

The impact of agricultural mechanization on smallholder agricultural productivity: Evidence from Mnquma Local Municipality in the Eastern Cape Province

Mdoda, L.¹, Mdletshe, S.T.C.², Dyiki, M.C.³, and Gidi, L.³

Corresponding author: L. Mdoda. Email: MdodaL@ukzn.ac.za

ABSTRACT

Smallholder agriculture is one of the imperative segments in the South African economy and it remains a vital sector for livelihood generation. Despite its numerous benefits and efforts, smallholder productivity has not improved as expected due to many underlying factors. This paper investigates factors influencing and the impact of agricultural mechanisation on smallholder agricultural production in Mquma Local Municipality located in the Eastern Cape Province. The study applied a descriptive survey research design. A stratified sampling procedure was used to gather information from 120 smallholder farmers using a semi-structured survey. Data collected were analysed using descriptive statistics, a Logistic Regression Model, and Propensity Score Matching. The results of the study reveal that about 90% of the smallholder farmers were using agricultural mechanisation for farming. The use of agricultural mechanisation has an impact on smallholder agricultural production. It ensured a proliferation in smallholder productivity, farm returns, and crop intensity. The study recommends that government and relevant stakeholders must develop effective agricultural access to credit by farmers as a strategy for increasing the adoption attitude to agricultural mechanization. The study suggests that reinforcement of the promotion of innovative technology adoption will have a crucial role in improving smallholder agriculture.

Keywords: Agricultural mechanization, Farm returns, Food security, Productivity, Smallholder farmers

¹ Discipline of Agricultural Economics, School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, P/Bag X01, Scottsville, Pietermaritzburg, 3209, South Africa. ORCID: 0000-0002-5402-1304.

² Department of Agricultural Economics and Extension, Faculty of Science and Agriculture, University of Fort Hare, P/Bag X1314, Alice, 5700, South Africa.

³ Department of Agricultural Economics and Animal Science, Faculty of Science and Agriculture, University of Limpopo (Turfloop Campus), P/Bag X1106, Sovenga, 0727, South Africa.

1. INTRODUCTION

Smallholder agriculture plays a pivotal role in the provision of better livelihood and food security in developing communities, in sub-Saharan Africa (Department of Agriculture, Forestry & Fisheries, 2016). Furthermore, Adam & Hassan (2015) argue that smallholder agriculture helps in sustaining livelihoods for farmers and communities through income generation and employment in rural South Africa. According to IFAD (YEAR) & UNEP (2013), smallholder farmers make up about 80% of home consumption (food), employment, and poverty reduction in many developing economies worldwide. Additionally, Musungwini (2018) points out that in line with achieving food security through the eradication of hunger and poverty alleviation as contemplated in the United Nations (UN) Sustainable Development Goals (SDGs), smallholder agriculture must be feasible, productive, and sustainable. However, this realization is impeded by the continued reliance of smallholder farmers on traditional methods of farming and this has lowered the level of productivity (Mwangi & Kariuku, 2015). It is imperative to enhance agricultural productivity to meet the expected escalating demand for food to meet a growing population and, as a result, it is important to make use of modern agricultural technologies to increase agricultural productivity. According to the Food Agricultural Organization (FAO) (2009), tools, implements, and powered machinery are essential and major inputs to agriculture as it can be argued that they are playing the most important role.

The term mechanization is defined as an overall description of the application of inputs (tools, implements, and powered machinery) as they bring innovative and impactful areas in the agriculture sector. Agricultural mechanisation is regularly deliberated from the perspective of large-scale profit-making farming, with reference to capital-intensive agricultural production schemes (Cossar, 2019). However, for farmers in emerging rural contexts, agricultural mechanisation is referring to circumstances where labour is still comparatively reduced, are using agricultural machinery, particularly in parts of Asia and Sub-Saharan Africa where small-scale machinery has become widespread (de Groote, Marangu, & Gitonga, 2018; Mottaleb, Rahut, Ali, Gérard & Erenstein, 2017).

Mrema, Soni & Rolle (2014) stipulated that agricultural mechanisation is a primary element for increasing agricultural productivity, enhancing food security, and sustainability of the entire agricultural system, especially in developing countries. According to the Food Agricultural

Organization (FAO) (2016), mechanization and appropriate mechanization strategies have a large role to play in improving agriculture productivity, to feed the growing world population. Tegegne (2017) argues that agricultural innovations also play a significant role in curbing poverty, lowering per-unit costs of production, as well as improving agricultural yields.

The opportunity must be guided in a way that meets smallholder farmers' needs and that does not require a Green-Revolution type of approach with high levels of agrochemical inputs and destructive ploughing operations that threaten soil health and fertility (FAO, 2016). Available evidence suggests that mechanisation has a major impact on the demand and supply of farm labour, agricultural profitability, and a change in a rural landscape to increase labour efficiency and productivity, (Schmitz and Moss, 2015). Contrary to FAO (2019), Srisompun *et al.* (2019) specified that the goal of agricultural mechanization is to reduce labour, lower the cost of production and enhance overall productivity. Increasing productivity by updating executive operations to gain more power, increasing the level of cultivated land, moving towards industrial development and strengthening the market for rural economic growth, and ultimately improving the livelihoods of farmers are the goals of mechanisation.

Mottaleb, Krupnik & Erenstein (2016) agree that the use of appropriate agricultural mechanisation has been highlighted as an essential strategy and development goal for smallholder farmers in enhancing their productivity which is often very low. The use of agricultural mechanization is significant for smallholder farmers because it advances production efficiency, reassures large-scale production, and increases the quality of farm produce. Ayandiji & Olofinsao (2015) contended that the use of agricultural mechanization by farmers has been realized as the spindle to the agricultural uprising in many parts of the world, especially developing countries (such as sub-Saharan Africa), and it has contributed prominently to the amplified output of food crops and other agricultural products.

In the developing world, engine power is generally on the increase as low-cost tractors and other engine-powered technologies become increasingly available for smallholder farmers. The use and adoption of improved technologies such as agricultural mechanisation have also led to the constant socio-economic development of smallholder farmers and agricultural mechanisation is an important factor in the achievement of the green revolution experienced by Asian countries (Mwangi & Kariuki, 2015).

