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Assessment of the Adoption of Conservation Farming Techniques on Small Scale Farmers in Chibombo District, Central Province Zambia

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Abstract

Conservation farming, a system that is still being widely recognized for its substancial benefits comprises of a set of agricultural practices that have long been promoted as a climate smart agriculture approach designed to protect, enhance, and sustain soil productivity while ensuring reliable crop yields. Different from conservation farming system is conventional systems that rely on repeated and intensive plowing, CF emphasizes on minimal soil disturbance, maintenance of soil cover through crop residues or cover crops, and the systematic rotation of different crops. Overall, conservation farming promotes an approach that works in harmony with natural soil processes. These practices help improve soil structure, enhance moisture retention, reduce erosion, and contribute to long-term agricultural sustainability. Despite these significant benefits and efforts by government agencies and non-governmental organizations to promote CF, adoption rates among rural farming communities remain uneven. This study therefore, seeks to assess the extent to which small-scale farmers are adopting conservation farming techniques. The study specifically aims determine the prevalence of conservation farming among small-scale farmers, identify the factors associated with CF adoption, establish the most commonly practiced CF techniques; and the challenges farmers encounter in implementing these methods. A cross-sectional survey design is employed, targeting smallholder households across Chibombo District. Data collection methods include structured questionnaires, key informant interviews, and direct field observations. Both descriptive and inferential statistical techniques are applied, with logistic regression planned to analyze the determinants of adoption. Adoption is modelled as a binary dependent variable, enabling estimation of the likelihood of adopting CF based on predictors such as farm size, education level, access to extension services, availability of inputs, and years of farming experience. The study highlights the awareness of conservation farming is relatively high however, the actual adoption rate is moderate. Practices such as minimum tillage, crop rotation, and residue retention are the most frequently implemented techniques. It further analyze that access to resources, technical training, and extension support emerges as key determinants of adoption.

Keywords: Conservation Farming, Sustainable Agriculture, Soil Productivity, Minimum Tillage, Soil Retention, Crop Rotation, Climate Smart Agriculture, Small Scale Farmers, Convection Farming

1. Introduction

Sustainable agriculture has gained recognition as a critical pathway for improving food security, soil health, and climate resilience in sub-Saharan Africa. Zambia, like many countries in the region, has experienced climate variability characterized by droughts, shortened rainy seasons, and declining soil fertility. These challenges disproportionately affect smallholder farmers who rely on rain-fed agriculture for their livelihoods. Conservation farming a system that has long been promoted as an approach capable of improving soil fertility, enhancing productivity, and supporting the resilience of smallholder farmers in central province, Zambia. However, adoption rates vary significantly across districts and farming communities. Central province, known for its significant agricultural potential, the challenges posed by changing weather patterns like droughts, and the need for improved food security. The Province is part of Zambia's highly productive Agro-ecological Region II, which contributes over half of the national maize output. Crop Forecast Survey data consistently show that more than 80% of farmers in the province depend on rain-fed maize cultivation, exposing them to climate shocks and declining soil fertility (MoA, 2022). Recent agricultural and environmental assessments indicate that the province is experiencing notable soil fertility decline, increasing climate variability, and heavy dependence on rain-fed maize production, making CF a crucial intervention for

sustainable agricultural productivity. Conservation Farming, which emphasizes minimum tillage, soil cover, and crop rotation, has been recommended as a sustainable approach to enhance soil productivity and mitigate climate-related yield losses. Conservation farming (CF), sometimes referred to as conservation agriculture, has emerged as a potential solution. It promotes principles such as reduced soil disturbance, permanent soil cover, and crop rotations. CF aims to reduce erosion, improve moisture retention, and enhance long-term productivity. In Zambia, the Ministry of Agriculture, NGOs such as the Conservation Farming Unit (CFU), and development partners have actively promoted CF for over two decades. Despite the many interventions, adoption remains uncertain. Some districts report substantial uptake, while others, including parts of Chibombo, show relatively modest adoption. Understanding the factors that influence adoption is essential for designing targeted interventions.

