method (Guo and Fraser, 2015). It provided the current smallholder farmers' attitude and practices on the adoption of CA.

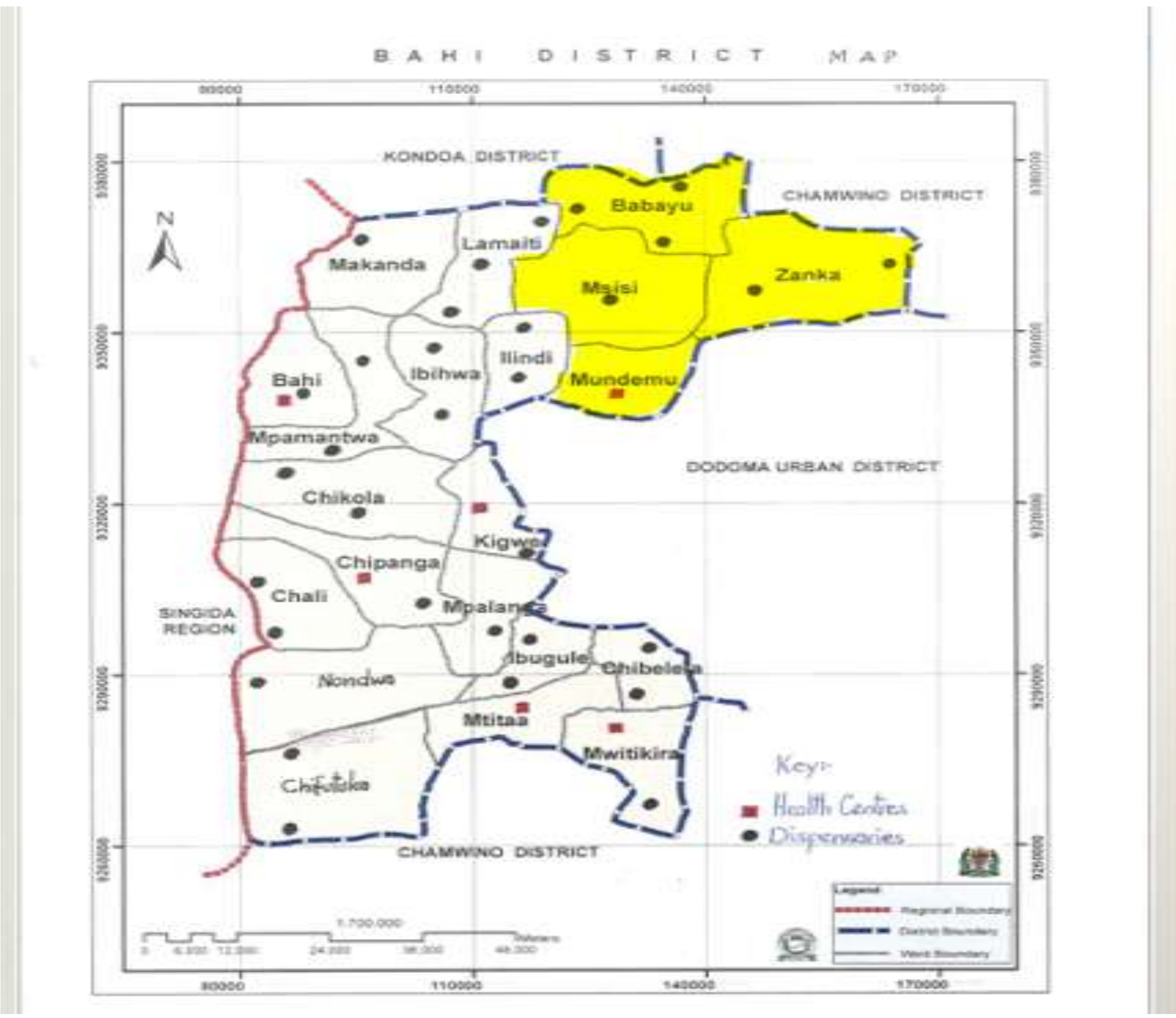

Figure1: Study area highlighted in yellow colour.