As a result, the majority of smallholder farmers are still less productive and profitable. Reports indicate that rural households have moved away from smallholder farming due to a shortage of inputs, farming techniques, and low agricultural production (Baiphethi, 2009). This is because of a lack of incentives for smallholder farmers to strengthen farming production by using fertiliser due to high costs and limited access to credit (Ekepu & Tirivanhu, 2016). As a result of the lack of incentives, smallholder farmers are forced to share agricultural mechanisation as they prepare their farms at the same time of the year, resulting in rising rental fees for tools and machines.

Baudron *et al.* (2019) argues that valuations of demand for agricultural mechanization, conversely are subjugated by macroeconomic analyses which use data that capture regional and household level diversity in terms of mechanization use and demand but do not look at the impact on smallholder agriculture. However, new innovative agricultural mechanization is often approved slowly and several aspects of acceptance remain poorly unstated despite being seen as an important route out of poverty in most developing countries.

Besides improving production efficiency, mechanization encourages large-scale production and enhances the quality of farm produce from smallholder farmers. On the other hand, it can displace unskilled farm labour and cause environmental degradation (such as pollution, deforestation, and soil erosion), especially if applied short-sightedly rather than holistically (Jung, 2015). Therefore, this study is designed to determine factors that affect the use and the impact of agricultural mechanisation on smallholder productivity in Mquma Local Municipality in the Eastern Cape Province.

2. METHODOLOGY

2.1 Study area and population

The study was carried out in Mquma Local Municipality (MLM) in the Eastern Cape Province. Mquma Local Municipality is a Category B municipality located in the southeastern part of the Eastern Cape Province. It falls under the jurisdiction of the Amathole District Municipality and comprises an amalgamation of the former Butterworth, Ngqamakhwe, and Centane Transitional Regional Councils. The municipality shares borders with three other local municipalities, the Chris Hani District and the Indian Ocean. It is one of six municipalities in

the Amathole District. MLM is estimated to be 3 137km² and has a population of 246 813, 99% of which are isiXhosa speaking.

The remaining 1% of the population speaks English, Afrikaans, isiZulu, and seSotho. This municipal area comprises 53.4% women and 46.7% men of the total population and consists of approximately 69 732 households. Mquma is one of the municipalities in the Province where the majority of people live below the poverty line due rise in unemployment, a reduction in household incomes, and a decline in business profits, which generally plunged many people into poverty. The Mquma population has limited access to credit, are unable to finance their children's education, and use child support grant as a source of income.

The majority of households in the municipality rely on farming to sustain their livelihood. The main farming activities include crop, vegetable, livestock farming, and households practice farming only to support their families and only sell surpluses to generate farm income.

2.2 Sample size and sampling procedure

The targeted population for this study were smallholder farmers using agricultural mechanisation for improving their smallholder productivity and bridging the knowledge and skill gap about agriculture. The study made use of both qualitative and quantitative approaches to gather and analyze the data set. A descriptive research design survey was conducted, and data were collected using semi-structured questionnaires.

The study made use of stratified sampling to choose farmers who would participate in the research. The farmers were separated into the subsequent sections: irrigation operators and non-operators. Random sampling was used to attain 80% mechanization users and 20% non-mechanization users. Cochran's formula was used to determine the sample size (Cochran 1963).

$$n_0 = \frac{Z^2 pq}{e^2} \dots\dots\dots 1$$

Where

N₀ is the sample size

Z is the critical value of the confidence interval

p is the response distribution

q is $1-p$

e is the margin of error

A sample of smallholder farmers' using mechanization for agrarian purposes, representing 80% of the sample size (96), were randomly selected from the farmers who are using mechanisation for agrarian purposes and 20% of the sample size (24), were selected randomly from the usage of the non-mechanisation. The sample size comprised agricultural mechanization users and non-agricultural mechanization users, and this was essential for evaluating the effect of using mechanization to enhance farmers' productivity.

2.3 Data Collection

Primary data were generated through surveys. Following that, the researchers designed a semi-structured questionnaire, established from an evaluation of the literature. The semi-structured questionnaire was first pre-tested and was overseen with the help of skilled enumerators who speaks the local language (IsiXhosa) fluently. The final version of the survey was later overseen by the farmers' head and in the absence of the head, the oldest member of the farm was chosen. The information on the semi-structured questionnaire included farmers' demographic data, asset ownership, access to mechanisation, use of mechanisation for farming, the impact of using mechanisation for smallholder productivity and welfare, and problems encountered by smallholder farmers in accessing and using mechanisation in the farm. The farm survey was conducted from 20 June to 15 July 2019 in Mnquma in the Eastern Cape Province.

2.4 Data

This section represents demographic characteristics that were considered for the study, but the variables were selected based on the consultation of specialists and relevant personnel working in the study area and related issues. Table 1 shows data collected in the study.

Table 1. Description of variables used in the study

Variable	Description	Measurement
X ₁	Gender of the farmer	1= male, 0 = otherwise
X ₂	Age of the farmer	Actual years
X ₃	Marital status of the farmer	1= married, 0 = otherwise
X ₄	Family size of the farmer	1 = > 4, 0 = otherwise
X ₅	Years spent in school by the farmer	1= actual years spent in school, 0 = otherwise
X ₆	Household source of income by the farmer	1= social grants, 0 = otherwise
X ₇	Farming years by the farmer	Actual years of farming
X ₈	Distance to the agricultural marketing center	1= 10 km, 0 = otherwise
X ₉	Access to extension agents by the farmer	1= access to extension agents, 0 = otherwise
X ₁₀	Access to a financial institution by the farmer	1= access to finance, 0 = otherwise
X ₁₁	Member of farm organization	1= member of farm organization, 0 = otherwise
X ₁₂	Household monthly income	1=> 1500, 0 = otherwise
X ₁₃	Occupation by the household head	1= full time farmer, 0 = otherwise

2.5 Data Analysis

Data from questionnaires and individual interviews were coded and entered into the Statistical Package for Social Science (SPSS) version 24 and STATA 15. This section explores three types of analytical frameworks. Firstly, descriptive statistics like frequencies, percentages as well as mean values were calculated to summarize the farmers' profiles and characteristics in the study area. A logistic regression model was used to determine factors influencing the use of agricultural mechanisation by smallholder farmers, and Propensity Score Matching was used to measure the impact of agricultural mechanization on farmers' productivity.

