# Factors influencing the adoption of conservation agriculture by smallholder farmers in KwaZulu-Natal, South Africa

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Research Article

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**Abstract:** The various efforts done to promote conservation agriculture (CA) in the Sub-Saharan Africa and the Republic of South Africa have diminished over time. This study was carried out to determine the factors that influenced the adoption of CA in the Okhahlamba Local Municipality of Uthukela District Municipality in KwaZulu Natal Province of South Africa. It used a dataset collected through a structured questionnaire from 273 smallholder farmers. A systematic random sampling technique was used to select the households, whereas descriptive statistics (such as frequency count and percentages) and logistic regression analysis were used to determine the factors that influenced the adoption of CA. The results revealed that the respondents' age, access to credit, visits by extension agents, and training showed a significant influence on the adoption of CA practices by farmers. The results emphasized the important role of extension agents and of more female farmers in the promotion of CA practices. The study recommended intentional and direct effort by all stakeholders in promoting and encouraging farmers' participation at all age levels, and to make the CA programmes flexible to accommodate the illiterate farming households. The study further recommended additional extension agents to adequately guide and train farmers on CA through all-inclusive extension services.

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**Keywords:** conservation agriculture, no-till soil conservation, systematic sampling, logistic regression, extension agents, smallholder farmers

## 1 Introduction

By year 2050, agricultural production is expected to increase by more than 55% globally following the growth of human population and food consumption [1–3]. Agriculture remains a key sector with a high potential of contributing to the social and economic growth in many developing nations [4–6]. This is accompanied by the deteriorating state of soil fertility and a degraded land that is prevalent. Preservation of scarce resources and decrease in waste need to be optimized so that agriculture is able to respond optimally to the future challenges whereby new innovations will be effectively used [7–9]. This, as related to the United Nations' Sustainable Developments Goals (UN SDG, 2030), is achievable through the promotion and support of sustainable policies and provision of incentives for farmers to adopt conservation agriculture (CA) practices for improvement over a given time [10–13]. CA techniques are usually based on three uncompromised linked principles: (i) minimal soil disturbance or zero-tillage, (ii) adequate soil cover maintenance, and (iii) diverse crop rotations [14,15]. Although these principles are applicable in various agro-ecological environments, their success is site specific and should always be consciously tailored for local conditions to guarantee good success [16,17].

CA is increasingly seen as a natural resource cropping pattern that strives to achieve acceptable profits while concurrently preserving the resource base [18–20]. However, to achieve favourable results, all principles of CA must be applied simultaneously. Regardless of the attractiveness of CA practice, many ideals channelled at promoting uptake in Sub-Saharan Africa (SSA) remain limited [11,21]. In South Africa, like other SSA nations, both government agencies and non-government organizations have been promoting the benefits that could be derived from CA. However, the challenge is that its adoption is still low [22]. Alongside (partial) adoption, reversion to entrenched paradigms inclined to old traditional practices was not uncommon among farmers; hence, it cannot be surprising that many claims of the adoption of CA were made only during active implementation of government and NGO projects.

The aim of this study is to explore factors that influenced CA adoption among small-scale farmers. Analysis of these factors is very important in designing relevant support systems that will help in promoting sustainable farming practices [22]. This work is expected to help in developing a strategy to enhance soil management practices that are environmentally friendly, and which at a long run improve soil fertility and promote CA in SSA with rural communities of South Africa included. There is a need to understand the motive behind non-adoption of CA among small-scale farmers in the Okhahlamba Local Municipality (OLM), which serves as the basis for this research work. Useful information that could contribute to an improvement in household food security and agricultural productivity will be drawn out of this research. This study is intended to show the opportunities available to increase the use of CA among small-scale farmers in South Africa.