2.2. Sampling

The sampling frame for the study consisted of all smallholder farmers at Msisi, Babayu, Zanka, and Mundemu wards, with the individual smallholder farmer serving as the sampling unit. The study employed probability sampling whereby a stratified sampling technique was used to categorize smallholder farmers by ward considering both CA-trained and non-CA- trained farmers. Subsequently, simple random sampling was applied to select farmers from each stratum, ensuring a representative sample across the wards. In non-probability sampling, purposive sampling was used to select key informants, including Agricultural Field Officers, Ward Executive Officers (WEOs) and Village Chairpersons. The total sample size was 379 respondents, determined using Yamane's (1967) formula, as the study population was known as shown below:

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

Whereby;
n= Sample size estimate
N= Population size or sampling frame
e= Error of prediction, 5% = 0.05
Hence,
$n = 7380/[1+7380(0.05)^2] = 379.43$
In order to ensure that the sample of each ward is proportional to its size in the overall population, proportional sampling was employed to represent all wards in the sample adequately.

2.3. Data Collection Methods and Tools

The study used survey, key-informant interviews and focus group discussion methods. A structured survey was employed to collect data from smallholder farmers in each ward and a questionnaire with closed and open-ended questions was used as a tool. This method allowed farmers to provide in-depth responses due to its flexible conversational style that encouraged farmers to share the required information. Key-informant interview was used to collect data from key informants such as Agricultural Field Officers, Ward Executive Officers (WEOs) and Village Chairpersons whereby a checklist developed by considering study objectives was used as a tool. Concerning the focus group discussion, five groups with a total of twelve participants each organized. This procedure allowed smallholder farmers to discuss and share collective experiences and attitudes regarding conservation agriculture and its practices.

2.4. Data Validity and Reliability

To ensure validity, a pilot study was conducted using 10% of the total sample size (38 respondents). The pilot aimed to identify and resolve potential issues with the data collection methods and tools, such as unclear questions, confusing instructions, or logistical challenges. Based on the findings, necessary revisions were made, including editing, adding, or omitting certain questions to enhance data accuracy. Additionally, the study employed multiple data collection methods to enable triangulation, which helped cross-check findings and ensure consistency. All research assistants received training on data collection procedures and adherence to research ethics, thereby enhancing the reliability of the study. To assess internal consistency, a Cronbach's Alpha test was conducted on 18 Likert-scale statements. The resulting coefficient was 0.816, indicating excellent internal consistency, as values equal to or greater than 0.7 are considered acceptable.

2.5. Data Analysis

Attitudes were measured using an index developed from a five-point Likert scale, while smallholder farmers' practices related to Conservation Agriculture (CA) were assessed using a structured questionnaire comprising both closed- and open-ended questions. The collected data were analysed using IBM SPSS Statistics, version 25. Quantitative data were analysed using descriptive statistics, including frequencies, percentages, means, as well as minimum and maximum values. Multiple response analysis was employed to explore farmers' CA-related practices, preferred crops and challenges faced during the implementation of CA. Additionally, cross-tabulation with the Chi-square test was used to examine the relationship between demographic characteristics and the adoption of CA practices. Qualitative data were analysed using thematic analysis, which involved identifying key themes from the dataset that aligned with the study's objectives. Findings were presented in both tables and texts.

3. Results

3.1. Demographic Characteristics of the Respondents

Table 1 shows that the majority (43.3%) of respondents belonged to 45+ age group while only a few (1.6 %) were in the 18-24 age group. Most of the respondents (54.1%) were male, and 45.9% were female. In terms of education, the majority (63.6%) had primary education, 9.5% had secondary education, 15.1% had no formal education, and only 1.8% had tertiary education. Also, the result indicates that 77.6% of the respondents were married, followed by widowed (8.4%) and singles (7.9%). Respondents' household size ranged between 1(min) and 20 (max) with an average of 4.9, and their farm size of 0.25 acre (min) to 22 acres (max) giving an average of 5.5, while respondents' farming experience ranged from 1 year (min) to 60 years (max) with an average of 17.3.

