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Research Article

Comparison of the profitability of conservation and conventional agriculture in Bahi District, Dodoma, Tanzania

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Abstract: *Conservation agriculture is gaining global recognition as an alternative to conventional farming, offering economic and environmental benefits. However, despite efforts to promote it, many farmers continue to rely on conventional practices. This study was conducted in Bahi district, Dodoma region, Tanzania, to compare the financial performance of conservation and conventional agriculture. The research evaluated financial returns, profitability, crop yields, income, and input costs associated with both practices. Using a mix of purposive and random sampling techniques, data were analyzed through descriptive statistics, Return on Investment (ROI), Gross Profit Margin (GPM), and content analysis. Results showed that conservation agriculture yielded higher profitability, with an ROI of 189% and a GPM of 65% per hectare, compared to conventional agriculture's 34% ROI and 25% GPM. Despite Conservation Agriculture having more benefits, some farmers have continued to use conventional agriculture due to various barriers including financial constraints, limited exposure, knowledge gaps, inadequate agricultural inputs, drought, pest and disease issues, and market unavailability. Additionally, the labor-intensive nature of farm preparation and the lack of farm instruments further hinder adoption. To enhance the adoption of conservation agriculture, the study recommends collaboration among the government, agricultural research institutions, and project implementers to address key challenges. Specifically, efforts should focus on improving access to agricultural loans to overcome financial barriers, raising awareness through training programs, ensuring the availability of agricultural inputs, and developing innovations to simplify CA processes.*

Keywords: Adoption, Conservation Agriculture, Gross Profit Margin, Return on Investment
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1. Introduction

Agriculture continues to be an important sector with the potential to contribute to social and economic development in many developing countries. Agriculture in developing countries is affected by climate change impacts and poor agronomic techniques which in turn contribute to food insecurity and poverty (Challinor *et al.*, 2007; Schlenker and Lobell 2010). The number of smallholder farmer households in Africa is projected to be 120-150 million, of which the majority will continue to rely on rain-fed farming as the key driver of development (Dixon *et al.,* 2001). Rain-fed agriculture in sub-Saharan African countries including Tanzania is characterized by diminishing soil fertility, erratic and unpredictable rainfall and soil and water loss through erosion (Msuya *et al.*, 2008). In many fertile areas, nutrients are being depleted rapidly due to farming practices that extract them faster than they are replaced (Shetto *et al.*, 2007). Smallholder farmers often use conventional agriculture which involves extensive tilling, burning crop residue, and removing nutrients from the soil, increased input costs and vulnerability to climate change (Msuya *et al.,* 2008). Conventional agriculture does not prioritize sustainability or minimize environmental harm. To address food shortages and poverty, agriculture needs to adopt better technology and sustainable practices. Conservation agriculture (CA) has emerged as one of the alternatives to conventional agriculture, focusing on preserving soil fertility and mitigating the impacts of climate change (FAO, 2011).

Conservation agriculture involves a set of methods for managing soil that can boost crop yields while promoting the long-term sustainability of farming both financially and environmentally. It aims to minimize disturbances to the soil's structure, composition, and natural biodiversity. It includes farming techniques that reduce mechanical soil disruption (such as no-tillage and direct seeding), maintain a layer of carbon-rich organic material on the soil surface (like straw, crop residues, and cover crops), and use crop rotations or combinations that include nitrogen-fixing plants like trees and legumes. CA integrates the management of soil, water, and biological resources along with external inputs to conserve, improve, and use natural resources more efficiently (Erwin, 2007). This approach supports increased and consistent agricultural productivity while also preserving the environment (Dumanski *et al*., 2006). Many farmers are adopting CA and similar technologies to achieve sustainable and eco-friendly agricultural production.

Despite the environmental and economic importance of CA, the rate of adoption in Tanzania is reported to be slow and insufficient whereby the majority of the farmers are still practicing conventional agriculture compared to other parts of the world (Mkonda and He, 2017). The government and different CA stakeholders have been promoting CA in many parts of the country including Bahi, Kongwa, Karatu, Mbeya, and Babati but generally, its adoption is reported to be low (Shetto and Owenya, 2007). Also, the study conducted by Zhang *et al.* 2018 reported that out of a total area of 1,600 hectares in the Ugogoni and Mnyakongo villages, only 10% of the 400 households practicing conservation agriculture (CA) had adopted it, covering an area of 200 ha. At the district level, where 45,271 farming households reported cultivation across a total area of 258,219 ha, only 4,300 households had adopted CA, covering a total area of 20,000 ha in the Kongwa district (Hong *et al.*, 2018).