## 2 Materials and methods

### 2.1 Study area

This study was conducted in Potshini, Stulwane, and Emmaus rural villages in OLM, Uthukela District Municipality of KwaZulu-Natal Province of South Africa (Figures 1 and 2). The target communities were characterized by season fall from September to May and a mean annual rainfall of 700 mm/year [23]. There are four major types of soils that were identified in the study areas. First, the red (Hutton) and yellow-brown Apedal soil dominated by sandy loam and patches of sandy clay loam, whereas the second pattern comprised mesotrophic Avalon soils. The remaining two patterns, the Duplex and the Lithosolic, were of the least agricultural potential [24,25,36,37]. The palatability of the natural grasslands was very seasonal because of harsh climatic conditions, and for that reason, farmers had to provide supplementary feeding [26].

The smallholder farmers practised mixed livestock-crop farming system with maize plots and home gardens, where they grew vegetables. Maize remained the major staple crop grown in large part of the smallholder land [27,28]. During cropping seasons (summer), cattle are sent to the mountains and are only allowed to graze the fields

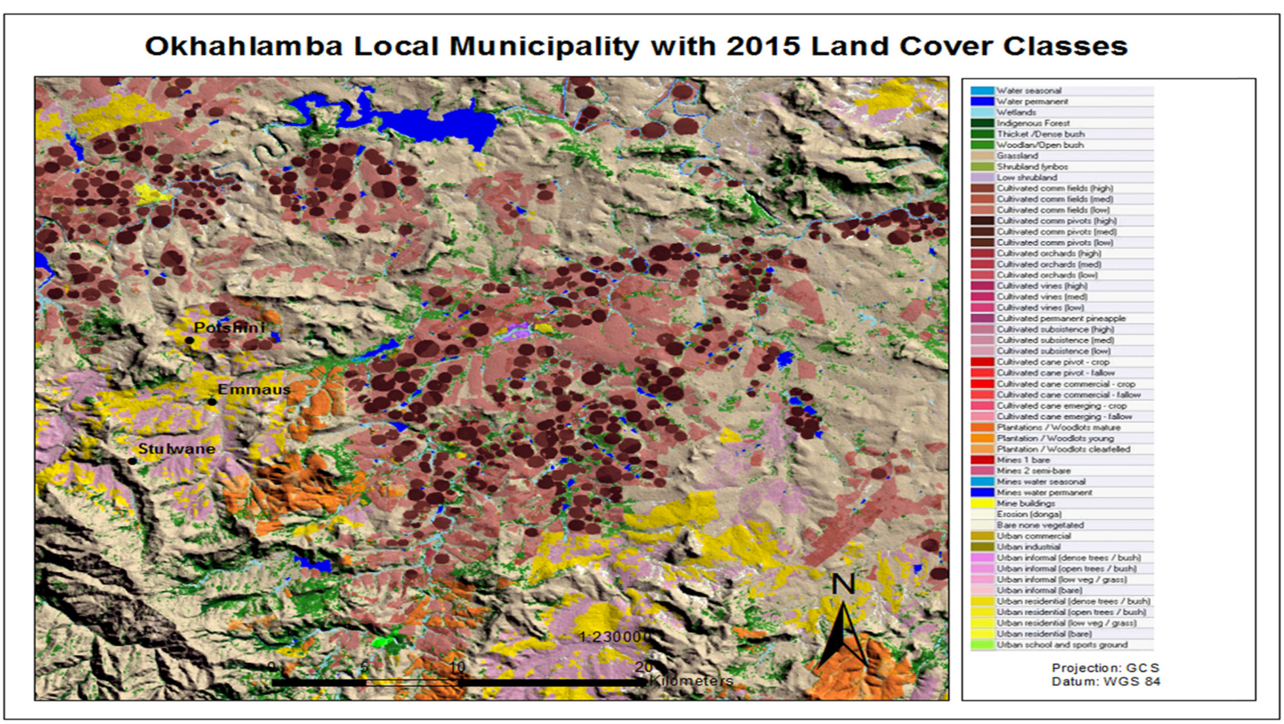


**Figure 1:** Map of the study area.

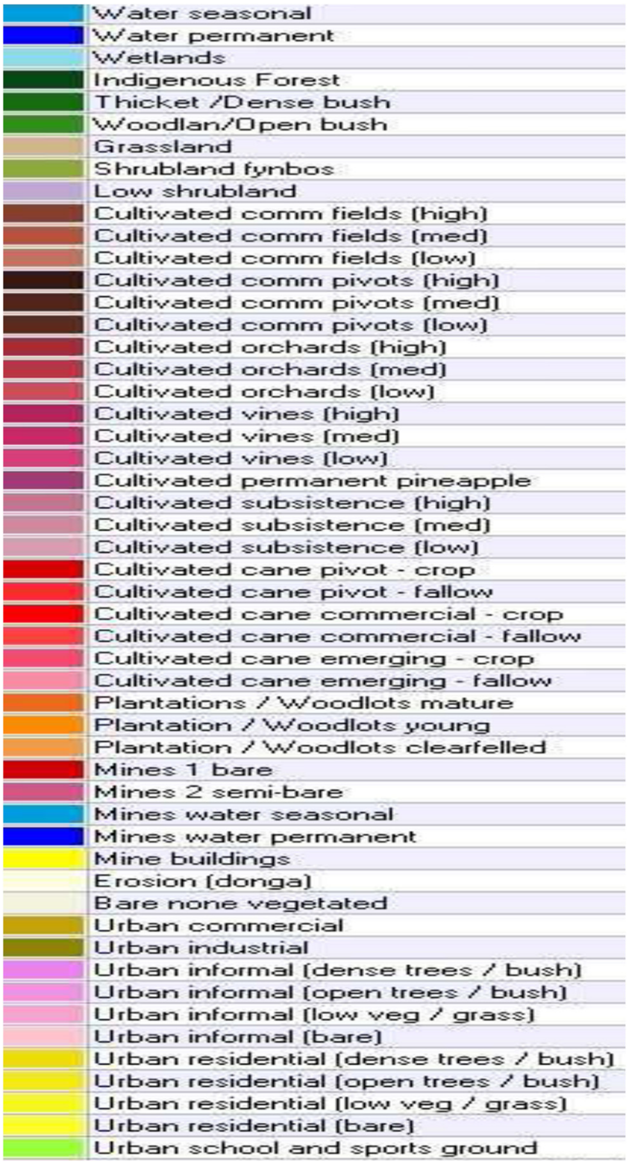


**Figure 2:** Map legend.

in the off-season (winter) [26]. The agricultural production relied on natural rainfall, as smallholder farmers practised dryland agriculture. The water collected from the rainwater harvesting tanks was used to irrigate home gardens.

## 2.2 Research approach

A quantitative and a qualitative approach was used in the study. The quantitative approach was used to integrate the techniques of observing, documentation, and analysing data, including character interpreting and defining participants in study. The qualitative approach was used to actively engage the farmers