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Adoption of Agricultural Conservation Technologies (ACTs) in Manzini Region of Eswatini

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ABSTRACT

Background and Objective: In spite of efforts to achieve self-sufficiency in food production, poverty reduction and improved livelihood outcomes of farm families, the adoption and utilization of agricultural conservation technologies by these households are overdue. The determinants of the adoption of agricultural conservation technologies in the Manzini Region of Eswatini were evaluated in this study. **Materials and Methods:** Primary data was obtained using a well-structured questionnaire from one hundred and twenty farmers. The data was analyzed using descriptive statistical techniques and the Tobit regression model. **Results:** Findings showed that majorities (65.83%) of the respondents were female, 50.83% had secondary education qualifications and 21.67% had primary education. Most (92.50%) of the respondents were introduced to intercropping and only 56.67% adopted it, 40.83% adopted mulching and few of the respondents adopted gully construction, plantation on degraded land and hedge establishment. Agricultural information was mainly obtained from the media. The major constraints to the adoption of agricultural conservation technologies were low yield, lack of technical know-how, shortage of land for farming, insufficient finance for farm operations, lack of capital, lack of motivation by extension agents, high cost of capital and low level of income. Also, household size, farm size, farm experience, shared experience among the farmers, financial access and training of new technologies significantly influence ACTs. **Conclusion:** Farmers with larger households were less likely to adopt ACTs but there is a higher chance of adoption when there is adequate training, an increase in the number of extension agents and a review of land reforms.

KEYWORDS

Adoption, conservation, environment, intercropping, livestock, technologies

INTRODUCTION

Like some other Southern African countries, agriculture is the backbone of Eswatini's economy. Agriculture employs this rural population and forms the basic instrument for achieving food security, reducing poverty and sustainable development. But as the population increases, the demand for food continually increases putting pressure on farmers as result in their turn depleting the soil structure, composition and natural biodiversity in trying to keep up with the increasing demand for food.

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It is therefore imperative to consider improving means of achieving sustainable food production. Agricultural conservation technology adoption is one of the ways out of poverty and food insecurity for smallholder farmers. Mwangi and Kariuki[1] argued that adoption of agricultural technologies could lead to improvement in the production of food and fiber. These technologies are critical to enhancing productivity which is relatively low in most Sub-Sahara African countries. Scaling over the challenges emanating from unpredicted weather conditions, soil nutrient depletion and soil or land degradation suggest the adoption of agricultural conservation technologies.

Agricultural conservation technologies are gaining acceptance in many parts of the world, even in Eswatini as an alternative to both conventional agriculture and organic agriculture. Conservation agriculture is not a new agricultural production method in Southern Africa, it has been seen to encourage minimal soil disturbance through tillage, management of residues and waste and optimum utilization of chemical inputs[2,3]. This invariably reduces the rate at which land and water are polluted, soil erosion, prolonged dependence on external inputs and reduction of greenhouse gas emissions. Also, it enhances better management of the environment and improvement of both water quality and efficiency[4-6].

Agricultural conservation technologies provide direct benefits to environmental issues of global importance. It also allows nature to regenerate and retain soil structure thus improving water and nutrients available to plants and reducing soil erosion[7]. Despite the proven economic and environmental benefits of CA, its adoption is still recorded to be low[8]. The promotion of CA has continued to witness setbacks as many controversies geared against it in the smallholder farming systems, especially in Sub-Sahara Africa. The introduction of CA gives an insightful change in farm management. It may result in reducing the washing away of topsoil through erosion and enhancement of stable agricultural production. For many factors, all of the CA principles are not always fully implemented by farmers and results are not as favorable as expected[9].

With the challenges associated with climate change, there is a greater risk of agricultural businesses running at a loss. Though crop growth is expected, the reality of the expected growth becomes thinner as drought impacts water availability for use, crops and livestock production. The erratic climate pattern endangers agricultural planning activities in most parts of the country and poses challenges to productivity. The need to increase the adoption of CA technologies to meet the food demand of the populace is thereby required. However, this study studied the determinants of the adoption of the CA in the Manzini Region of Eswatini.

MATERIALS AND METHODS

Study area: The study was conducted in the Manzini Region of the Kingdom of Eswatini between the 2018 to 2019 production cycles. It is in the center-west of the country. It has an area of 4,093.59 km^2 and a population of 319,530. The Kingdom of Eswatini is made up of six agroecological zones. The study was conducted on the two ecological zones of the Manzini Region which are the upper middleveld and lower middleveld. The upper middleveld occupies 33% land area, 600-800 m and 18°C. The lower middleveld covers 14% land area, altitude of 400-600 m and rainfall of 700-850 mm and 21°C. The middleveld covers 65-85% of the farm with grass strips. The Manzini Region is a good climatic region for maize production.