The efficiency of the adoption and utilization of new technology depends on economic profitability, social advantages, and other visible results that can be obtained from the newly introduced technology or practice (Ehui *et al.*, 2004; Rodgers, 1995). Therefore, the adoption of CA over conventional agricultural practices depends on the economic profitability and visible results that farmers using CA should achieve compared to those using conventional agricultural practices, although different scholars have varying opinions regarding the economic profitability experienced by farmers using CA versus those using conventional agriculture. There is evidence of the benefits of CA practice in promoting food and livelihood security, resulting from high-yield production (Bloem *et al.*, 2009; Govaerts *et al.*, 2009). This has been justified by a survey conducted in Southern Uluguru Mountains, Morogoro, Tanzania, where the mean gross margin obtained by farmers using CA was TZS 526,800 per acre, while the gross margin for farmers using conventional agriculture was TZS 200,360 per acre (Mahenge, 2014). Contrary to the arguments above, a study conducted by Janosky *et al.* (2002) and Ribera, (2004), reported that there is no discernible economic difference between conservation agriculture and conventional agricultural practices. Hence, there is no motivation to switch technologies, and that is why farmers are still practicing conventional agriculture.

Based on the diverse perspectives of scholars and the varying levels of adoption of CA, there is a disagreement regarding whether conservation agriculture is economically more advantageous compared to conventional agriculture which is practiced by the majority of farmers in Tanzania. This disparity between scholars and the low adoption rate of CA has resulted in an information gap that needs to be filled concerning the financial performance of CA in contrast to conventional agriculture, as well as the challenges impeding the widespread adoption of CA. Therefore, this paper focuses on conducting a financial performance analysis between conservation agriculture and conventional agriculture in Bahi district, Dodoma region. The study also identifies the main challenges that hinder the adoption and scaling-up of CA, despite its documented economic and environmental benefits.

The results of this research will contribute in a constructive way to the scholar’s discussion and other agriculture stakeholders on how financially conservation agriculture is performing as compared to conventional agriculture by providing evidence. Also, the study will provide way forward on challenges that hinder the adoption of CA and its small-scale application. Also, the study's findings will have significant implications for farmers, policymakers, and other key stakeholders by assisting them in making well-informed decisions regarding the most financially viable farming approach.

This study was guided by the Theory of Diffusion Innovation developed by Rogers in 1995. According to Rodgers (1995), an innovation is defined as an idea, activity, or thing that is viewed as new by an individual. On the other hand, diffusion is the process through which members of a social system gradually learn about an innovation through a particular channel. The theory aids in understanding the variables that affect an individual's decision to adopt CA. Based on this theory, the adoption of innovations can be made easy or difficult depending on five factors: compatibility, which is the degree to which an innovation is viewed as consistent with existing value, past experiences, and needs of potential adopters; relative advantage, which is the degree to which an innovation is perceived better than the idea it supersedes; Trialability, the ability to test an innovation on a small scale (in the field) or adopt it gradually; Complexity, the degree to which a new idea is viewed as relatively difficult to understand and apply; and Observability, the degree to which an innovation's effects are visible to others.

In the context of this study, the degree of relative advantage is frequently articulated as financial gain, social position, and other additional benefits. For instance, if the target audiences for CA adoption perceive it offers considerable advantages over conventional agriculture, it is expected the adoption of CA to increase compared to conventional agriculture. Also, if the practices of CA are more compatible and less uncertain to the potential adopter and fit more closely with the situation of the individual compared to conventional agriculture, its adoption therefore expected to increase. Any new idea may be categorized on the complexity, simplicity or continuum, if CA is clear in its meaning to potential adopters and easy to apply then it will be adopted more. Also, if the farmers can easily try the CA to find out how it works under one’s environment, then its adoption will increase lastly, if the results of CA are simple to see and explain to others then its adoption will increase, examples of CA results that can be seen easily are increase in productivity and cost savings from less inputs like labour or pesticides. It is important to understand these attributes to design effective strategies to increase conservation agriculture adoption in the study area.

2. Methodology

2.1. Description of the study area

The study was carried out in Bahi district, Dodoma region (Figure 1). Bahi district lies approximately around 05º 58’ 58’’ South and 35º 18’ 57’’ East. The district is bordered by Chamwino district and Dodoma municipality in the East; Kondoa district and Iringa region in the Southwest, and Manyoni district in the West. According to URT (2022), the population size of Bahi District is estimated to be 322,526, with 156,427 males and 166,099 females. The majority of the population is engaged in agriculture as their primary economic activity to sustain their livelihoods.