of the study area and get a better understanding of factors that discouraged adoption of CA. According to Aspers and Corte [29], qualitative approach means to observe attributes that are difficult to quantify. It refers to variables that are categorical and nominal. Aspers and Corte [29] indicate that the qualitative approach is iterative and it improves understanding of complex situations. The positive aspect about qualitative approach is that it offers a researcher a chance to develop insights to complex situations. It provides an opportunity to understand the context of what is going on instead of looking at only the choices or behaviours.

## 2.3 Sampling size and procedure

The study sample size consisted of 273 farmers who represented one third (about 33%) of about 843 farmers (population) who are into the adoption of CA. The study sample was selected using a probability stratified sampling method. The stratified sampling method was used because it correctly represents the population surveyed. Stratified random sampling ensures that all sections of the population are not over or underrepresented. The sample size was determined by drawing from the farmer's registers in each study area, which served as the sampling frame. Farmers comprised two distinct categories, (adopters) and (non-adopters). Respondents' list of non-adopters (those not practising CA) was obtained from homestead registers submitted by local leadership (village heads and ward councillors), whereas the lists of CA practising farmers were identified through the district's Department of Agriculture and Environmental Affairs. To obtain the desired sample, authors like Yamane (1973) proposed a sampling formula. Yamane proposed the following detailed mathematical formula:

$$n = N/1 + N\,(e^2), \qquad (1)$$

where $n$ denotes required sample size; $N$ denotes the population size = 843; $e$ is the degree of accuracy (sampling error) = (0.05).