Table 1: Demographic characteristics of the respondents

Variable	Category	Frequency	Percentage
Age	18-24	6	1.6
	25-34	77	20.3
	35-44	132	34.8
	45+	164	43.3
Sex	Male	205	54.1
	Female	174	45.9
Education Level	Primary education	241	63.6
	Secondary education	74	19.5
	Tertiary education	7	1.8
	No formal education	57	15.1
Marital Status	Married	294	77.6
	Divorced	23	6.1
	Widow or widower	32	8.4
	Single	30	7.9
	Minimum	**Maximum**	**Mean**
Household Size	1	20	4.89
Farm Size	0.25	22	5.51
Farming Experience	1	60	17.27

Also, the study used cross-tabulation to show the relationship between demographic characteristics (sex of the respondent-Table 2 and education level Table 3) and adoption of conservation agriculture specifically practices that mostly used. The relationship was tested in 5% level of significance using Chi-square test.

Table 2 presents relationship between sex of the respondents and adoption of conservation agriculture practices. The results show that male farmers 37 (56.1%) are leading adopters of CA whereby 37(57.8%) implemented minimum soil disturbance and 23(54.8%) of all CA adopters used maintaining soil cover. While female farmers 29 (43.9%) adopted CA in which 27 (42.2%) implemented minimum soil disturbance and 19 (45.2%) used maintaining soil cover mostly. This implies that male farmers preferred minimum soil disturbance and female farmers preferred maintaining soil cover in their farming activities. However, sex of the respondent has no significant relationship to adoption of CA practices (*P>0.05*).

Table 2: Sex of the respondent * Adoption of conservation agriculture (Cross-tabulation)

		Implementation of CA practices		Total	p-Value
		Yes	No		
Sex of the respondent	Male	37	168	205	0.724
	Female	29	145	174	
Total		**66**	**313**	**379**	
		Minimum soil disturbance		**Total**	
		not selected	selected		0.105
Sex of the respondent	Male	0	37	37	
	Female	2	27	29	
Total		**2**	**64**	**66**	
		Maintaining soil cover		**Total**	
		not selected	selected		0.779
Sex of the respondent	Male	14	23	37	
	Female	10	19	29	
Total		**24**	**42**	**66**	

Results in Table 3 show the relationship between education level and adoption of conservation agriculture. The study found that adopters of CA who had primary education were 50 (75.8%), whereby 49(76.6%) implemented minimum soil disturbance and 30 (71.4%) of CA adopters implemented maintaining soil cover, followed by 15 (22.7%) who had secondary education, 14(21.9%) among them implemented minimum soil disturbance, and 11(26.2%) used maintaining soil cover. But only 1(1.5%) claimed to have tertiary education and implemented both minimum soil disturbance (1.7%) and maintaining soil cover (2.4%). Also, results show that education level has a significant relationship with the adoption of CA (*P<0.05*) but is insignificant to a particular conservation agriculture practice (*P>0.05*).

Table 3: Education level * Adoption of conservation agriculture (Cross-tabulation)

		Implementation of CA practices		Total	p-Value
		Yes	No		
Education level	Primary education	50	191	241	
	Secondary education	15	59	74	0.002
	Tertiary education	1	6	7	
	No formal education	0	57	57	
Total		**66**	**313**	**379**	
		Minimum soil disturbance		**Total**	
		not selected	selected		
Education level	Primary education	1	49	50	0.642
	Secondary education	1	14	15	
	Tertiary education	0	1	1	
Total		**2**	**64**	**66**	
		Maintaining soil cover		**Total**	
		not selected	selected		
Education level	Primary education	20	30	50	0.480
	Secondary education	4	11	15	
	Tertiary education	0	1	1	
Total		**24**	**42**	**66**	

3.2. Smallholder Farmers' Attitude towards Adoption of CA

Result in Table 4 shows that, majority of the respondents had neutral attitude towards the adoption of CA, indicated by mean scores between 2.5 to 3.4. This suggests that factors such as willingness, compatibility with traditional values, technical know-how, expert support, access to inputs and perceived benefits influence adoption decisions

Table 4: Smallholder farmers attitude towards adoption of CA (n = 379)