2.5.1 Analytical Framework

This study investigates factors influencing mechanization in improving smallholder productivity in Mnquma Local Municipality, Eastern Cape Province, South Africa. Therefore, the Logistic regression model was used to analyze the factors influencing mechanisation in

enlightening smallholder productivity. The study used Logistic regression to observe the factors that have an influence on mechanization in enlightening smallholder productivity. Machethe (2016) revealed that the Logit coefficients can be interpreted as the effect of a unit of change in the independent variable on the predicted logits with the other variables in the model held constant.

The model as a direct probability model gives the likelihood of individuals giving a negative or positive response; that is, a yes or no answer. An additional benefit of the Logit model is its capacity to give legitimate estimates that are interpretable, regardless of study design. The word “logit” denotes the log-likelihoods which stipulates the likelihood of declining interest in 1 of 2 groups on the detailed elasticity of concentration (Wooldridge, 2009). Besides, Mdoda *et al.*, (2019) and Chauke *et al.* (2013) specified that the logistic regression dimension may be used to evaluate the likelihood relationship for autonomous variables in a model.

The logit model was used for this study because of the dichotomous nature of the dependent variable; meaning the respondents are categorised into using mechanisation and not using mechanisation in the farm. In this research, the use of mechanisation is referred to as farmers who have implemented and used mechanization to enhance smallholder productivity. The regression scrutiny is comprised of two distinct substitutes. This study custom a binomial logistic model given that the reliance on the variable is binary: 0 when a farmer did not use mechanisation on the farm and 1 when using mechanisation on the farm.

For this paper, the two choices are “using mechanization” or “not use mechanization”. A twofold regression was established to explain $Y=1$ for a state anywhere the farmer did use mechanization on the farm and $Y=0$ for states wherever the farmer did not use mechanization in the farm. Based on the assumption that X is a trajectory of eloquent variables and p is the likelihood that $Y=1$, dualistic probabilistic associations as quantified by Wooldridge (2009).

The logit model used was:

$$\ln \left\{ \frac{P}{1 - P} \right\} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \epsilon \dots \dots \dots 1$$

P = Probability of using mechanization in the farm

$1-P$ = odds of not using mechanization in the farm

β_0 = Intercepts

β_1 ----- β_8 = regression coefficient predictors

X_1 ----- X_8 = predictor variables

ϵ = random residual term

The odds (β_1 ... β_{10}) were interpreted as the proportion of using mechanization versus farmers not using mechanization. Similar ordinal logistic regressions were used to estimate the probability of using mechanization, as well as households attaining high productivity throughout the year.

Propensity Score Matching (PSM)

The Propensity score matching was utilized to examine the impact of mechanization being adopted on smallholder productivity. The PSM has been used extensively to evaluate the impacts of modern farm technological adoption on smallholder productivity (Kabunga, Dubois & Qaim, 2014). The model is specified as the restrictive likelihood that the smallholder adopts modern farm technology, given pre-embracing features. The real impression after equivalent is catching a group who are non-participants (farmers who do not adopt) and are comparable to ones who participate (farmers who adopt) in all applicable pre-treatment attributes. Thus, the first thing to do in the solicitation of the model is to guesstimate the anticipated likelihood that the farmer is adopting a given modern farm technology, otherwise referred to as the propensity score. The propensity score matching method poises the detected dispersal of covariance through the adopters and non-adopters group based upon observables. The propensity scores assessed by the logit model were applied to match non-adopters of modern farm technology to those that adopted these modern farm technologies. The PSM model is exemplified as follows:

$p(Z) =$

$Pr \{D = 1|Z\} E \{D|Z\}..... 1$

Where $D= \{0, 1\}$ represents an indicator for using mechanization while Z represents the vector of pre-mechanization qualities. Thus, the conditional distribution of Z , provided by $p(Z)$ is parallel in both users and non-mechanization groupings.

As soon as the propensity score is calculated, the average treatment effect (ATE) of the population, average the treatment effect on the treatment (ATT) as well as the average

treatment effect on untreated farmers (ATU) will be figured. The difference between the projected results after users and non-mechanization is known as the average treatment effect (ATE) of the population.

The population’s average treatment effect (ATE), can be expressed thus:

$$\tau_{ATE} = E(\tau) = E[Y(1) - Y(0)] \dots\dots\dots 2$$

The interest here is to determine the effect of the treatment on the treated (ATT) on-farm productivity. Likewise, as described by Caliendo & Kopeinig (2008), we are interested in the average treatment impacts of using mechanization on the untreated (ATU) farmers to understand the hypothetical impact of the technologies on the non-mechanization provided they had decided to use mechanization. The ATT is the distinction between the expected result either with or without treatment for farmers who took part in the treatment. The average treatment effect on the treated (ATT) may be estimated as shown in the following equation once the propensity score is calculated:

$$\tau_{ATT} = E(Y_{1i} - Y_{0i} | D_i = 1) = E[E\{(Y_{1i} - Y_{0i} | D_i = 1), p(Z_i)\}] \dots\dots\dots 3$$

$$= E[E\{Y_{1i} | D_i = 1, p(Z_i)\} - E\{Y_{0i} | D_0 = 0, p(Z_i)\} | D_i = 1]$$

Where Y_1 and Y_0 are the values generated from the outcome variable of interest for the farmers who use mechanization and the ones who do not respectively, while i refers to the farming households.