When this formula was applied to 843-sample population of farmers in the study areas, it gives,

$$n = 843/1 + 843 * (0.05^2). \qquad (2)$$

Study sample size ($n$) = 271.279.

Having shown the interest to participate in the survey, it was impossible to discount other potential participants. However, two (2) farmers were added to account for those farmers who could be difficult to locate during data collection to make a total of 273 respondents. Initially, the idea was for each group to have equal number of participants and providing everyone in each category with an equal chance of being chosen.

### 2.4 Data collection

Qualitative and quantitative data were collected using primary and secondary data to capture all information necessary for the research from 273 respondents. A pre-tested structured questionnaire was used to elicit data for the study. A pilot study was conducted to pre-test the research instruments. To obtain primary data, questionnaire surveys, interviews, and field observation of farmers were used in the study. The initial questionnaire was piloted on 15 farmers who were randomly selected from three villages of Potshini, Stulwane, and Emmaus, and based on the findings, the requisite changes and corrections were made. Fifteen qualified enumerators administered the revised questionnaire.

The questionnaire included mostly closed-ended questions designed to elicit information from such as farmers' age, level of formal education, income, access to agricultural information, hectares, farmers' adoption behaviour of the technology's package, membership of formal and informal organizations, land tenure, and other farming details. Open-ended questions solicited respondent's understanding of CA, agricultural extension, and advisory support. The questionnaire was meticulously designed and worded to avoid ambiguous, sensitive, and provocative questions. With such length of time, the intention was to obtain more carefully thought out responses from the respondents.

### 2.5 Data analysis

Descriptive statistics using mainly frequencies, percentages, and inferential statistic using mainly logistic regression model provided by XLSTAT software 2014.4.06 version were used to analyse the collected data. Logistic regression model was used to predict variables that determined adoption of CA components and to reveal main variables that affected investment decision of the farmers. The results were tested for significance at the 0.05 (95% confidence level).

### 2.6 Analytical model

Following Gujarati [30], Logistic regression model was used because of its simplicity in the interpretations of the coefficients [30–33] and had been found to be efficient in explaining dichotomous decision variables. The effect a given set of explanatory variables has on adoption of CA technology can be specified as:

$$\begin{aligned}\text{Prob}(Y=1) &= \text{In}\left(\frac{P}{1-P}\right)\\ &= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_i X_i + U_i,\end{aligned} \tag{3}$$

where $Y$ is the regress or which assigned the value of 1 for adoption of CA and 0 for otherwise, $\beta_0$ is an intercept, $\beta_i$ represents the regression coefficients of the explanatory variables, $U_i$ is the error term with a logistic distribution, and $X_i$ shows a matrix of predictor variables related to the adoption of CA technology. The decision to adopt technologies at individual farmer level is always determined by several factors: ($X_1$ = Household head's gender, $X_2$ = Household heads, $X_3$ = Educational level, $X_4$ = Credit access, $X_5$ = Extension visit, $X_6$ = Training; Table 1).

## 3 Results and discussion

### 3.1 Summary of descriptive statistics

This study looked into farmers' socio-economic conditions such as gender, age, level of education, access to extension service, access to credit, and training. The study results in Table 2 show that the adoption of CA was high in male-headed farming households (78.39%) than female-headed farming households (21.61%). The higher percentage of male-headed farming households can be attributed to the stereotype nature of homeland agriculture in Africa whereby males are expected to dominate farming activities, whereas females dominate other income-generating activities such as food processing and trading to increase family income [34–36]. This is consistent with the fact that agriculture in Africa is characterized by use of crude and highly labour intensive (encouraging drudgery) implements, which is detrimental to the health status of the users, and which at long run discourages women participation in some farming activities such as land clearing, weeding, and ridging [37].