Problem Statement

Although Conservation farming (CF) is being recognized as a sustainable approach that can improve soil fertility, boost crop yields, and help farmers adapt to climate variability. Despite these benefits, adoption among small-scale farmers in Zambia remains uneven especially in the context of Chibombo district, there is limited information on the adoption extent in the district. Many farmers still rely on conventional practices such as repeated plowing and mono-cropping, which gradually degrade soils and reduce productivity. Over the years, government programs and NGOs have promoted CF through training and support initiatives, but there is limited information on how many farmers have actually adopted these techniques, what motivates them to do so, and the challenges they face. Understanding the extent of CF adoption and the factors affecting the adoption is therefore critical to supporting sustainable farming practices and improving food security.

Justification of the Study

The adoption of conservation farming techniques can play an important role is food security, crop and soil sustainability (Haggblade and Tembo (2003) farmers under conservation farming achieved significantly higher yields compared to those on convectional tillage, highlighting its potential to enhance household food and income. While Gupta, (2007) adds that convectional agriculture unlike conservation, assumingly leads to soil organic matter decline, water runoffs and soil erosion. The research hihg lights that conservation farming is sustainable and it's increasingly being promoted by various institutions to overcome problems of soil degradation, drought and low yields making this variable for research. (FAO, 2019; Mafongoya & Ajayi, 2017 highlighted that the district, which relies heavily on smallholder agriculture, has experienced the impacts of climate change and soil degradation, making sustainable farming practices critical. Yet, there is no solid grounds to which level of extent and factors affecting CF adoption in this district is limited to.

Purpose of the Study

The sole purpose of the study was to assess the adoption of conservation farming techniques on small scale farmers of Chibombo district in central province, Zambia.

Objective of the study

Main Objective

The overall objective of the study was to assess the adoption of conservation farming techniques among small scale farmers.

Specific Objectives

1. To determine the prevalence and level of adoption of conservation farming techniques among small-scale farmers in Chibombo District.
2. To identify the major factors influencing the adoption or non-adoption of conservation farming among small-scale farmers.
3. To examine the most common conservation farming techniques practiced and the challenges small scale farmers face.

Research Questions

1. What is the prevalence and level of adoption of conservation farming techniques among small-scale farmers in Chibombo District?
2. What factors influence the adoption or non-adoption of conservation farming techniques among small-scale farmers?
3. Which conservation farming techniques are most commonly practiced and the challenges faced by small scale farmers?

Significance of the Study

Declining soil fertility and land productivity as a result of convectional plowing and mono- cropping is a major problem facing smallholder farmers today. Conservation farming has emerged as the best alternative to curb these problems of soil infertility, climate change and soil degradation and as bonus, increase in crop yields. Hence the study will help policy makers, agriculture extension service providers and promoters and small scale farmers to invest much knowledge and resource in the adoption and implementation of conservation technologies in an effort to reduce the cost of crop production and encourage sustainability. This will help increase awareness level of conservation farming implements as a result, will bring about soil fertility and productivity of the land and yield in the district and the country at large.