Research protocol: The population of the study was all the farmers in the Manzini Region of Eswatini. The study was carried out in multiple stages. In the first stage, 5 constituencies were selected randomly from the 16 constituencies in the study area. The second stage involved the selection of 4 chiefdoms each from of the selected constituencies (making 20 chiefdoms). Lastly, six farmers from each chiefdom were randomly selected and this gives a sample size of one hundred and twenty farmers. Data were collected through the used structured questionnaire and interview schedule. Descriptive statistics and the Tobit regression model were used to analyze the data.

Tobit regression model: The Tobit regression model was used to estimate the determinants of the adoption of conservation agriculture in the study area. The model uses Maximum Likelihood Estimate (MLE) to estimate the vector of coefficients. The standard Tobit regression model is defined as:

$$y_i^* = x_i\beta+\varepsilon_i \quad (1)$$

$$y_i = y_i^* \text{ if } y_i>0 \quad (2)$$

$$y_i = 0 \text{ if } y_i\leq 0 \quad (3)$$

where, y_i is the latent dependent variable, y_i is the observed dependent variable, x_i is the vector of the independent variables, β is the vector of coefficients and the ε_i 's are assumed to be to be independently normally distributed: εi~N (0, σ^2) and therefore (y_i~N ($x_i\beta$, σ^2)).

The functional form of Tobit regression could be expressed in the linear combination of observable explanatory variables as:

$$y_i^* = x_i\beta+\varepsilon_i \quad (4)$$

This can be represented algebraically for the i^{th} adopters of ACTs:

$$Y_i = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8+\varepsilon_i \quad (5)$$

Where, y_i is the dependent variable (adoption rate), x_i are the explanatory variables i.e. Age (X_1), Sex (X_2), Married (X_3), Years of schooling (X_4), Household size (X_5), Farming experience (X_6), Farm size (X_7) and Membership of organization (X_8).

RESULTS AND DISCUSSION

Table 1 showed that 31.67% of the respondents' ages were between 51-60 years and 13.33% were below 40 years. The mean age of the respondents was 47.2, this implied the involvement of young farmers who were active and at their productive age. Younger farmers are known to adopt new technologies that will increase productivity and enhance the generation of more income. The result corroborated with the findings of Owombo and Idumah[10], they found out that about 50% of the farmers are not more than 50 years on average. The table also reveals that the majority (65.83%) of farmers were female while 34.17% were male. The findings implied that the majority of the farm activities are performed by women. The result opposed the finding of Nkonki-Mandleni *et al.*[11]. About 53% were married, 24.17% of the respondents were single and 17.50% of them were widowers. This implied that the majority of respondents were married and who tend to be more responsible and emotionally stable.

Also, the level of education of the respondents was presented in the table and it showed that about 51% of the respondents have a secondary school education, 21.67% have gone up to primary level and 7.50% have tertiary education. From the result, it could be deduced that most of the respondents had formal education. The table also showed that the respondents with a household size of not more than 5 were 41.67% and those that had a household size above 10 were 12.50%. The mean household size was 6.9, an indication that most of the respondents had a large household size. The larger-sized family could provide the required labor for implementing and maintaining conservation practices.

Furthermore, education is an important driver of the adoption of new technology. It is always difficult for farmers with less or no education to adopt a new innovation. This study revealed that about 68% of the respondents had between 6-10 years of farming experience and of those that have not more than 5 years

Table 1: Distribution of respondents' socioeconomic characteristics

Characteristics	Frequency	Percentage	Mean
Age (years)			
≤30	16	13.33	47.2
31-40	27	22.50	
41-50	28	23.33	
51-60	38	31.67	
Above 60	11	9.17	
Total	120	100.00	
Sex			
Male	41	34.17	
Female	79	65.83	
Total	120	100.00	
Marital status			
Single	29	24.17	
Married	64	53.33	
Divorced	6	5.00	
Widower/widow	21	17.50	
Total	120	100.00	
Education			
Non formal education	22	18.33	
Primary education	26	21.67	
Secondary education	61	50.83	
Tertiary education	9	7.50	
Loyal	2	1.67	
Total	120	100.00	
Household size			
<=5	50	41.67	6.9
6-10	55	45.83	
Above 10	15	12.50	
Total	120	100.00	
Farming experience (Years)			
≤5	2	1.67	13.07
6-15	83	69.17	
16-25	29	24.17	
Total	120	100.00	
Farm size (hectares)			
<=5	113	94.17	2.57
>5-10	7	5.83	
Total	120	100.00	