The essential assessment problem ascends because just one of the possible effects is observed for each i . The unobserved effect is referred to as the counterfactual effect: what impact the participants (treated units) would have had provided they didn’t participate. Therefore, assessing the treatment effect τ_{ATT} of the individual is not viable except in cases where the counterfactual effect problem is circumvented. It will be hard to observe how they would have accomplished if peradventure they had not used mechanization, but we perceive a corresponding impact for the group without treatment. Therefore, the untreated values’ effect (ones that do not use mechanization) aids the development of a counterfactual for the group that is treated, and the ATT is being estimated (Kebebe, 2015).

In this case, the ATT refers to the average influence of using mechanization (meaning; the adoption of improved yields, machinery, fertilizers, and pesticides) on smallholder productivity. The average treatment effects (ATT, ATE, and ATU) have been computed using Kernel's matching algorithm (Becerril & Abdulai, 2010). In estimating the average treatment effects, Kernel's matching statistically descends a subjective average effect of "neighbours" of the group who are non-mechanization and possess a propensity score that is near that of the group who use mechanization. The PSMATCH2 STATA was utilized to estimate the module treatment effects (Leuven & Sianesi, 2012).

3. RESULTS AND DISCUSSIONS

In this section, descriptive statistics of the variables and the estimation results of the Logistic regression and PSM are presented. The results cover the impact of agricultural mechanization on smallholder productivity in the study area.

3.1 Demographic characteristics of smallholder farmers

The demographic attributes of farming households play an important role in influencing the use of agricultural mechanization in their farms. The study results reveal that about 90% of the smallholder farmers in the study area are using mechanization for farming. The study result further reveals that most of the smallholder farmers in the Mnquma Local Municipality (MLM) were men, with a proportion of 58% while women were 42% of the population. The average age of the household head among both smallholder agriculture was 60 years for agricultural mechanization users and 61 years for non-agricultural mechanization, which means that agriculture in the study areas is dominated by elderly people.

The findings on the age of farmers are comparable with that of Bastian, Swanepoel & Van Niekerk (2019), Stats SA (2016) and AgriSA (2016) who report that the mean size of South African farmers is 62 years. The findings indicate that 58% of the farmers were married and had an average family size of 4 people per household. Family size plays a significant role in farming, and most farmers rely primarily on family labour for farming. The majority of the smallholder farmers spent 10 years in school, which specified that farmers had some basic education.

This means that farmers were literate and were able to analyse information and use innovative technologies for their farms (Mdoda & Obi, 2019). The study results show that the average farm size was 3 hectares with a farming experience of 11 years. These results are in line with Bastian et al. (2019) in their study of effective mechanization programs in the Western Cape District, which found that farmers had more than 10 years of farm experience.

Study results reveal that a majority of farmers (88%) were full-time farmers as they were deriving a livelihood from farming and were land owners were 94% of this population. The majority of the farmers (81%) approved that farming was their main source of income and they also reported that the social security grants they received from the government were another important source of income. The results reveal that farm income per month was R 4 400.00 and imply that the majority of farmers in MLM earn a very low income.

The majority (80%) of the farmers in the study area, had access to extension personnel and were members of farm organisation at 78%, which assisted them in adopting and using agricultural mechanization in their farms. Smallholder farmers specified that most of the agricultural mechanization they were using were farm implements, hoes, tractors, spreaders and irrigators, drought power, and sprayers in enhancing their smallholder productivity. Concerning ownership of agricultural implements, only 54% owned certain implements while other implements were hired.

3.2 Type of farm implements used by smallholder farmers

Figure 1 illustrates the use of farm implements by farmers to enhance agricultural productivity in the study area. The study reveals that the majority of farmers (84%) indicated that they used farm implements as part of agricultural mechanization in their farming enterprises to enhance agricultural output.

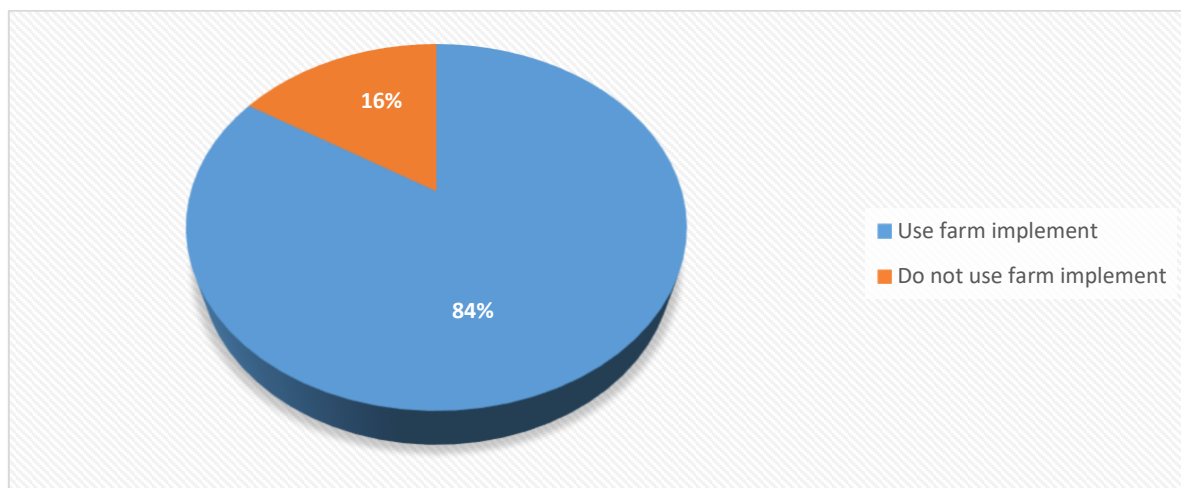


Figure 1. Use of farm implements by farmers

Farmers made use of different agricultural mechanization in their farms. Table 2, below, displays the different types of implements that were utilized by the farmers.