The soils in Bahi District are characterized by shallow depth, moderate organic matter concentration, and moderate to poor permeability are the main soil types present in the Bahi district, which leads to higher surface runoff. Dark grey and brown sand soils are among the different soil textural classes present in the district, particularly in the southwest and center. The other regions are distinguished by their dark grey clay sands and sand loams to brown loamy soil. Because of the granitic parent materials and the scant vegetative cover, the soils of the Bahi district typically have low nutritional status and low organic matter content (Kashaigili, 2010).

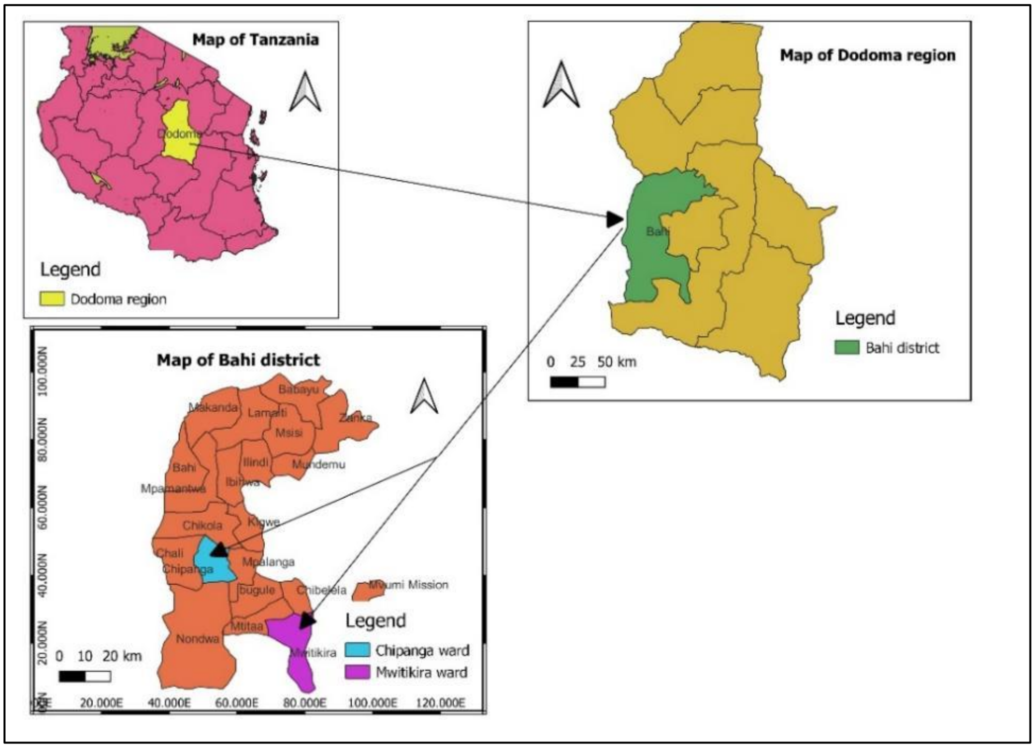

Figure 1: Map of the study area

2.2. Research design

This study employed a cross-sectional research design, which allows the collection of multiple-information at a single point in time. The design was chosen for its simplicity, cost-effectiveness, and efficiency in time utilization (Neuman, 2014).

2.3. Sampling techniques and sample size

Multi-stage sampling method was employed to select the sample of the study in two stages. In the first stage, Bahi District was purposively selected due to the fact that it is located in a semi-arid area where susceptibility to the impact of climate change and environmental degradation is highly experienced. Thereafter, three villages were selected intentionally based on criteria that a project advocating conservation agriculture was implemented therein. In the second stage, simple random sampling was used to select the number of farmers practicing CA and those using conventional agriculture from the list of all farmers practicing CA and those practicing conventional agriculture in those villages. The updated list of households registered in the sampled villages was used as a sampling frame. A total sample size of 176 respondents was randomly selected in the chosen villages. The number of sampled respondents was calculated from the formula suggested by Krejcie and Morgan (1970) indicated below.

$$x = \frac{X^2 \text{NP } (1-\text{P})}{d^2(\text{N} - 1) + X^2 \text{ P } (1-\text{P})} \qquad [1]$$

Where

N = Household size (1716)

n = Sample size

X^2 = Tabulated value of Chi-square for one degree of freedom at the desired confidence level (1.96 for 95% confidence level)

P = Population proportion (assumed to be 0.5 which provides the maximum sample size)

D = Degree of accuracy expressed as a proportion (0.05).