Statement	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Mean
Farmers are open to learn new techniques associated with conservation agriculture.	0 (0.0)	1 (0.3)	77 (20.3)	156 (41.2)	145(38.3)	4.2
Adopting conservation agriculture practices will benefit farming in the long term.	2 (0.5)	7 (1.8)	197 (52)	125 (33.0)	48 (12.7)	3.6
Cultural beliefs discourage the adoption of conservation agriculture practices.	206(54.4)	134 (35.4)	16 (4.2)	19 (5.0)	4 (1.1)	1.6
Cultural values should be adapted to incorporate modern conservation practices.	1(0.3)	2(0.5)	32(8.4)	288(76.0)	56(14.8)	4.0
Conservation agriculture has met farmers' expectations since the benefits outweigh the challenges farmers face.	3(0.8)	5(1.3)	310(81.8)	46(12.1)	15(4.0)	3.2
Conservation agriculture practices have positively impacted farmers in the overall farming experience.	1(0.3)	10(2.6)	199(52.5)	109(28.8)	60(15.8)	3.6
Farmers are more likely to adopt conservation agriculture if other farmers in the community are adopting it.	0(0.0)	0(0.0)	22(5.8)	81(21.4)	276(72.8)	4.7
Farmers who use conservation agriculture have shared positive outcomes with farmers who have not adopted it.	7(1.8)	31(8.2)	190(50.1)	114(30.1)	37(9.8)	3.4
Farmers consistently apply soil cover as part of conservation agriculture to maintain soil health.	3(0.8)	20(5.3)	243(64.1)	82(21.6)	31(8.2)	3.3
Farmers consistently apply crop rotation as part of conservation agriculture to maintain soil health.	0(0.0)	36(9.5)	276(72.8)	50(13.2)	17(4.5)	3.1
Farmers rarely deviate from the recommended practices of conservation agriculture.	1(0.3)	10(2.6)	298(78.6)	64(16.9)	6(1.6)	3.2
Government extension officers promote conservation agriculture in the community.	24(6.3)	75(19.8)	62(16.4)	197(52.0)	21(5.5)	3.3
Local agricultural groups encourage farmers to adopt CA	33(8.7)	132(34.8)	109(28.8)	100(26.4)	5(1.3)	2.8
Non-Governmental Organizations provide support (financial, technical and materials) for adopting conservation agriculture practices.	33(8.7)	102(26.9)	179(47.2)	59(15.6)	6(1.6)	2.7
Conservation agriculture practices are effective in improving crop yields.	0(0.0)	4(1.1)	200(52.8)	76(20.1)	99(26.1)	3.7
Conservation agriculture helps farmers to address soil degradation problems and water scarcity.	0(0.0)	1(0.3)	217(57.3)	62(16.4)	99(26.1)	3.7
The initial cost of adopting conservation agriculture practices is a major challenge.	26(6.9)	79(20.8)	202(53.3)	48(12.7)	24(6.3)	2.9
Limited access to necessary inputs (e.g., training, tools, labour and seeds) hinders the adoption of conservation agriculture practices.	27(7.1)	71(18.7)	163(43.0)	52(13.7)	66(17.4)	3.2

Smallholder farmers revealed that farmers are more likely to adopt CA practices if other farmers in their community are adopting it. Qualitative findings support this. During the interview at ward executive office, one key informant noted:

"Smallholder farmers are willing to adopt conservation agriculture, but its complexity hinders fully implementation of its practices. Consequently, some farmers who were trained on CA are not applying it as expected." (KII with Ward executive officer, March 2025).

3.3. The Practice of Smallholder Farmers in Relation to CA

This part analyses the implementation of conservation agriculture, ways of learning and adoption of conservation practices.

Table 5 shows that only 17.4% of respondents implemented CA practices, while 82.6% did not. Among adopters, the majority (80.3%) acquired CA knowledge through training, followed by 18.2% who learnt from fellow farmers. Only 1.5% cited ancestral knowledge. Some farmers used multiple practices simultaneously.

Table 5: The practice of smallholder farmers in relation to CA

	Category	**Frequency**	**Percent**
Implementation of conservation agriculture practices	Yes	66	17.4
	No	313	82.6
	Total	**379**	**100.0**
Source of knowledge about CA		Frequency	Percent
	Training	53	80.3
	Fellow farmers	12	18.2
	From ancestors	1	1.5
	Total	**66**	**100**
		Frequency	**Percent of cases**
CA practices used by smallholder farmers	Minimum soil disturbance	64	97.0
	Maintaining soil cover	42	63.6
	Crop rotation (diversification)	11	16.7
	Intercropping	12	18.2

Table 6 shows total farmland under CA ranged from 0.25 to 6 acres, with an average of 1.3. The majority (52.6%) claimed that maize was performing better than other crops such as millet (21.8%), groundnut (9.0%), sunflower (6.4%), tomato (3.8%), pear millet (2.6%), vegetables (2.6%) and cowpeas (1.3%).