Table 2. Types of farm implements used by farmers

Agricultural implements	Percentage (%)
Tractor	82
Planter	73
Drought power	73
Sprayer	50
Feed blocker	71
Weeders	50
Spreader and irrigators	42
Hand tools	75

Table 2 shows the most used farm implements by smallholder farmers in the study area. From the results, tractor usage was the main implement used by farmers because a tractor is fast, accurate, and does not consume too much labour. Hand tools were the second most widely used agricultural mechanization because, according to farmers, they have always believed in hand tools since they started using them in their childhood when working in their home gardens and farming fields. Planter and drought power are other agricultural implements used because it makes it easier to plant using planter and drought power than using hands in planting and this

is fast and quick to finish as decreases human labour drudgery. Feed blocker is one of the improved agricultural mechanization used by livestock farmers. The least used farm implements were spreaders and irrigators as farmers prefer others due to the financial implications involved.

3.4 Benefits of using agricultural mechanization on the farm

Table 3 below displays the benefits of using agricultural mechanization by smallholder agriculture in MLM. The usage of agricultural mechanization has resulted in greater substantial in attaining optimum yields from different crops, which has been possible through the use of agricultural mechanization.

Table 3. Benefits of using agricultural mechanizations

Benefit	Percentage (%)
Enhanced agricultural production and productivity	90
Increased farm returns	78
Cropping intensity	80

These results are in line with Dagninet & Wolelaw (2016) who found that agricultural mechanization has enhanced agricultural production and productivity in smallholder farmers in Ethiopia. Agricultural mechanization has significantly aided the enhancement of the farming community in the overall economic upliftment. The usage of agricultural mechanization by smallholder farmers has produced an increase in farm returns than those with no agricultural mechanization usage. These results agree with Amare & Endalew (2016) that using mechanization lead to higher yield per hectare and higher gross income compared to non-mechanization farms. The use of agricultural mechanization has made an imperative contribution and improvement in cropping intensity. These results agree with Singh (2005) in his study in India that using agricultural mechanization does improve cropping intensity as the consistent affirmative relationship with mechanization.

3.5 Challenges faced by smallholder farmers

A large number of farmers specified that the unavailability of mechanization centres nearby is the main problem that affects their accessibility and usage of agricultural mechanization in

their farms, thus significantly affecting the productivity of the farmers. Table 4 shows challenges encountered by farmers in using agricultural mechanization.

Table 4. Challenges faced by smallholder farmers

Challenge faced	Percentage (%)
Unavailability of agricultural mechanization centres	66
Financial constraints	62
Knowledge	55

Several farmers indicated that financial constraints are another main challenge they face in terms of expanding their enterprises. Inputs, infrastructure, and the high costs of buying or even hiring implements was primarily an obstacle to developing and farming sustainably. Knowledge is the biggest challenge faced by farmers and as a result, is adversely affecting farm productivity. The study results reveal that farmers lack knowledge, which affects the awareness of farmers about agricultural mechanization used to enhance agricultural output. This is the challenge because farming is all about using agricultural mechanization for better enhancement of productivity, and the lack of knowledge and awareness by farmers, negatively affects farmers' productivity and well-being.

3.6 Estimating factors influencing usage of agricultural mechanization

Agricultural mechanization is an essential component of agricultural development. The study used Logit regression to determine the factors influencing agricultural mechanization use in enhancing smallholder productivity in the study area. The use of agricultural mechanization was a binary variable, where 0 denotes farmers who use agricultural mechanization in their farms and 1 if farmers do not use agricultural mechanization in their farms. Table 5 illustrates the estimation outcomes from the Logit regression and model fit is also explained. The principal one is the pseudo-R squared and the second one is the Likelihood ratio Chi-square which is a valuation of how well the model ordered defendants appropriately built on assessed likelihoods. The likelihood ratio of Chi-square of 197.006 with a p-value of 0.0000 expresses that our model is statistically substantial. The R^2 is 70% and the adjusted R^2 is 68% recommends a good-fit (Table 5).

Table 5. Factors influencing the use of agricultural mechanization

Variable	Coefficient	Standard Error	P>z	Marginal effect
Age	-0.082	0.093	0.001****	0.1420
Years spent in School	0.428	0.741	0.009****	0.1232
Distance to agricultural market center	-0.628	0.950	0.037**	0.2126
Farm income	0.346	0.563	0.013**	0.2410
Access to extension services	0.569	0.841	0.006****	0.1745
Membership of farm organization	0.346	0.726	0.013**	0.1913
Farm experience	-0.630	0.971	0.003****	0.1809
Farm size	0.852	0.364	0.015**	0.1568
Constant	0.045	0.085	1.968	0.1987
Number of observers = 120 F (10, 79) = 60.33 Prob > Chi-Square = 0.001				
R-squared = 0.70 Adjusted R-squared = 0.68				

Note: ** and ** represents significant levels of 5% and 1%.**

Table 5 displays factors influencing the use of agricultural mechanization by smallholder farmers in the study area. Farmers' age was found to have a negative relationship with the use of agricultural mechanization and was statistically significant at the 1% level. This suggests that a unit increase of 1 additional year in farmers' age, will induce a decrease in the use of agricultural mechanization. This implies the older the farmer, the more a farmer is risk-averse and fearful than younger farmers who are risk preferers. The estimated marginal effect of this variable indicates that the probability of using agricultural mechanization increases by 14% if a farmer is younger (reduces by 14% if a farmer is older). These findings are consistent with As-Sunny, Huang & Karimanzira (2018) and Ghimire & Huang (2016) who established that older people will be fearful and less welcoming to the use of agricultural mechanization in their farms as compared to younger farmers.

Moreover, more attention is required to be given to the service providers to increase the older farmers' response towards agricultural mechanization usage. Farm income has a positive coefficient and is statistically significant at a 5% level. This implies that a unit increase of R1

in farm income will induce an increase in the use of agricultural mechanization. This suggests the higher the farm income, the more farmers are adopting and using agricultural mechanization by smallholder farmers to enhance farm productivity. The estimated marginal effect of this variable indicates that the probability of using agricultural mechanization increases by 24% if a farmer has a higher farm income. These results agree with the findings of As-Sunny *et al.* (2018) which specify that the greater the farm income, the more usage of agricultural mechanization by smallholder farmers.