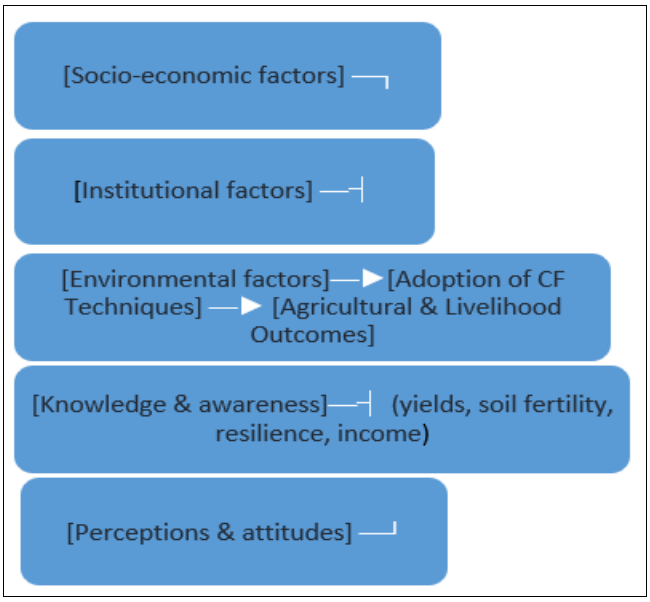
Scope of the STUDY

The study is confined to Chibombo District and does not cover other districts or provinces. It targets only small-scale farmers, excluding medium- and large-scale commercial farmers, as their access to inputs, capital, and technology differs substantially. In addition, the scope is limited to the 2024/2025 farming season, meaning that results reflect this specific period and may not fully capture long-term adoption trends. The research further narrows its content to the adoption process of CF techniques, without conducting controlled field trials to measure soil health or long-term crop yield changes. Instead, it relies on farmer surveys, interviews, and observations to generate data. These methodological choices, while suitable for adoption studies, mean that detailed biophysical and economic impact analyses fall outside the boundaries of this research.

Conceptual Framework

The illustration below shows the relationship between the

adoption as the dependent variable, which is adopter and non-adopter the factors that influence adoption are treated as independent variables institutional factors, environmental factors, social factors, perceptions and the expected outcomes.



Ethical Considerations

The research was presented before the Information and Communications University research committee for scrutiny to ensure it met research standards.

2. Materials and Methods

Location of the Study Site

A study survey was carried out in Chibombo District, located in Zambia's Central Province. This district covers approximately 15,000 square kilometers and is primarily agrarian, with about 80% of the population engaged in subsistence farming. The area experiences a tropical climate with a distinct rainy season from November to April, which influences farming activities. The district has been a focus area for various government and NGO-led conservation agriculture programs, including training and input support, making it an ideal site for assessing adoption patterns. Key crops grown in the area include maize, groundnuts, and legumes, which are also the focus of conservation farming techniques promoted.

Target Population

The population target for this study includes all householders and small scale farmers that have been practicing either conservational or convictional farming techniques for a reasonable amount of time.

Determination of a Sample Size

Data collection method for this research will mainly include questionaires, interviews, content observation and surveys. In depth, key interviews will be conducted with farmers, approximately 200-400 farmers. For sample size determination of surveys, a confidence level of 95%and a margin of error 5% will be used. On a population approximately 1.5 to 2 million people in central as in the years 2010- 2022, the required sample size is 300 to 400 respondents (Cochran 1997). The sample size adequately represents diversity the local population.

Sampling Techniques

A combination of purposive and random sampling techniques was employed in this study to select participants for the quantitative survey components respectively, purposive sampling will be employed to select respondents who represent both farming systems.

Data Collection Method

This study involves the quantitative survey approach of data collection method of structured questionnaires which were employed to systematically capture quantitative data on farmer demographics, farm size, and specific management practices thereby allowing meaningful comparison between those practicing conservational farming and those with convection methods. (Mwinga, 2021; Chipolola nd Kaonga, 2019). Observations and in-depth interviews were carried out to get information about farmer's perceptions and challenges.

Data Collection Instruments

The data collection instruments for this study will include structured questionnaires and semi structured interview guides and observations where the surveys will be designed to capture quantitative data on participant perception on conservational techniques, level of adoption, challenges and involvement in the adoption. The survey will include close-ended questions to gather demographic information, data on conservation techniques, factors and challenges in the adoption of conservation farming. Semi structured interview guides will be used to conduct in depth interviews with farmers, theses guides will include open ended questions designed to elect detailed responses from the questionnaires. In addition to, an analysis of content will be held on relevant documents and reports to supplement the primary data collected from surveys and interviews. The data collection instruments have been highlighted as; Key Informant Interviews: Semi-structured interviews with lead farmers will provide context on support systems, adoption drivers, and institutional challenges, much like approaches used in multiple Zambia CA studies (e.g., education, extension services, input access in Mwiinga, 2021); Field Observations: Checklists will record soil condition, residue cover, tillage methods, erosion signs, and crop diversity. This parallels Descriptive statistics such as frequencies, percentages, means, and standard deviations will be computed to summarize the characteristics of respondents and the extent of adoption of conservation farming practices. To understand the factors influencing adoption, binary logistic regression analysis will be performed. The dependent variable is dichotomous (1 = adopter, 0 = non-adopter). This cross sectional approach ensures that a comprehensive and nuanced understanding factors that influence the adoption of conservation farming.