Source: Field Survey, 2019

of farming experience 1.67% and 5% had between 25 and 30 years of farming experience. The average years of farming experience of 13.07 years imply that they were more conversant with farming techniques, having a higher number of farming experiences years could help in the decision to adopt or disadopt ACTs. And lastly, 94.17% of the respondents have a farm size of less or equal to 5 hectares, while 5.83% have a farm size of between 5-10 hectares. The mean farm size of the respondents was 2.57 hectares.

Awareness and adoption of conservation agricultural technologies: The result presented in Table 2 showed that the number of respondents that were aware of agricultural conservation technologies is less than those that adopted them. There were 89.17% of the respondents were introduced to mulching, 40.83% of the respondents adopted mulching. The 86.67% were introduced to cover cropping and 33.33% adopted cover cropping. In crop rotation 92.50% of respondents have been introduced and 37.50% adopted. The 27.50% were introduced in minimal or no tillage while 14.17% adopted. Moreover, in inter-cropping, 92.50% were enclosed and 56.67% did not take in inter-cropping, to no bush burning 60.83% of the respondents were prefaced and 2.50% swept up. Of those that were engaged in terrace improvement, there were 4.17% and 42.50% that dramatize it. Moving on to contour farming 45.83% of the respondents were preceded to it and 20.83% embraced it. The 53.33% were ushered in hedge

Table 2: Distribution of respondents based on conservation technologies awareness and adoption

Types of agricultural conservation technology	Awareness		Adoption	
	Yes	No	Yes	No
Mulching	107 (89.17)	13 (10.83)	49 (40.83)	71 (59.17)
Crop rotation	104 (86.67)	16 (13.33)	40 (33.33)	80 (66.77)
Cover cropping	111 (92.50)	9 (7.50)	45 (37.50)	75 (62.50)
Minimum\no tillage	33 (27.50)	87 (72.50)	17 (14.17)	103 (85.83)
Intercropping	111 (92.50)	9 (7.50)	68 (56.67)	52 (43.33)
No-bush burning	73 (60.83)	47 (39.17)	3 (2.50)	117 (97.50)
Terrace farming	5 (4.17)	115 (95.83)	51 (42.50)	69 (57.50)
Contour farming	55 (45.83)	65 (54.17)	25 (20.83)	95 (79.17)
Hedge establishment	64 (53.33)	56 (46.67)	21 (17.50)	99 (82.50)
Check dams	47 (39.17)	73 (60.83)	23 (19.17)	97 (80.83)
Gull construction	11 (9.17)	109 (90.83)	7 (5.83)	113 (94.17)
Trail improvement	67 (55.83)	53 (44.17)	26 (21.67)	94 (78.33)
Planting on degraded land	18(15.00)	102 (85.00)	13 (10.83)	107 (89.17)
Improved fallow	102 (85.00)	18 (15.00)	52 (43.33)	68 (56.67)

Source: Field Survey, 2019 Percentage in parenthesis

establishment and 17.50 took it in. The 39.17% were inaugurated to check dams and 19.17% of them dramatized it. The 9.17% has been introduced to gully control 5.83% adopted. Trail improvements there were 55.83% of the respondents prefaced it and 21.67% took it up. Planted on degraded land there were 15% were introduced to it and 10.83% were adopted. 85% of all of them were aware of the improved following but only 43.33% embraced it.

Mulching, intercropping, terrace farming and improved fallow have been adopted by most of the respondents. This indicated that these agricultural conservation technologies were the most popular among these respondents based on the percentage of respondents. Cover cropping, crop rotation and trail improvement also have high percentages of respondents involved in them with 33.33%, 37.50% and 21.67%, respectively and this implied that they were also popular with the respondent. Minimal or zero tillage, no bush burning, contour farming, hedge establishment, check dams, gull control and planting on degraded land is less popular. The low percentage of the adoption of some of these conservation technologies may be due to a lack of finance in its adaptation and it may be due to a lack of technical know-how.