The results as presented in Table 2 show that the majority (75.73%) of the survey respondents were still

**Table 1:** Description of variables of factors affecting adoption of CA

| Variables | Description |
|---|---|
| Dependent variable | Dummy, 1 if CA technologies adopter, 0 otherwise |
| Independent variables | |
| Household head's gender (GENDER) | Dummy, 1 male, 0 otherwise |
| Household head's age (AGE) | Number of years (continuous) |
| Educational level (EDU LEVEL) | Dummy, 1 no education, 0 otherwise |
| Credit access (CRDTACSS) | Dummy, 1 if yes, 0 if otherwise |
| Extension visit/contact (EXTVST) | Dummy, 1 if yes, 0 if otherwise |
| Training (TRAINING) | Dummy, 1 if yes, 0 if otherwise |

**Table 2:** Demographic characteristics of the farmers ($N$ = 273)

| Variables | Adopters ($n$ = 136) | | Non-Adopters ($n$ = 137) | | All Farmers ($n$ = 273) | |
|---|---|---|---|---|---|---|
| | Frequency | Percentage | Frequency | Percentage | Frequency | Percentage |
| **Gender** | | | | | | |
| Male | 103 | 75.74 | 111 | 81.02 | 214 | 78.39 |
| Female | 33 | 24.26 | 26 | 18.98 | 59 | 21.61 |
| **Age** | | | | | | |
| 18–27 | 40 | 29.41 | 41 | 29.92 | 81 | 29.67 |
| 28–37 | 25 | 18.38 | 32 | 23.36 | 57 | 20.88 |
| 38–47 | 38 | 27.94 | 36 | 26.28 | 74 | 27.11 |
| 48–57 | 26 | 19.12 | 23 | 16.79 | 49 | 17.95 |
| >58 | 7 | 5.15 | 5 | 3.65 | 12 | 4.42 |
| **Education** | | | | | | |
| Pre-school | 19 | 13.97 | 19 | 13.87 | 38 | 13.92 |
| Grade 3 | 25 | 18.38 | 17 | 12.41 | 42 | 15.38 |
| Grade 8 | 30 | 22.06 | 38 | 27.74 | 68 | 24.91 |
| Grade 12 | 32 | 23.53 | 28 | 20.44 | 60 | 21.98 |
| Higher | 5 | 3.68 | 2 | 1.46 | 7 | 2.56 |
| None | 25 | 18.38 | 33 | 24.09 | 58 | 21.25 |
| **Extension visit** | | | | | | |
| Yes | 92 | 67.65 | 56 | 40.88 | 148 | 54.21 |
| No | 44 | 32.35 | 81 | 59.12 | 125 | 45.79 |
| **Credit access** | | | | | | |
| Yes | 83 | 61.03 | 73 | 53.28 | 156 | 56.6 |
| No | 53 | 38.97 | 64 | 46.72 | 117 | 43.4 |
| **Training** | | | | | | |
| Yes | 96 | 70.59 | 18 | 13.14 | 114 | 41.76 |
| No | 40 | 29.41 | 119 | 86.86 | 159 | 58.24 |

in their active productive age (less than age 48 years), whereas minority (4.4%) were of the age above 57 years. Existing studies opined that young farmers should be the main target to ensure a successful implementation of complex technologies, which include CA [38,39]. On the other hand, education is one of the most powerful human capacity tools that have a bearing on adoption of agricultural technologies. The farmers' educational background becomes an important element that determines the readiness to accept and properly apply technologies [4,40,41]. Table 2 shows that majority (24.91%) of the respondents had Grade 8 education. It can be deduced that there is low level of education among the farming household heads, and this conforms with the assertion of Bazezew [42] that low level of education increases the possibility of farmers' rejection of new technology and innovation, which can lead to poor agricultural output.