According to the formula above, the sample size of the farm households was 176 in number [2] where 89 were practicing conservation agriculture and 87 were practicing conventional agriculture (Table 1).

$$n = \frac{1.96^2 \text{x } 1716 \text{ x } 0.5\ (1-0.5)}{0.05^2(1716-1) + 1.96^2 \text{ x } 0.5\ (1-0.5)} \qquad [2]$$

Table 1: Sample size of farm households

Village	Conservation agriculture farmers	Conventional agriculture farmers
Chipanga A	31	30
Chiguluka	27	29
Mwitikira	31	28
Total	89	87

2.4. Data collection method

The study employed household questionnaire surveys and key informant interviews (KIIs) as the principal methods for primary data collection. Quantitative data were collected through the questionnaire survey, which consisted of a series of questions arranged to facilitate easy responses from households. The primary quantitative data collected included the quantities of sorghum, bulrush millet, and cowpeas harvested by farmers, the selling prices, input costs, and other expenses incurred by the farmers. On the other hand, qualitative data were gathered through KIIs, focusing on agricultural practices in the study area and the challenges hindering the uptake and scaling up of CA.

2.5. Data analysis method

Evaluation of farmers' profitability was conducted through the calculation of Return on Investment (ROI) and Gross Profit Margin (GPM).

2.5.1. Return on investment

Return on Investment was used to compare income obtained from CA over Conventional agriculture. ROI was chosen since it is widely used by academics as a simple but effective method of assessing a particular business's financial performance (Antwi and Aborisade, 2017; Ngabitsinze, 2014). The following formula was used to estimate the Return on Investment:

$$\text{Return on Investment (ROI)} = \frac{\text{Net profit} \times 100}{\text{Total cost of production}} \quad [3]$$

Where

Net Profit (TZS) = Total Income (TI) – Total Cost of Production (TCP); Total Cost of Production (TCP) = Total Variable Cost (TVC) + Total Fixed Cost (TFC).

The variable cost in this study included costs of seeds, pesticides, packaging materials, fertilizers, hiring machines for ploughing and harrowing, planting, weeding and harvesting during the 2021/2022 production season, while fixed cost included the cost of hiring the land.

2.5.2. Gross profit margin

The Gross Profit Margin (GPM) was used to compare the farmers who adopted Conservation Agriculture and Conventional farming. The Gross profit margin was computed as follows:

$$Gross\ Profit\ Margin = \frac{(\text{Total revenue} - \text{Total cost}) \ x\ 100}{\text{Total revenue}} \quad [4]$$

3. Results and Discussion

3.1. Farming area under conservation agriculture

The study findings, summarized in Table 2, show the total area of land cultivated by farmers who adopted CA principles. Among the CA adopters, only 3.37% were applying CA on the whole farm and 96.63% of the CA adopters were applying CA in small pieces of their land. This finding implies that the majority of the adopters are practicing CA in small parts of their farms. CA adopters in the study area were requested to share their perspectives regarding factors that led them to not to implement CA across their entire farm. It is noted that 5.10% of the respondents attributed their limited application of CA to the low availability of instruments, specifically *magoe* rippers (Table 3) which are essential instruments in CA during farm preparation. The laborious nature of farm preparation under CA was reported by 21.9% of respondents as a reason for practicing CA in small portions of their farms (Table 3).

The study results are in line with Rogers' Innovation Diffusion theory from 1995, specifically regarding the complexity attribute when an innovation is perceived as difficult to understand and use. Tediousness under CA in farm preparation and required knowledge of soil management, crop rotation and cover cropping make CA more complex compared to conventional farming. Also, farmers with limited education and resources may encounter challenges in comprehending these concepts and putting them into practice.

Table 2: Proportion of farmers practicing conservation agriculture

Area under CA	Frequency	Percentage (%)
The whole farm	3	3.37
Part of the farm	86	96.63

Furthermore, as indicated by the results in Table 3, 27.7% of respondents reported that the lengthy process of farm preparation led them to limit its CA application to smaller areas of their farms, driven by the fear of missing the first rains. In addition, 22.6% of respondents identified the costs associated with CA practices such as the application of manure, use of improved seeds, and hiring magoe rippers as significant barriers to the broader adoption of CA.

The findings of the present study are consistent with the study by Araya *et al.* (2024), which highlighted that the focus on immediate returns often deters farmers from adopting CA. This is because CA practices require initial investments that low-income farmers may not afford, despite the long-term benefits. Consequently, conventional farming practices are often perceived as yielding quicker results, while the benefits of CA take time to materialize. The study's findings are further supported by research conducted by Sims and Kienzle (2016), who reported that many farmers face resource constraints, including limited access to loans, advanced farming equipment, and essential inputs such as improved seeds and fertilizers, which hinder their ability to widely adopt improved technologies on their farms. Given these financial limitations, conventional agriculture is often viewed as a more straightforward and cost-effective solution.