Moreover, looking at the more numbers of farmers that are aware of each of the agricultural conservation technologies compared to those that had actually adopted them, this work contradicted the work of Owombo and Idumah[10] on their work titled "Determinants of land conservation technologies adoption among arable crop farmers in Nigeria: A multinomial logit approach" where the number of adopters was higher than those that were aware of the conservation agriculture technology. The findings implied that more need to be done to educate farmers in agricultural conservation technologies until a larger percentage adopts them.

Usage of the adopted conservation agriculture technologies: Table 3 showed that 15.83% of the respondents use mulching some of the time and 83.33% of the respondent use mulching all the time, 22.50% of the respondent practice cover cropping some of the time and 77.50% of the respondents practice cover cropping all the time, 46.67% of the respondents adhere to crop rotation some of the time and 53.33% of the respondents adhere to crop rotation all the time.

Also, 76.76% of the respondents often use minimum tillage some of the time and 23.33% of the respondents often use minimum tillage all the time, 32.50% of the respondents engage in inter-cropping some of the time and 67.50% of them engage in inter-cropping all the time. As, 52.50% of the

Table 3: Frequency of usage of agriculture conservation technologies by the respondents

	Some of the time		All the time	
Agricultural conservation technology	Frequency	Percentage	Frequency	Percentage
Mulching	19	15.83	100	83.33
Cover cropping	27	22.50	93	77.50
Crop rotation	56	46.67	64	53.33
Minimum Tillage	92	76.67	28	23.33
Inter-cropping	39	32.50	81	67.50
No bush burning	63	52.50	57	47.50
Terrace improvement	108	90.00	12	10.00
Construction of terrace bunds	70	58.33	50	41.67
Hedge establishment	73	60.83	47	39.50
Dam construction	75	62.50	45	37.50
Gully control	111	92.50	9	7.50
Trail improvement	90	75.00	30	25.00
Plantation on degraded land	105	87.50	15	12.50
Improved fallow	18	15.00	102	85.00

Source: Field Survey, 2019

Table 4: Constraints faced in the adoption of agricultural conservation technologies distribution by respondent

	Serious		Mild		Not a constraint	
Constraints	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Low yield	44	36.67	38	31.67	38	31.67
Technological Support	76	63.33	23	19.17	21	17.50
Shortage of land	50	41.67	30	25.00	40	33.33
Lack of capital	79	65.83	23	19.17	18	15.00
Lack of extension	81	67.50	25	20.83	14	11.67
High capital cost	01	00.83	62	51.67	57	47.50
Low income	87	72.50	18	15.00	15	12.50

Source: Field Survey, 2019

respondents often use no bush burning, 90.00% of the respondents often use terrace improvement, 58.33% of the respondents often use the construction of terrace bunds, 60.83% of the respondents often use hedge establishment and 62.50% of the respondents often use dam construction some of the time and the following respondents often use the conservation technologies all the time 47.50% of the respondents often use no bush burning, 10.00% of the respondents often use terrace improvement, 41.67% of the respondents often use the construction of terrace bunds 39.17% of the respondents often use hedge establishment and 37.50% of the respondents often use dam construction.

Furthermore, 92.50% of the respondents often use gully control some of the time, 7.50% of the respondents often use gully control all the time,75.00% of the respondents often use trail improvement some of the time, 25.00% of the respondents often use trail improvement all the time, 87.50% of the respondents often use gully control some of the time plantation on degraded land 12.50% of the respondents often use plantation on degraded land 32.50% of the respondents often use gully control some of the time Improved fallow 67.50% of the respondents often use improved fallow.

Lastly, the highest number of conservation agriculture technologies that are often used some of the times are as follows: Terrace improvement, gully control, trail improvement and plantation on degraded land. Those with the highest number that is used all the time are as follows: Mulching, cover cropping, plantation on degraded land and intercropping.

Constraints faced by the respondents in the adoption of agricultural conservation technologies: In Table 4, 36.67% of the respondents have serious constraints in low yield, 31.67% of the respondents face a mild degree of low yield and 31.67% have no constraint in the degree of low yield. Moreover, 63.33% of the farmers have a serious constraint in lacking technical know-how, 19.17% of them have a mild

Table 5: Parameter estimate on the determinants of adoption of agricultural conservation technologies using the Tobit model