Furthermore, credit is an important factor that creates and maintains an adequate flow of inputs required for adoption of conservation farming and thus increases efficiency in farm production [43]. Table 2 shows more than half of the respondents (56.6%) had access to credit, whereas 43.4% did not. Credit availability and contact with extension agents augment the ability of farmers to use modern technologies and advanced practices. The regular contact with the extension officers improves farmer's knowledge about the technology and so enhances its successful implementation [44,45]. More than half (54.21%) of the respondents had a contact with extension agent compared with non-adopters (45.79%) presented in Table 2. Without proper knowledge of practices associated with CA, adoption is unlikely [10].

Table 2 shows that 70.59% of the farmers (adopters) declared that they received training in CA. This implies that remaining 29.41% (CA adopters) who had received no formal CA training might have received training from other farmers through farmer-to-farmer information exchanges or through their neighbourhood networks.

## 3.2 Logistic regression model of factors influencing the adoption of CA by smallholder farmers in OLM

The logistic model identified variables that influenced sustainable agricultural practice investment decision of the farmers. The variance inflation factor tested the multicollinearity occurrence probability among the continuous explanatory variables and discrete explanatory variables, and none of the explanatory variables correlated. Hence, variables were found free from the problem. The measurement of goodness of fit of the model confirmed that this model fits the data. Less than 1% probability level of Pearson Chi-square test showed overall correctness and goodness of fit of the model.

In the study, the variable age (28–37 years) had a coefficient of −1.3874 (Table 3), suggesting that CA adoption was negatively related to the age of the farmer. The plausible reason might be that young people are more receptive to new innovations and ideal than the older farmers [46]. Older people who are already used to a particular way of doing things may not be interested in improved technologies. Adesina and Zinnah [47] also reported that long-term conservation investment and age are inversely related. A similar argument was also advanced by Gilbert [48] and Rukuni et al., [49] who claimed that being older created a conservative feeling among farmers and hence resistance to change. This may imply the excess of workforce for implementing CA technology [50]. Young farmers should be the main target to ensure a successful implementation of complex technologies, which include CA [38].

The parameter of credit access hypothesized access to credit is positively related to adoption of CA technology and was significant at $P < 0.05$ as shown in Table 3. The odd ratio of 2.047 shows that under the constant condition, the odd ratio in favour of the

**Table 3:** Logistic regression results on factors affecting adoption of CA

| Parameter | Estimate | Standard error | Wald Chi-square | Pr > Chi sq. | Exp. (Est.) |
|---|---|---|---|---|---|
| Constant | 2.8234 | 59.5893 | 0.0022 | 0.9622 | 16.834 |
| Gender | 0.5171 | 0.3450 | 2.2465 | 0.1339 | 1.677 |
| Age groups | | | | | |
| 1. (18–27) years | 0.9650 | 1.1053 | 0.7622 | 0.3826 | 2.625 |
| 2. (28–37) years | −1.3874 | 0.6816 | 4.1429 | 0.0418** | 0.250 |
| 3. (38–47) years | 0.6118 | 0.5134 | 1.4200 | 0.2334 | 1.844 |
| 4. (48–57) years | −0.4997 | 0.6147 | 0.6607 | 0.4163 | 0.607 |
| Educational level | | | | | |
| Pre-school | 1.2577 | 45.2415 | 0.0008 | 0.9778 | 3.517 |
| Grade 3 | 1.6422 | 45.2405 | 0.0013 | 0.9710 | 5.166 |
| Grade 8 | 0.7714 | 45.2389 | 0.0003 | 0.9864 | 2.163 |
| Grade 12 | 2.0443 | 45.2390 | 0.0020 | 0.9640 | 7.723 |
| Higher | −6.7347 | 226.2 | 0.0009 | 0.9762 | 0.001 |
| Credit access | 0.7166 | 0.3281 | 4.7713 | 0.0289** | 2.047 |
| Extension visit | 1.0539 | 0.3166 | 11.0812 | 0.0009** | 2.869 |
| Training | 3.0465 | 0.7562 | 16.2293 | 0.0001*** | 0.048 |

Significance at the 10, 5, and 1% levels are indicated by *, **, and ***, respectively.

adoption of CA increased by 2.047 as access to credit increases by a unit. This implies that adoption of CA increases as farmers' access to credit increased. This fortifies the crucial role of credit in relaxing the financial burden of farmers when adopting CA. When financial aptitude is bolstered, farmers have a greater capacity to invest in and undertake the risk of practising CA [51]. A similar argument was also advanced by Ministry of Food and Agriculture [46,52].