About 13.9% of respondents also mentioned inadequate manpower as the primary reason that hinders the wider application of CA in their farms. CA requires a substantial labor force during farm preparation. Livestock disturbance was mentioned by 3.6% of respondents as a factor for the limited application of CA (Table 3). Livestock keepers use crop residues left on farms as mulches to feed their livestock. Furthermore, 2.9% of respondents pointed to the low availability of manure required for CA farming as a constraint, and 2.2% indicated that the efficiency of managing CA farms tends to decrease as the farming area increases therefore, they decided to apply CA on a small portion of their farms. These findings are in line with the study by Lee and Gambiza (2022) which revealed that not all the adopters practice CA on the whole farm because CA involves changing traditional farming practices into new practices, and farmers may be risk-averse when it comes to adopting new practices, thus choosing to experiment a small portion of the farm.

Table 3: Reasons for not practicing conservation agriculture on the whole farmland (Multiple response results)

Reasons	**Frequency**	**Percentage (%)**
Low availability of instrument (*magoe* ripper)	7	5.10
Tediousness on CA farm preparation	30	21.90
Livestock disturbance causes CA	5	3.60
The long process of CA farm preparation	38	27.70
Low availability of manure	4	2.90
Inadequate manpower	19	13.90
High cost	31	22.60
Efficiency in the management of CA farms decreases as the area increase	3	2.20
Total	**137**	**100**

3.2. Principles of conservation agriculture practiced by farmers

Results in Figure 2 show that minimum soil disturbance is the major CA practice (38.5%), followed by crop diversification and crop rotation (34.8%), then lastly (26.7%) permanent soil cover. With a proportion of 38.5%, minimum soil disturbance was the most commonly used CA practice among farmers (Figure 3). The farmers who took part in the survey had a high adoption rate of minimum soil disturbance because most semi-arid areas, including the study area, are susceptible to soil erosion, particularly during periods of heavy rainfall. Practices that involve minimal disturbance, such as minimum or no-till farming, contribute to the preservation of the topsoil, which is inherently more fertile, preventing its erosion. Consequently, these practices help maintain soil fertility and mitigate land degradation. Moreover, minimal soil disturbance practices are often more efficient in terms of time and cost when compared to traditional tillage farming, as they require less labor, fuel, and equipment. It shows a favorable trend toward more environmentally responsible and sustainable farming methods, which can boost ecosystem health and agricultural resilience over the long run. The findings are in line with the study of Skaalsveen *et al.,* (2019), which stated that farmers who adopted CA most likely used no-till or reduced-till techniques to cultivate their crops.

In addition, crop diversification and crop rotation practices were the second most adopted CA techniques (34.8%) because they guarantee food availability and crop rotation breaks the cycle of diseases on farms. These results are consistent with a study by Tahat *et al.,* (2020), whose finding shows that crop rotation enhances soil health, pest management, and overall sustainability in agriculture. Moreover, the permanent soil cover exhibited the lowest adoption rate among the surveyed farmers, at 26.7%. This is noteworthy despite its crucial roles in minimizing herbicide costs, reducing labor for weeding, and safeguarding the soil from extreme temperatures, ultimately decreasing surface evaporation. The diminished adoption rate is attributed to the prevalent practice of free grazing among livestock keepers in the study areas whereby crop residues serve as animal feeds, leading to competition between animals and soil-cover plants. A study done by Owenya *et al.* (2011) reported that some of the advantages of cover crops which included reduced soil erosion, reduced labour power especially in weeding, conserving soil moisture, reduced soil compaction and increased soil nitrogen. The low adoption of cover crops technique is in line with the study done by Kahimba *et al.,* (2014) who reported the low adoption of cover crops in Dodoma was due to the free grazing mode of livestock keeping.