Socioeconomic factors	Coefficient	Standard error	t	P>|t|
Age	-0.0132856	0.0159569	-0.83	0.407
Sex	-0.5045709	0.3618085	-1.39	0.166
Married	0.0813224	0.3473473	0.23	0.815
Education	0.047212	0.0381179	1.24	0.218
Household size	-0.0897744	0.0462644	-1.94	0.055*
Farm specific factors				
Farming experience	0.0543113	0.0273733	1.98	0.050**
Farm size	1.111468	0.1118403	9.94	0.000***
Experience sharing	2.012089	0.6521241	3.09	0.003***
Institutional factors				
Financial access	1.383611	0.5396843	2.56	0.012***
Training	2.048226	0.8234814	2.49	0.014***
Constant	8.3809	0.9386772	8.93	0.000***
Diagnostics				
LR chi2 (10) = 143.94				
Prob> chi2 = 0.0000				
Pseudo R2 = 0.2614				
Log likelihood = -203.36232				
Sigma	0.1287291	0.092971		

Source: Field Survey, 2019 and ***Statistically significant at 1%

constraint and 17.50% of the farmers have no constraint in the adoption of agricultural conservation technology. Shortage of land for farming there were: 41.67% serious, 25.00% mild and 33.33% with no constraint in shortage of land for farming. About 65.83% of the respondent faced a serious constraint in the adoption of agricultural conservation technologies due to lack of capital, about 19.17% of the farmers have a mild constraint and 15.00% have no constraint in lacking capital in the adoption of agricultural conservation technology. Of those that face a serious constraint in the adoption of agricultural conservation technologies due to lack of motivation of extension agents, there were 67.50%, about 20.83% of respondents face a mild constraint and about 11.76% of respondents have no constraint. Those that face constraints in the high cost of capital were about 0.83% of the farmers, about 51.67% of the farmers faced a mild constrain and about 47.50% of the farmers do not face a constraint in the adoption of agricultural conservation technologies due to high cost of capital. Low level of income, about 72.50% have serious constraints, 15.00% mild constraints and about 12.50% do not face a constraint in the adoption of agricultural conservation technology.

Determinant of adoption of agricultural conservation technology: In Table 5, socioeconomic, farm-specific and institutional factors were fitted into the model to estimate the determinants of the adoption of agricultural conservation technology in the study area. The result revealed household size, farming experience, farm size, experience sharing, financial access/support and extension training to be significant factors influencing the adoption of agricultural conservation technologies. The coefficient of farming experience, farm size, experience sharing, financial access/support and extension training was positive and statistically significant in the model, this indicated a direct relationship with the adoption of ACTs in the study area. Sharing of experience among the farmers was found to significantly influence ACTs at a 1% level, this indicated that the more the farmers shared their experiences in ACTs, the more the likelihood of adoption. Likewise, the result showed that an increase in financial access/support, extension training, farming experience and farm size will increase the chance of adoption of ACTs in the study area. Giller *et al*.[9] found out that the benefit and cost of implementing CA is an important factor that influences adoption. Also, farmers with larger farmland are more likely to adopt ACTs than those who are with smaller farm sizes. Guo *et al*.[12] found out that planting area significantly influences the adoption of conservation tillage technologies.

The coefficient of household size was negative and significant at a 10% level, indicating an inverse relationship with the adoption of ACTs. The result implied that a unit increase in household size leads to a decrease in the probability of adopting agricultural conservation technologies. The table also showed the diagnostics, the likelihood ratio χ^2 was estimated at 143.94, the log-likelihood was -203.36232 and it was significant at a 1% level, this showed that the model is the best fit and the coefficient is non-zero. Although the coefficient of age was negative and insignificant, it follows the a-priori expectation, as older farmers are always suspicious of the adoption of new technology.

CONCLUSION

The study examined various conservation agricultural technologies in Eswatini and the rate of their adoption and use of the technologies. The drivers of the adoption rate of these technologies were also estimated and holistically described as the major constraint militating against the adoption or the use of these technologies in the study area. Current results showed that most of the farmers are still within the productive age, married and had a fair number of household members. Although, we found out that the increased number of household members significantly retard the adoption of these technologies but farming experience, farm size and experience sharing which is strengthened by social interaction among peers, financial access and extensive training showed an increase in the adoption of the technologies. The study however recommends strengthening institutional factors such as associations, farmer's groups, cooperative societies and many more among the farmers.

SIGNIFICANCE STATEMENT

This study was able to find out prominent conservative technologies adopted by smallholder farmers in Eswatini. But the concern might be the dis-adoption of these technologies and their impacts on agricultural production which this study was limited in accounting for. But it will help more research and probably on arriving at a new change theory.

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