The variable of years spent in school has a positive coefficient with agricultural mechanization usage and was statistically significant at a 5% level. These results depict the positive relationship between years spent in school and the use of agricultural mechanization. This suggests that a unit increase of 1 additional year in school will induce an increase in the use of agricultural mechanization. This implies that usage of agricultural mechanization by farmers, increases when the farmer has at least a primary education, which is the case in this study to enhance farm productivity. The estimated marginal effect of this variable indicates that the probability of using agricultural mechanization increases by 12% if a farmer has at least primary education. These results agree with Dhraief *et al.* (2018) findings which state that years spent in school positively influenced the adoption and use of innovative technology by smallholder farmers in Tunisia.

Farming experience has a negative coefficient and was statistically significant at the 1% level. The results of the study reveal that a unit increase of 1 additional year in farm experience led to a decrease in the use of agricultural mechanization. These results suggest that the more experienced a farmer is, the less likely to adopt and use agricultural mechanization on the farm to enhance farm productivity. Thus, states that farmers with more years of experience in our study areas are more likely to stick with the original methods that are familiar to them than using agricultural mechanization. The marginal effects of farming experience deciphered to the probability of using agricultural mechanization decreases by 18%. These results are in line with Lydia *et al.* (2017) who established that the more experienced the farmer is, the less likely to use and adopt agricultural technology in Uganda Potato farmers.

Farm size was found to be positive and statistically significant at a 5% level. This implies that a unit increase of 1 additional hectare of farm size will induce an increase in the usage of

agricultural mechanization. The result signposted that farmers owning a larger proportion of farm size are more likely to use agricultural mechanization in their farms to enhance farm productivity. The marginal effects of farm size deciphered to the probability of using agricultural mechanization increases by 16%. These results are in line with Takele & Selassie (2018) that the greater the farm size, the more farmers adopt and use agricultural mechanization in their farms in Ethiopia.

Distance to the agricultural market centre had a negative coefficient and was statistically significant at a 5% level. This suggests that a component rise of 1 km in distance travelled by farmers to agricultural market centres will decrease the use of agricultural mechanization. This suggests that the longer the distance travelled to market centres to get agricultural mechanization, the lower the use of agricultural mechanization by farmers to enhance productivity instead opt for traditional methods. The marginal effects of distance to the agricultural market centre deciphered to the probability of using agricultural mechanization increases by 13%.

The extension services were also found to be statistically significant at 1% and positively correlated with the use of agricultural mechanization. This implies that a unit increase of 1% in access to extension services will induce an increase in the use of agricultural mechanization. This result designates that the more access to extension services by farmers, the more use of agricultural mechanization to enhance farm productivity. The marginal effects of access to extension services translated to the probability of using agricultural mechanization increase by 17%. Membership in farm organisations was statistically significant at 5% and had a positive coefficient with the use of agricultural mechanization. This implies that an increase of 1% in being a member of a farm organization will induce an increase in the use of agricultural mechanization. This suggests that the use of agricultural mechanization increases when the farmer is a member of a farm organization. In this way, this form of farm organization assists farmers with information about innovative and modern technologies, which will improve their farm productivity. The marginal effects of farm organization membership decoded to the probability of using agricultural mechanization increases by 19%. These results agree with Dhraief et al. (2018) findings, which state that being a member of a farm organization influences the adoption and use of innovative technology positively by smallholder farmers in Tunisia.

3.7 The Effect of agricultural mechanization on smallholder productivity and farm returns

The nearest neighbour and Kernel corresponding methods were used to assess the effect of agricultural mechanization usage on smallholder productivity and farm returns. Table 6 displays outcomes from the PSM model that was measured for evaluation observances with the action magnitude model results. Two identical examiners, the nearest neighbour, and the Kernel-constructed corresponding algorithms were active as robustness checks.

Table 6. PSM to measure the impact of agricultural mechanization

Matching Method	Farm Returns (R/Ha)				
	Treatment	Control	ATT	Standard Error	P>z
Nearest neighbor	2044.01	522.12	1354.13	128.14	0.015***
Kernel matching	1977.67	543.41	1347.30	206.13	0.008***
Matching Method	Farm Yields (KG/Ha)				
	Treatment	Control	ATT	Standard Error	T-Test
Nearest neighbor	21356.30	632.12	1879.16	124.14	0.020**
Kernel matching	20963.72	653.41	1795.23	206.13	0.003***

Notes: * and ** and * means significant levels at 1% and 5% respectively**

The corresponding consequences specify that using agricultural mechanization has a profitable sizeable upshot on the smallholder farmers' well-being. Smallholder farmer's farm returns were established to be between R1 354 and R1 347 more than the non-agricultural mechanization users based on the corresponding technique approved. The teamwork from the nearest neighbour and Kernel matching methods point to the fact that using agricultural mechanization has an extensive effect on farm revenue. These results were in line with Christian & Mdoda (2019) findings, which established that smallholder farmers' participation in irrigation farming

has increased their farm revenues in Qabakhwe in the Eastern Cape. Both matches specify that using agricultural mechanization by smallholder farmers bears fruit and a prominent increase in farm returns as productivity increases, as excessive production and larger revenues for farmers.

As presented in Table 6, the adoption and use of innovative farm technology such as agricultural mechanization is positive and significantly increases smallholder productivity. These results agree with Khonje, Manda, Alene & Kassie (2015) that the adoption of modern agricultural technology and innovative mechanization enhances farm productivity. The estimates for the average farm productivity earned enhanced from smallholder farmers having adopted modern farm technology assortments to be between 1896 Kg/Ha and 1795 Kg/Ha, depending on the matching method used.

All estimates were statistically significantly different from zero at 1% to 5% critical level. The results show that the increase in the use of agricultural mechanization by farmers rises the productivity of the farmers that use innovative technology on their farms. The adoption of modern farm technology was found to be statistically significant at 1% with a coefficient of 1796 Kg/Ha using the Kernel Matching Method. This advocates that advances in the use of agricultural mechanization will result in increased farm productivity for farmers who use innovative technology, prominent to sophisticated productivity and returns as agricultural mechanization are imperious in transforming smallholder farmers as well as enhancing their consumption expenditure and welfare improvement.