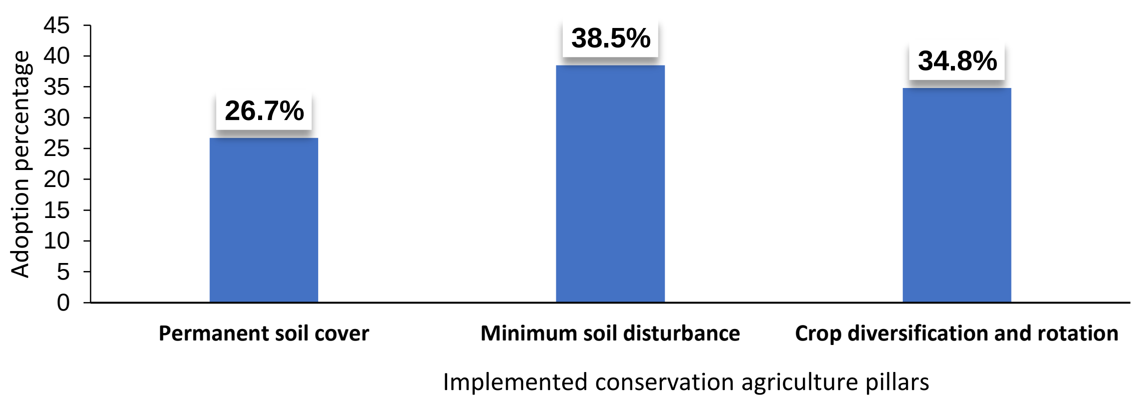

Figure 2: Adoption of the pillars of conservation agriculture

Figure 3: Minimum soil disturbance approach practiced by farmers in Mwitikira Village (left) and Sorghum farming with a cover crop in Chiguluka Village (right)

3.3. Comparison of the profitability of conservation agriculture adopters vs. conventional farmers

Return on Investment and Gross Profit Margin were used in the determination of the profitability of conservation agriculture and conventional farming per hectare. According to the study findings CA was more profitable compared to conventional agriculture with an ROI of 189% and GPM of 65% while conventional farming had an ROI of 34% and GPM of 25% per hectare as shown in Table 4 below.

Table 4: Return on investment and gross profit margin for CA adopters and conventional farmers per hectare of sorghum, bulrush millet and cowpeas crops

Item	Units of measure	Conservation agriculture (Tsh)	Conventional agriculture (Tsh)
Costs			
Seeds	Kg	19,768	24,710
Pesticides	Liters	24,710	-
Packaging materials	Bags	14,826	7,413
Manure	Kg	49,420	-
Land hiring	Lumpsum	49,420	49,420
Ploughing	Lumpsum	61,775	74,130
Harrowing	Lumpsum	49,420	61,775
Planting	Manday	37,065	49,420
Weeding	Manday	49,420	74,130
Harvesting	Manday	37,065	24,710
Total Cost of Production		**392,889**	**365,708**
Benefits			
Yield per hectare (Sorghum/Bulrush millet)	Bags	15	7
Yield per hectare (Cowpeas)	Bucket/debe	10	-
Output price (Sorghum/Bulrush millet)		70,000	70,000
Output price (Cowpeas)		10,000	-
Total Revenue		**1,137,820**	**490,000**
Net Profit		**744,931**	**124,292**
Return on Investment (ROI)		**189%**	**34%**
Gross Profit Margin (GPM)		**65%**	**25%**

Tsh = Tanzanian Shilling

The difference in ROI and GPM between CA adopters and conventional farming may be attributed to high productivity in CA compared to conventional farming, the high productivity in CA resulted from using improved seed varieties, manure, pesticides and CA techniques which improve the soil structure, enhance water holding capacity, reduce surface evaporation and break diseases cycle. Conventional farming had low productivity which was attributed to the use of local seed varieties and poor farming practices. The cost of production in CA was higher than the conventional farming due to associated costs of pesticides and manure application which was not applied in conventional farming, but the cost of harvesting in CA farming was also high due to the quantities of crops on the farm. Furthermore, high productivity in CA adopters resulted in high total revenue and high gross profit per hectare, but for conventional farming low productivity resulted in low total revenue and low gross profit per hectare. The result suggests that conservation agriculture can contribute positively compared to conventional farming to the household income and food security for farmers who produce mainly for their consumption and increased income for those who sell on the market. These results therefore imply that the adoption of CA is one of the ways to improve the livelihoods of smallholder farmers.

Furthermore, the analysis was carried out to establish whether there is a statistical difference between Return on Investment (ROI) and Gross Profit Margin (GPM) between CA adopters and Conventional farmers. Independent t-test results in Table 5 showed that there was a significant difference in Return on Investment (ROI) and Gross Profit Margin (GPM) between the two groups of farmers (Conservation and Convention agriculture farmers).