On the other hand, the coefficient of the extension visits variable as expected had a significant and positive relationship with CA technology adoption ($P < 0.01$). In terms of the odds of adoption, a unit increase in the number of contacts with extension agents increased the odds of adoption of CA by the factor of 2.869. This implies that households that often contacted extension services had the higher probability of adopting CA than those who did not. This was because extension services built the capacity of farmers, increased their knowledge, and reduced their uncertainty in decision-making [53,54]. Similar results were reported by Baidu-Forson [55] that showed the positive bearing the extension agents had in the enhancement of CA adoption.

Finally, the parameter for the training of the farmers was significant ($P < 0.01$); it influenced the decision to adopt CA negatively. Training resources were significant factors to reckon with in terms of skill and ideal on agricultural soil conversation and adoption of CA. Furthermore, holding other factors constant, a unit increase in training of the farmers about CA brought about an increase in odds of adoption of CA by the factor of 0.048 unit in the study area. This implies that farmers who did not attend field day training or demonstrations by experts or extension agents and were not duly exposed to agricultural practical information on CA technology were more likely to reject CA practice than those farmers who attended field day training. This result agrees with the study conducted by Bazezew [42] who found that low level of education in terms of training and information increases the possibility of farmers' rejection of new technology and innovation.

# 4 Conclusion and recommendations

An understanding of the causal factors of CA adoption can inform efforts to develop more appropriate technical innovations or support services. This study used descriptive statistics (frequency counts and percentages) and the logistic regression model to assess factors that influenced CA adoption in Potshini, Stulwane, and Emmaus villages. Study results revealed that access to credit and extension were positive and influential in the adoption of CA technologies, whereas age (28–37 years) and training level were negatively related to CA adoption. The poor state of educational status for most smallholders of OLM and their inexperience with new or alternative technologies is a contributor to non-adoption of CA technologies. The study also concluded that in OLM, younger farmers practised CA more than their older counterparts.

As a recommendation, it is crucial to motivate the youth and also show the importance of CA to older farmers by enlightening them on its benefits. Bursaries and scholarships should be made accessible to young people keen to study CA to spike interest in CA. It also came out of the study that most CA adopters in OLM were men. The study therefore recommends that information dissemination and training efforts should be tailored in such a way that they provide the differences in knowledge acquisition and retention between male and female farmers. This will at long run encourage more female farmers in agriculture and adopting of CA technology. Necessary strategies should be designed and used to enable women to participate equally in decision-making and development activities of the community. Training courses with relevant content will help farmers gain necessary information and quick understanding of CA technology components. This is expected to play a significant role in improving their decision-making levels and adoption of innovations, hence improving productivity and food security.

Results further showed that access to credit was one of the major challenges in the subsistence farming sector. A sizeable number of the farmers did not use credit in their farming operations. The high level of farmers not having access to formal credit from the financial institutions in the study areas has been linked to lack of collateral or security to secure the loan. It is believed that a lack of adequate access to credit may have negative effect on the adoption of CA. The recommendation therefore is that there is a need to set up smallholder credit agencies in rural areas to enhance the farmers' awareness of the credit services and their accessibility. The findings also showed that the extent to which extension workers interacted with farmers was low although significant. Thus, it is recommended to increase the flow of information for CA through a strengthening of the extension service system in the locality. Technical guidance such as extension training is also expected to augment adoption of the CA technology.

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