Data Analysis

Raw data obtained from questionnaires, interviews, field observations, and surveys may contain inconsistencies, errors, or missing values that could compromise the validity of the results if left unaddressed. Quantitative responses will be coded and organized into numerical formats suitable for statistical analysis, while qualitative data from interviews and discussions will be transcribed, categorized, and thematically analyzed to identify patterns and insights. (Mwiinga, 2021; Chompolola & Kaonga, 2019; Sakambuta,

2017). For data analysis logistic regression will be employed, Logistic regression measures the relationship between the categorical target variable and one or more independent variables (Kirk Patel Data Processing: Quantitative data will be coded and entered into statistical software (e.g. SPSS, Stata) for cleaning. Qualitative data will be transcribed, organized, and thematically sorted, aligning with standard mixed-methods frameworks in CA studies across Zambia. Descriptive Statistics: Frequencies, means, medians, and percentages will present farmer profiles and agricultural practices. These basic statistics are foundational in generating context and are consistent with methodologies used by Chompolola & Kaonga (2019) and Mwiinga (2021). Comparative Analysis: t-tests will compare mean maize yields and soil parameters between conservation and conventional farms. Paired t-tests are also suitable for field matches. Chi-square tests will assess associations (e.g., adoption status vs. education or gender), similar to socio-economic modeling in CA adoption research. Transcripts from KIIs/FGDs will undergo thematic content coding to reveal common narratives around adoption incentives, constraints, and farmer perceptions. This supports triangulation with quantitative results, as done in other CA research (e.g., insights from extension officers and farmers in earlier Zambia studies). Cross-checking between farmer-reported yield and direct measurements, or between perceived soil health validity. This triangulation aligns with protocols used in Solomon and international CA trials.

3. Results and Discussion

Respondent Characteristics

A survey with questionnaires was conducted, total of 300 small-scale farmers participated in the study. Most respondents were male (73%) and married (90%). The dominant age category was 35–44 years (43%), followed by 45–54 years (23%). Education levels were generally low, with 56.6% having only primary schooling and 8% holding tertiary qualifications. Most farmers (65%) cultivated between 1–5 hectares.

Table 1: Demographic Characteristics of Respondents

Variable	Category	%
Gender	Male	73.0
	Female	27.0
Age group (years)	25–34	21.0
	35–44	43.0
	45–54	23.0
	55+	13.0
Education Level	No formal	12.7
	Primary	56.6
	Secondary	21.3
	Tertiary	8.0
Farm Size	1–5 ha	65.0
	>5 ha	35.0

Adoption Levels of Conservation Farming

Only 22.3% of the farmers reported adopting Conservation Farming (CF). Most adopters had practiced CF for fewer than five years. Adoption intensity remained modest, with most allocating 25–50% of their land to CF practices.

Table 2: Adoption of Conservation Farming

Indicator	Category	%
CF Adoption	Adopters	22.3
	Non-adopters	77.7
Years practicing CF (among adopters)	<2 years	35.7
	2–5 years	36.3
	>5 years	28.0
Land allocated to CF	<25%	32.0
	25–50%	48.0
	>50%	20.0

Institutional Exposure

Institutional support for CF was limited. Only 26.7% had ever received CF-related training, and 13% were members of farmer groups.

Table 3: Institutional Exposure to CF Information

Exposure Indicator	%
Attended CF Training	26.7
Belong to Farmer Group	13.0

Factors Influencing Adoption

Logistic regression analysis showed that education level and CF knowledge significantly predicted adoption. Farmers with tertiary education and those with higher CF knowledge were more likely to adopt CF. Gender, age, marital status, and group membership were not statistically significant.