Table 5: Independent - Sample T-test statistics for ROI and GPM between CA adopters and conventional farmers

Independent sample test	F-Value	Mean	Significance (p-value)*
ROI of CA adopters and Conventional farmers	4.428	1840.6 and 873.7	0.037
GPM of CA adopter and Conventional farmers	54.526	0.81 and 0.50	0.000

* Statistically significant at $p<0.05$; ROI = Return on Investment; GPM = Gross Profit Margin

3.4. Challenges hindering farmers to adopt CA practices

Drought resulting from climate change was identified as one of the challenges by 42.2% of the farmers who participated in the study as shown in Table 6. The presence of drought in the study area impedes farmers from embracing conservation agricultural practices. Agriculture in the study area is predominantly rain-fed, significantly impacted by drought, causing farmers to be hesitant in adopting CA practices that rely on consistent and predictable rainfall. Drought increases the risks associated with agricultural activities due to the rise in uncertain weather conditions, making farmers reluctant to embrace new and potentially unfamiliar CA practices fearing the negative impacts on their yield and livelihoods. Additionally, it was noted that, due to drought in the study area, the primary concern for the majority of farmers is ensuring food security for their families. This focus on immediate needs diverts their attention and resources away from adopting long-term conservation agriculture practices. These findings align with the research conducted by Wallander *et al.,* (2013), which highlighted that droughts amplify uncertainty and risks in farming. Consequently, farmers might be reluctant to adopt conservation practices, typically entailing modifications to traditional farming methods, due to apprehensions about potential failures or financial losses during periods of water scarcity. The following statement made by 43-Year-Old Male Respondents, 2023, reinforces the aforementioned arguments:

"*Irrigation agriculture, use of drought tolerant crops should be highly enhanced among the farmers in our area since most of the farmers here do not want to the risk of using the conservation agriculture practices due to the alteration of climatic conditions which may not support a good yield of our crops*"

Table 6 also illustrates that inadequate availability of agricultural inputs constitutes another significant challenge for farmers, affecting 19.2% of them. These farmers expressed difficulties in obtaining essential agricultural resources such as seeds, fertilizer, pesticides, machinery, and other inputs crucial for supporting their farming operations, especially in the context of CA. The insufficient availability of these inputs, coupled with their associated costs, typically constrains farmers' capacity to implement recommended practices. For instance, the utilization of herbicides for weed control is a prevalent aspect of conservation agriculture. Consequently, in areas where these inputs are scarce or expensive, a majority of farmers tend to opt for conventional farming practices that involve more labor-intensive weed control methods. Limited access to agrochemicals leads to heightened labor requirements and reduced efficiency in weed management, discouraging the widespread adoption of conservation agriculture. These findings align with existing literature (Thiombiano & Meshack, 2009; Burnham *et al.,* 2023), which argues that the insufficient availability of agricultural inputs ranks among the foremost challenges faced by farmers when adopting conservation agriculture practices. This argument is supported by what was said by one of the key informants in VEO, Chiguluka 2023:

“The agricultural inputs are very costly compared to farmers' ability to purchase. Sometimes, among them, they even fail to get some basic needs. Therefore the government should provide subsidies on essential agriculture inputs such as seeds, fertilizers and pesticides”.

Another challenge was the incidence of pests and diseases, which was the challenge for most of the farmers (10.5%) in adopting conservation agriculture practices (Table 6). This implies that pests and diseases are among the significant challenges facing farmers in adopting conservation agriculture practices. Maintaining crop residues in the field, as practiced in CA, can provide shelter and food sources for certain pests, thereby increasing pest pressure. If not managed properly, these residues can become reservoirs for diseases, leading to higher infection rates and consequently resulting in losses in subsequent crops. Additionally, the practice of minimum tillage results in an increase in weed growth, which serves as a host for pests and diseases, competing with crops for nutrients and water. Consequently, this leads to an elevated application of chemical pesticides which then imposes an economic burden on the majority of farmers in the study area, hence majority of the farmers are hesitant to choose CA over conventional farming. These findings align with the study conducted by Skendzic *et al.,* (2021) which reported that crop damage from pests and diseases can be severe, leading to decreased yields and financial losses for farmers, this outcome disappointing farmers who are attempting to implement conservation techniques to increase yield.

Therefore, addressing the challenges posed by pests and diseases necessitates the implementation of comprehensive and sustainable strategies. This involves a heightened investment in agricultural research institutions for the development and distribution of improved crop varieties resistant to diseases and pests. Additionally, there is a need to encourage the adoption of crop varieties that exhibit tolerance to prevalent pests and diseases. Also, Agrometeorological information should be effectively downscaled and timely disseminated to farmers through their extension officers. This information plays a crucial role in enabling farmers to predict and prepare preventive measures in advance, particularly for conditions conducive to pest and disease outbreaks. Furthermore, the government, in collaboration with other stakeholders, need to establish an early detection and monitoring system for pests and diseases. Farmers should be equipped with the necessary training in pest and disease identification, alongside tools enabling them to promptly report any unusual occurrences.