4. CONCLUSION

The study was investigating the impact of agricultural mechanization on smallholder agricultural production in Mquma Local Municipality in the Eastern Cape Province of South Africa. The study results reveal that about 90% of the smallholder farmers in the study area are using mechanization for farming. The study results reveal that smallholder farmers in the Province are male-headed farmers with an average age of 61 years and a family size of four people in a household. The majority of the farmers were married which assisted in the provision of family labour and spent 10 years in school which played an imperative role in assisting farmers in understanding the innovative technologies to be used in farming. The majority of

the farmers are using agricultural mechanization for farming such as tools, implements, farm machinery, sprayers, irrigators, and hoes.

The usage of agricultural mechanization has led to improvement in smallholder productivity, farm returns, and crop intensity among those farmers who adopted and used agricultural mechanization. Smallholder agriculture in MLM indicated that distance to agricultural market centres, finance, and knowledge are the main challenges faced by smallholder farmers in accessing and using agricultural mechanization. The empirical results show that socio-economic and institutional factors are impeding factors influencing the use of agricultural mechanization by smallholder agriculture.

The study concludes that agricultural mechanization has a dual extensive impact on smallholder agricultural production. The econometric outcomes show that the investment in agricultural mechanization by smallholder agriculture enhances farm productivity and farm returns. Socio-economic and institutional factors influence the use of agricultural mechanization in the study area. The study recommends that policymakers; government (National Department of Agriculture, Land Reform, and Agrarian) must reassure proper distribution of agricultural mechanization to farmers.

The study further recommends that public extension agents and NGOs must embark on farmer field schools where they provide education training to smallholder farmers about agricultural inputs, marketing, technology adoption, and transfer as an approach to improve agricultural output and farm returns. There are prospects for private sector involvement to fill gaps in input supply and education awareness about the adoption of modern farm technologies by smallholder farmers.

REFERENCES

- ADAM, S. A. S. & HASSAN, T.A., 2015. Socio-economic factors influencing small-scale farmer's livelihoods and food security in central Darfur state – Sudan. *International Journal of Cur. Res. Lif. Sci.*, 4 (11): 464-468.
- AGRISA., 2015. Youth in Agriculture. Available from: <https://mg.co.za/article/2015-06-18-the-youth-are-agricultures-future>.

- AMARE, D. & ENDALEW, W., 2016. Agricultural Mechanization: Assessment of Mechanization Impact Experiences on the Rural Population and the Implications for Ethiopian Smallholders. *Eng. App. Sci.*, 1 (2): 39-48. Available from: 10.11648/j.eas.20160102.15
- AS-SUNNY, F., HUANG, Z. & KARIMANZIRA, T. T. P., 2018. Investigating Key Factors Influencing Farming Decisions Based on Soil Testing and Fertilizer Recommendation Facilities (STFRF)—A Case Study on Rural Bangladesh. *Sus.*, 10: 4331
- AYANDIJI, A. & OLOFINSAO, O. T., 2015. Socio-Economic Factors affecting Adoption of Farm Mechanization by Cassava Farmers in Ondo State, Nigeria. *IOSR J. Env. Sci. Tox. Foo. Tech.*, 9 (3): 39-45.
- BASTIAN, R. M., SWANEPOEL, J. W. & VAN NIEKERK, J. A., 2019. Effectiveness of the implementation of the mechanization program for emerging farmers in the Overberg and Eden Districts of the Western Cape. *S. Afr. J. Agric. Ext.*, 47 (2): 58 – 71. Available from: <http://dx.doi.org/10.17159/2413-3221/2019/v47n2a503>
- BAUDRON, F., MISIKO, M., GETNET, B., NAZARE, R., SARIAH, J. & KAUMBUTHO, P., 2019. A farm-level assessment of labor and mechanization in Eastern and Southern Africa. *Agr. Sus. Dev.*, 39: 17. Available from: <https://doi.org/10.1007/s13593-019-0563-5>.
- BAIPHETHI, M. N., 2009. The contribution of subsistence farming to food security in South Africa. *Agr. J. SA*, 48 (4): 22-423.
- BECERRIL, J. & ABDULAI, A., 2010. The impact of improved maize varieties on poverty in Mexico: a propensity score matching approach. *Wor. Dev.*, 38: 1024-1035.
- CALIENDO, M. & KOPEINIG, S., 2008. Some practical guidance for the implementation of propensity score matching. *J. Econ. Sur.*, 22, 31-72.
- CHAUKE, P. K., MOTLHATLANA, M. L., PFUMAYARAMBA, T. K. & ANIM, F. D. K., 2013. Factors influencing access to credit: A case study of smallholder farmers in the Capricorn district of South Africa. *Afri. J. Agr. Res.*, 8 (7): 582-585.
- CHRISTIAN, M. & MDODA, L., 2019. Household Food Security, Dietary Diversity and Coping Strategies amongst Irrigators in Nqamakwe, Eastern Cape. *J Hum Ecol*, 68 (1-3): 78-88. Available from:10.31901/24566608.2019/68.1-3.3169.
- COCHRAN, W. G., 1963. Sampling Techniques, 2nd Ed., New York: John Wiley and Sons,

Inc.