Table 4: Logistic Regression Predicting Adoption of Conservation Farming

Predictor	Adjusted Odds Ratio (AOR)	p-value	Significance
Tertiary Education	0.30	0.034	*Significant*
High CF Knowledge	3.12	0.001	*Significant*
Gender	1.08	0.420	NS
Age	0.97	0.501	NS
Marital Status	1.12	0.336	NS
Farmer Group Membership	1.25	0.290	NS

NS = Not Significant

Awareness and Use of CF Practices

Awareness was highest for crop rotation (54%) and mulching (38.7%). Adoption patterns were similar, with crop rotation (42.3%) and mulching (38%) being the most practiced.

Table 5: Awareness and Adoption of Specific CF Practices

CF Practice	Awareness (%)	Adoption (%)
Crop rotation	54.0	42.3
Mulching	38.7	38.0
Minimum Tillage	7.3	13.7
Planting Basins	3.0	6.0
Cover Cropping	<2.0	<1.0

Production Activities

The main production activities revealed that most farmers used hand hoes (66.7%) compared to animal draft and tractor, this is because hand-hoes are less expensive and readily available can be accessed by any farmers. This for land preparation. The major crop grown was maize (48.7%),

as the staple food followed by groundnuts and soybeans. That provide with the essential vegetable proteins.

Table 6: Main Production Characteristics

Variable	Category	%
Land preparation method	Hand hoe	66.7
	Animal draft power	18.3
	Tractor	15.0
Major crops grown	Maize	48.7
	Groundnuts	25.0
	Soybeans	10.7

Reasons for Adoption and Non-Adoption

Adopters cited improved soil fertility and yield gains as primary motivations. Non-adopters emphasized cost barriers and lack of knowledge.

Table 7: Reasons for Adopting CF

Reason	% of Adopters
Improve soil fertility	56.3
Increase yields	22.7
Received training	12.3
Reduce production costs	8.7

Table 8: Reasons for Not Adopting CF

Barrier	% of Non-Adopters
High perceived costs	44.0
Lack of knowledge	32.7
General cost concerns	16.3
Time constraints	7.0

Challenges Faced by CF Adopters

The most significant challenge was limited access to inputs (over 60%) most farmers are unable to access the quality inputs for their cultivation, followed by inadequate knowledge and lack of tools other respondents are un aware of the benefits of conservation farming.

Table 9: Challenges Experienced by CF Adopters

Challenge	%
Lack of inputs	>60
Inadequate knowledge	21
Lack of tools/equipment	8–10
High labor demands	8–10
Cultural beliefs	3

4. Discussion and Conclusion

Discussion

The findings of this study indicate that the adoption of conservation farming (CF) among small-scale farmers is influenced by an interplay of socio-economic, institutional, and knowledge-related factors. By integrating evidence from descriptive statistics and logistic regression analysis and comparing these results with existing literature, several notable patterns emerge. Socio-economic characteristics, particularly age and education level, were significant predictors of CF adoption. Younger farmers were more inclined to adopt conservation farming practices than older farmers, suggesting that younger individuals may be more open to innovation, adaptable to new technologies, and more willing to assume the risks associated with unfamiliar farming methods. This is consistent with the work of Nyanga (2012) and Ng'ombe *et al*. (2017), who also reported an inverse relationship between age and adoption of CF practices in Zambia and other parts of Sub-Saharan Africa. Interestingly, education demonstrated a negative and statistically significant relationship with CF adoption. Farmers with lower levels of formal education were more likely to adopt CF compared with their more educated counterparts. One possible explanation is that less-educated farmers rely more heavily on agriculture for their livelihoods and are therefore more motivated to adopt technologies that promise improved productivity and soil health. More educated farmers, on the other hand, may have diversified income sources, reducing their dependence on agricultural innovations. This finding is consistent with Manda *et al*. (2016), who also observed a negative correlation between education level and CF adoption in rural Zambia. Gender and marital status were found to be statistically insignificant in influencing adoption. This suggests that men and women in the study area have relatively equal access to CF training and extension services. The finding may reflect deliberate efforts by government agencies and non-governmental organizations to promote gender-inclusive extension programs in the Chibombo District. Institutional factors emerged as some of the strongest determinants of adoption. Access to training, knowledge dissemination, and membership in farmer groups all strongly influenced farmers' decisions to adopt CF practices. Nearly all farmers who had attended CF training sessions or belonged to farmer groups reported adopting the techniques, resulting in issues of perfect prediction in the regression model. Nonetheless, this pattern underscores the central role of exposure to information in shaping adoption behaviors. As shown in the work of Ngwira *et al*. (2013), training programs—such as farmer field schools and demonstration plots—effectively improve technical capacity, enhance perceptions of CF, and boost adoption rates in Malawi and Zambia. Membership in farmer groups was also a significant factor. These organizations provide platforms for information sharing, collective action, and improved access to resources such as inputs and extension services. This finding aligns with Rogers' (2003) diffusion theory and empirical evidence from Kassie *et al*. (2015), both of which emphasize the importance of social networks in facilitating the spread of agricultural innovations. The study also found that land preparation methods and labor availability play important roles in CF adoption. Farmers already practicing minimum tillage or basin planting were more likely to adopt CF techniques than those using conventional plowing. However, the logistic analysis showed extremely high or low odds ratios for some variables due to perfect prediction, indicating that nearly all farmers employing improved land preparation methods were adopters. Labor availability emerged as a notable constraint. Conservation farming can be labor-intensive during the land preparation phase, especially when implemented using hand tools. This is consistent with the findings of Giller *et al*. (2009) [3], who observed that labor shortages and high labor demands can discourage adoption among resource-constrained households. As such, interventions promoting mechanization or affordable labor-saving technologies may be essential to support continued and widespread adoption of CF practices. Overall, the study highlights the multifaceted nature of CF adoption and underscores the need for integrated strategies that strengthen institutional support, enhance access to training, and address labor-related constraints faced by small-scale farmers.