Another challenge was unavailability of the market for crops, which was mentioned by 13.9% of farmers (Table 6). The majority of farmers are more inclined to adopt CA practices when they perceive financial benefits, the absence of markets for their crops diminishes the economic motivation for them to embrace CA. Farmers require assurance that their investment in CA will yield profitable returns. Additionally, it was noted that the adoption of CA necessitates costs, which most farmers obtain through credit. However, without reliable markets, many financial institutions become reluctant to provide credit, further impeding the adoption of CA. The study’s finding is in line with what was reported in the literature by Bazrafkan *et al.,* (2022) who reported that farmers may be hesitant to adopt conservation practices if they perceive them as increasing the risk of financial losses due to the unavailability of a market for their crops. Therefore, it is essential to provide farmers with the necessary knowledge and resources to access markets effectively while adopting conservation practices. This can include promoting value chain approaches to CA, introducing commercial or high-value crops in CA programs, and value addition on farmers' produce. Also, improved access to the necessary support services such as markets for seed, fertilizer, herbicides, and equipment, as well as reliable extension services can possibly enhance adoption of CA.

Lastly, inadequate awareness of good agricultural practices accounts for 14.3% of the barriers to adopting CA (Table 6). Farmers in the study area face a knowledge deficit when it comes to implementing proper agricultural practices, which contributes to their reluctance to adopt CA practices. Most farmers continue to rely on conventional techniques passed down through generations, prioritizing short-term gains over long-term sustainability. The introduction of CA is seen as a major shift, and many farmers resist adopting it due to a fear of failure, compounded by their lack of awareness regarding the potential benefits of CA. This knowledge gap is largely attributed to insufficient extension services and training, leaving many farmers without access to reliable information about CA practices. These findings align with Chinseu *et al*. (2019), who observed that a lack of information and instruction on CA is a key factor contributing to low adoption rates. Similarly, Makondo and Thomas (2018) reported that farmers' hesitance to change conventional methods stems from their familiarity with these practices and limited exposure to alternatives such as CA. Giller *et al.* (2011) also noted that the lack of knowledge is a major reason why farmers continue to rely on conventional practices. The study's findings are further supported by the Diffusion of Innovation theory (Rogers, 1995), which suggests that a lack of awareness of the relative advantages of CA such as increased productivity, reduced costs, and improved soil health hinders adoption. Without opportunities to attend workshops, receive extension services, or engage in knowledge-sharing activities, farmers' limited knowledge of sustainable agricultural methods remains a significant barrier to the adoption of CA.

Table 6: Challenges facing farmers in adopting CA practices (Multiple response results)

Challenges	Frequency	Percentage (%)
Inadequate availability of agriculture inputs	55	19.2
Drought due to climate change	121	42.2
Incidence of pests and diseases	30	10.5
Limited access to the market for crops	40	13.9
inadequate CA awareness	41	14.3
Total	287	100

4. Conclusion and Recommendations

Based on the study's findings, despite the significant economic and environmental benefits of CA, the majority of farmers who practice CA have been observed to practice CA on a small portion of their farms. This limited adoption is attributed to the labor-intensive and time-consuming nature of farm preparation under CA, as well as the insufficient availability of essential farming tools required for its implementation. Additionally, several challenges have led farmers to continue relying on conventional farming methods rather than embracing CA. These challenges include financial constraints, limited exposure to alternative farming practices, a lack of knowledge regarding the benefits of CA, inadequate access to agricultural inputs, the impact of climate change resulting in droughts, the incidence of pests and diseases, and limited access to markets for their crops. Lastly, it is concluded that minimum soil disturbance is the most widely adopted CA practice among farmers in Bahi District followed by crop diversification and crop rotation practices, while permanent soil cover had the lowest adoption rate.

Based on the findings, the study recommends addressing challenges and promoting sustainable farming practices through policy interventions, financial support mechanisms, and targeted educational initiatives. Key priorities include tackling financial constraints, raising awareness, improving access to inputs, and integrating climate change strategies, such as promoting drought-resistant crops. Strengthening market linkages, supporting farmers' cooperatives, and fostering knowledge sharing are also essential. Furthermore, the government should collaborate with institutions such as Sokoine University of Agriculture (SUA), Centre for Agricultural Mechanization and Rural Technology (CAMARTEC), and Tanzania Commission for Science and Technology (COSTECH) to develop innovations that simplify CA processes and enhance access to affordable farming tools.

Conflict of interest

The author declared no conflict of interest associated with this work.

Data availability statement

Data will be made available upon request.

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