- COSSAR, F., 2019. Impact of mechanization on smallholder agricultural production: evidence from Ghana. Contributed Paper prepared for presentation at the 93rd Annual Conference of the Agricultural Economics Society, University of Warwick, England 15 – 17 April 2019.
- DAGNINET, A. & WOLELAW, E., 2016. Agricultural Mechanization: Assessment of Mechanization Impact Experiences on the Rural Population and the Implications for Ethiopian Smallholders. *Engineering and Applied Sciences*, 1 (2): 39-48.
- DE GROOTE, H., MARANGU, C. & GITONGA, Z. M., 2018. Trends in Agricultural Mechanization in Kenya's Maize Production Areas from 1992-2012. *Agr. Mec. Asi., Afr. Lat. Ame.*, 49 (4): 2010–2013.
- DEPARTMENT OF AGRICULTURE, FORESTRY, & FISHERIES (DAFF), 2016. Economic Review of the South African Agriculture 2016/17.
- DHRAIEFA, M. Z., BEDHIAF-ROMDHANIA, S., DHEHIBIB, B., OUESLATI-ZLAOUIA, M., JEBALIA, O. & BEN YOUSSEFA, S., 2018. Factors Affecting the Adoption of Innovative Technologies by Livestock Farmers in Arid Area of Tunisia. *FARA Research Report*, 3 (5): 22.
- EKEPU, D. & TIRIVANHU, P., 2016. Assessing socio-economic factors influencing adoption of legume-based multiple cropping systems among smallholder sorghum farmers in Soroti, Uganda. *S. Afr. J. Agric. Ext.*, 44 (2): 195 –215. Available from: <http://dx.doi.org/10.17159/2413-3221/2016/v44n2a421>
- FOOD & AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS (FAO). 2019. fao.org/sustainable-agricultural-mechanization/overview/why-mechanization-isimportant/en.
- FOOD & AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS (FAO), 2016. Sustainable Food and Agriculture: The role of mechanization in agricultural sustainability. Available on: <https://www.fao.org/sustainability/news/detail/en/c/460221/>
- FOOD & AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS (FAO), 2009. Agricultural Services Bulletin 45 – Rome. Agricultural Mechanization in Development - Guidelines for Strategy Development - by R.C. Gifford and the staff of AGSE.

- GHIMIRE, R. & HUANG, W., 2016. Adoption Pattern and Welfare Impact of Agricultural Technology: Empirical Evidence from Rice Farmers in Nepal. *J. Sou. Asi. Dev.*, 11(1): 113–137. Available from: 10.1177/0973174116629254
- IFAD AND UNEP. 2013. Smallholders, food security, and the environment, Via Paolo di Dono, 44 - 00142 Rome, Italy.
- KABUNGA, N. S., DUBOIS, T. & QAIM, M., 2014. Impact of tissue culture banana technology on farm household income and food security in Kenya. *Foo. Pol.*, 45: 25-34.
- KEBEBE. E. G., 2015. Understanding factors affecting technology adoption in smallholder livestock production systems in Ethiopia. Published Ph.D. Thesis, Wageningen University, Netherlands.
- KHONJE, M., MANDA, J., ALENE, A. D. AND KASSIE, M., 2015. Analysis of Adoption and Impacts of Improved Maize Varieties in Eastern Zambia. *Wor. Dev.*, 66: 695–706.
- LEUVEN, E. & SIANESI, B. 2012. PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing. Statistical Software Components.
- LYDIA, N. N., BJORN, V. C. & DAVID, A., 2017. Stimulating Agricultural Technology Adoption: Lessons from Fertilizer Use among Ugandan Potato Farmers, IFPRI Discussion Paper 1608, International Food Policy Research Institute (IFPRI): Washington, DC, USA: 36.
- MACHETHE, T. A., 2016. Economic and marketing analysis of smallholder broiler production in Mopani District of Limpopo Province, South Africa. Published MSc Dissertation, University of Limpopo, RSA.
- MDODA, L. & OBI, A., 2019. Analysis of profitability of smallholder Irrigated food plots in the Eastern Cape Province of South Africa. *J. Agr. Rur. Dev.*, 3 (53): 225–232. Available from: <http://dx.doi.org/10.17306/J>
- MDODA, L., MELENI, S., MUJURU, N. & ALAKA, K. O., 2019. Agricultural Credit Effects on Smallholder Crop Farmers Input Utilisation in the Eastern Cape Province, South Africa. *J. Hum. Eco.*, 66 (1-3): 45-55. Available from: 10.31901/24566608.2019.

- MOTTALEB, K. A., KRUPNIK, T. J. & ERENSTEIN, O., 2016. Factors associated with small-scale agricultural machinery adoption in Bangladesh: Census findings. *J. Rur. Stu.*, 46: 155-168.
- MREMA G., SONI P. & ROLLE R. S., 2014. A regional strategy for sustainable agricultural mechanization: sustainable mechanization across agri-food chains in Asia and the Pacific region. Bangkok: FAO.
- MWANGI, M. & KARIUKI, S., 2015. Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries. *J. Eco. Sus. Dev.*, 6 (5).
- MUSUNGWINI, S., 2018. Mobile phone use by Zimbabwean smallholder farmers: A baseline study. *The Afr. J. Inf. Com.*, 22: 29-52. Available from: <https://doi.org/10.23962/10539/26171>
- STATISTICS SOUTH AFRICA (STATS SA)., 2016. Community Survey of Agricultural Farming Households. Available on: <http://www.statssa.gov.za/?s=community+survey+2016+agricultural+households&item=publications>
- SCHMITZ, A. & MOSS, C. B., 2015. Mechanized agriculture: machine adoption, farm size, and labor displacement. *AgBioForum*, 18(3): 278–96.
- SINGH, J., 2005. Scope, progress and constraints of farm mechanization in India. Status of farm mechanization in India. 48-56.
- SRISOMPUN, O., ATHIPANYAKUL, T. & ISVILANONDA, S., 2019. The adoption of mechanization, labour productivity and household income: Evidence from rice production in Thailand. TVSEP Working Paper, No. WP-016, Leibniz Universität Hannover, Thailand Vietnam Socio Economic Panel (TVSEP), Hannover.
- TEGEGNE, Y., 2017. Factors affecting adoption of legume technology and its impact on the income of farmers: the case of Sinana and Ginir Woredas of Bale Zone. Published MSc. Thesis, Haramaya University, Haramaya.
- TAKELE, A. & SELASSIE, Y. G., 2018. Socio-economic analysis of conditions for the adoption of tractor hiring services among smallholder farmers, North-western Ethiopia. *Cog. Foo. Agri.*, 4(1): 145-978. Available from: <https://doi.org/10.1080/23311932.2018.1453978>

WOOLDRIDGE, J. M., 2009. *Introductory Econometrics, a Modern Approach*, Fourth Edition.
Michigan State University.