Table 6: Total farmland under CA and crops performance

	N	**Minimum**	**Maximum**	**Mean**
Total farmland under CA practices in acres	66	0.25	6.00	1.3
		Responses		Percent of Cases
		n	**Percent**	
Better performing crops under CA practices	Maize	41	52.6%	62.1%
	Millet	17	21.8%	25.8%
	Sunflower	5	6.4%	7.6%
	Groundnut	7	9.0%	10.6%
	Pear millet	2	2.6%	3.0%
	Tomato	3	3.8%	4.5%
	Vegetables	2	2.6%	3.0%
	Cowpeas	1	1.3%	1.5%

Table 7 presents challenges faced during the implementation of CA. The most common challenge reported was pest infestation (52.4%). Others included crops attacked by birds (13.1%) and climate change, specifically shortage of rainfall (9.5%). Only 7.1% of respondents claimed no challenge was encountered during CA implementation.

Table 7: Challenges facing smallholder farmers during implementation of CA practices

		Responses		Percent of Cases
		N	Percent	
Challenges in implementing conservation agriculture practices	Pests	44	52.4%	66.7%
	Climate change (shortage of rainfall)	8	9.5%	12.1%
	Shortage of labour	2	2.4%	3.0%
	Shortage of water for irrigation	2	2.4%	3.0%
	Cost of fertiliser (manure)	2	2.4%	3.0%
	Shortage of fertiliser (manure)	2	2.4%	3.0%
	Sometimes improved maize seed leads to pest outbreak	2	2.4%	3.0%
	Cost of improved seed	2	2.4%	3.0%
	Difficult in farm preparation	1	1.2%	1.5%
	Crop attacked by birds	11	13.1%	16.7%
	Crop residues regarded as pasture for animals that lead to soil problems	2	2.4%	3.0%
	No challenges	6	7.1%	9.1%

During the interview at the ward executive office, one of the key informants revealed that:

> *" CA practices are very crucial in addressing agricultural challenges and climate change effects, but some of the practices like minimum soil disturbance and maintaining soil cover are difficult in their application. As for minimum soil disturbance, most of the smallholder farmers lack the required inputs, like seed drill to simplify uniform planting and some residues are more used as pasture; then it becomes difficult to maintain soil cover."* (KII with agricultural field officer, March 2025).

During a focus group discussion, one of the smallholder farmers claimed that:

> *" Through training, I gained knowledge about CA practices, its benefits and how to apply them on my farm. I have been growing millet for three years now by adhering to CA practices; however, birds attacks lead to loss of yields. My fellow farmers who grow other crops like maize also suffer from pests, even after using improved seeds."* (FGD, March 2025).

4. Discussion of results

This section discusses the findings of the study in relation to existing research and literature on the adoption of CA practices by smallholder farmers.

The findings revealed that male farmers were leading adopters of CA and implemented minimum soil disturbance mostly, while female farmers used to maintain soil cover. The majority of respondents had primary and secondary education levels, which positively influenced their ability to learn and adopt new farming practices and the results show that education level had a significant relationship with the adoption of CA but was insignificant to minimum soil disturbance and maintaining soil cover. The predominance of male respondents may reflect the physical demands of farming, aligning with Topp et al. (2023), who noted that in the Mediterranean, male farmers often engage in labour-intensive agricultural activities and that higher education levels correlate with greater openness to innovation.

The study findings on farmers' attitudes toward the adoption of conservation agriculture (CA) practices revealed a generally neutral attitude. This suggests that adoption depends on observable benefits, willingness to learn, compatibility with cultural values, and the availability of support systems. These findings align with a study conducted in the Democratic Republic of the Congo by Mulimbi et al. (2019), who argued that farmers' willingness to adopt CA is influenced by their perceived benefits, particularly in terms of income reliability and food security. Similarly, in South Asia, Somasundaram et al. (2020) identified a traditional farming mindset as a primary obstacle to CA adoption. However, the current study contrasts with findings by Muniale et al. (2019), who reported that farmers in Morogoro Rural District held positive perceptions of conservation agriculture, recognizing its benefits in improving soil structure, reducing erosion and nutrient loss, and increasing yields of maize and legumes.