Conclusion

This study examined the factors influencing the adoption of conservation farming among smallholder farmers in Chibombo District and found that adoption is shaped by an interconnected set of socio-economic, institutional, and agronomic conditions. Younger farmers and those with higher levels of formal education were more inclined to adopt conservation farming practices, suggesting that demographic characteristics and livelihood dependence on agriculture play important roles in shaping innovation uptake. Institutional support, particularly access to training and participation in farmer groups proved to be a central driver of adoption, underscoring the importance of extension services, farmer networks, and community-based learning in promoting sustainable agricultural technologies. Agronomic familiarity with practices such as minimum tillage and crop rotation planting also encouraged adoption, whereas labor shortages emerged as a significant barrier, highlighting the need for interventions that reduce the labor burden associated with conservation farming. Taken together, the findings demonstrate that successful promotion of conservation farming requires more than technical recommendations; it demands a holistic approach that considers farmers' socio-economic realities, strengthens local institutions, and addresses practical constraints.

Limitations of the Study

The study faced several limiting factors such as logistical and operational challenges during fieldwork. Some households were located in remote and widely dispersed areas, making travel difficult and time-consuming. And the data collection process was influenced by varying levels of respondent engagement. Despite some of these limitations and challenges, the study provides valuable empirical insights that contribute to the growing body of literature on conservation farming adoption in Zambia.

Recommendations/suggestions for further research

Strengthen Extension and Training Services

- The Ministry of Agriculture and partner organizations should intensify conservation farming training programs and ensure consistent follow-up visits.
- Farmer field schools and demonstration plots should be expanded to cover more areas, enabling farmers to gain practical experience.

1. Enhance Youth Involvement in Agriculture
   - Targeted programs should be developed to attract young farmers, such as youth agribusiness funding, mentorship, and mechanization support, since younger farmers show greater willingness to adopt innovative practices.
2. Improve Access to Inputs and Equipment
   - The government and NGOs should facilitate access to affordable CF implements (rippers, planters, and herbicides) through cooperatives or subsidized programs to reduce labor intensity.
3. Strengthen Farmer Organizations
   - Support the formation and capacity building of farmer groups and cooperatives to enhance collective learning, access to information, and input procurement
4. Continuous Monitoring and Evaluation
   - Establish a monitoring framework to assess the long-term sustainability of conservation farming programs, ensuring that adoption translates into improved yields and income.

5. Acknowledgement

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