With regard to the practices of smallholder farmers in relation to CA, the study found that very few smallholder farmers were implementing CA, whereby minimum soil disturbance, maintaining soil cover, crop rotation and intercropping were implemented consistently. Minimum soil disturbance and maintaining soil cover emerged as the most widely adopted practices. This finding is consistent with a study conducted in Chamwino, Tanzania, by Selya et al. (2023), which reported that these two practices were most commonly implemented by farmers. The results also partially align with those of Nickens et al. (2023), who found that in Cambodia, the use of cover crops to maintain soil cover was prevalent. However, these findings contrast with Chichongue et al. (2019), who reported that in Mozambique, most CA adopters mostly practiced intercropping. Based on these studies, it is evident that farmers do not adopt all CA principles uniformly.

The study found that the total farmland under conservation agriculture (CA) was typically less than one acre. Farmers reported that implementing CA is challenging, particularly during planting, as it requires uniformity, making it time-consuming and costly on larger plots. This finding is consistent with a study conducted in Bahi, Tanzania, by Mbaga et al. (2024), which found that most CA adopters implemented the practice on only small portions of their land. The main crops grown under CA included maize, millet, sunflower, groundnut, pearl millet, tomato, various vegetables, and cowpeas. Among these, maize followed by millet was found to perform better than the other crops. This aligns with findings by Corbeels et al. (2020), who reported significantly higher maize yields under CA in Sub-Saharan Africa. Similarly, a study in Ghana by Boimah et al. (2020) revealed that maize had a high yield stability index (0.93). Additionally, Gebeyehu (2023) reported that in Southern Ethiopia, both maize productivity and farmers' annual income under CA practices were higher compared to conventional agriculture. However, these findings contrast with those of Selya et al. (2023), who found that sorghum, followed by pearl millet, performed better under CA than other crops. This variation suggests that the success of specific crops under CA depends on local soil types and conditions.

Implementing Conservation Agriculture (CA) practices offers several benefits, including increased crop yields, improved soil fertility, and greater resilience to climate change (Ngoma et al., 2021). However, certain challenges hinder its full adoption. The study found that pest infestation is a major challenge during CA implementation. Even when improved seeds were used, pest outbreaks led to significant yield losses, particularly affecting maize and groundnut. Millet was also frequently attacked by wild birds. Additionally, climate change, especially erratic rainfall patterns was reported to negatively affect crop growth by disrupting soil moisture levels. These findings are in line with those of Mbaga et al. (2024), who identified climate change (particularly drought), along with pest and disease outbreaks, as main challenges to CA adoption. Similarly, Nickens et al. (2023) reported that many CA adopters experienced crop failures due to water shortages. However, these findings contrast with those of Murindangabo et al. (2021), who emphasized that in Rwanda, the main barriers to CA adoption were a lack of follow-up and guidance from extension officers, limited farmer training, poor access to materials and insufficient equipment. These differences highlight the importance of considering the local context when designing support interventions to address the diverse challenges facing farmers in the successful implementation of CA practices.

5. Conclusion and Recommendations

The study concludes that smallholder farmers had a neutral attitude towards the adoption of conservation agriculture practices. This finding indicates that adoption is influenced by willingness, cultural compatibility, technical knowledge, availability of inputs and perceived benefits. Very few farmers practised CA despite the training offered. The most common practices were minimum soil disturbance and maintaining soil cover. Crops such as maize, millet, and groundnut performed best under CA. However, implementation faced setbacks, notably pest infestations and bird attacks. Therefore, the study recommends that local government through agricultural extension officers and agricultural field officers in collaboration with non-governmental organization should continue with the provision of knowledge about CA benefits and support to farmers, such as provision of tools and seeds to encourage its implementation. Also, local government in collaboration with the Tanzania Official Seed Certification Institute (TOSCI) should provide education on seeds which have resistant capacity to pest outbreaks to farmers. This will build farmers trust as well as encourage them to apply CA practices on their farms. Additionally, further research on how CA relates to other agricultural systems is crucial in terms of benefits and disadvantages.

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