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DETERMINANTS OF ADOPTION OF MULTIPLE SUSTAINABLE AGRICULTURAL PRACTICES (SAPS) BY SMALLHOLDER FARMERS IN THE EASTERN CAPE PROVINCE IN SOUTH AFRICA

Mdoda L[1]*, Christian M[2] and L Gidi[3]

Mdoda Lelethu

*Corresponding author email: MdodaL@ukzn.ac.za

[1]Discipline of Agricultural Economics, University of KwaZulu-Natal, P/Bag X01, Scottsville, Pietermaritzburg, 3209, South Africa

[2]Department of Agriculture and Game Management, Nelson Mandela University, PO Box 77000, Port Elizabeth, 6031, South Africa

[3]Department of Agricultural Economics and Animal Sciences, University of Limpopo, Turfloop Campus, Private Bag X1106, Sovenga, 0727, South Africa

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ABSTRACT

This study investigated factors influencing the adoption of multiple sustainable agricultural practices by smallholder farmers in the Eastern Cape Province. The study made use of a cross-sectional research design and a multi-stage sampling procedure. Data were collected from 168 smallholder farmers using a semi-structured questionnaire and the validity of the collected data was confirmed. Descriptive statistics and a multivariate probit regression model were used to analyze data. The results indicated that farming is practiced mostly by females (70%) with an average of 45 years and 6 people in the households, which act as family labour. The study reported that 54% of farmers adopted an improved variety of crops, use organic manure, integrated pest management, irrigation, and intercropping. Smallholder farmers faced identical constraints which limited their adoption of SAPs. The use of an improved variety of crops was influenced positively by age, years spent in school, household labour, and member of farm organizations. While income level had a negative influence, the use of organic manure was influenced positively by age, years spent in school, farm size, and members of farm organizations. Integrated pest management was positively influenced by years spent in school, income level, farm size, household labour, and member of farm organizations while age had a negative influence. Lastly, irrigation was positively influenced by years spent in school, income level, farm size, members of farm organizations, and household labour. The study concluded that the combination of multiple SAPs adoption had a positive impact on farming in the study area and their adoption was influenced by socioeconomic, institutional, and cultural factors. Therefore, the study recommended that government should provide resources and infrastructure to improve the quality and outreach of extension services through field demonstration trials and training. To fast-track the adoption of SAPs by smallholder farmers, policymakers and NGOs should focus on improving farmers' access to financial institutes to address the credit constraints by farmers so that they can purchase these SAPs. This information will assist policymakers and extension agents in developing and promoting a package of SAPs that will be user-friendly to farmers.

Key words: Adoption, Eastern Cape, Farmers, Food Security, Productivity, Sustainable agricultural practices

INTRODUCTION

Sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that over the long term will satisfy human food and fiber needs, as well as enhance environmental quality and the natural resource base upon which the agricultural economy depends. Examples of sustainable agricultural practices include conservation agriculture, agroforestry, legume intercropping, legume crop rotations, improved crop varieties, drought-tolerant crop varieties, integrated pest management, use of animal manure, and soil and water conservation. The use of Sustainable Agricultural Practices (SAPs) remains a viable option on the policy and research agenda of many developing countries, especially sub-Saharan Africa. Sustainable agricultural practices (SAPs) offer a practical pathway for farmers to improve the productivity and resilience of agricultural production systems while conserving the natural resource base. Sustainable Agricultural Practices (SAPs) boost and improve productivity, and increase the income, efficiency, welfare, and food security of smallholder farmers [1]. As a result, sustainable agricultural practices continue to be at the forefront of global development due to their potential in withstanding and mitigating the numerous and intricate biophysical challenges that agriculture is facing, such as soil fertility, degradation of land, pest and diseases prevalence, climate change, shocks, and natural disasters [2, 3]. Sustainable agricultural practices (SAPs) offer an applied path for smallholder farmers to boost the productivity and elasticity of agricultural production classifications while preserving the ordinary supply base. Sustainable Agricultural Practices (SAPs) are used to promote climate-smart agriculture, restore soil health and bolster the resilience of smallholder farming systems in developing countries that are declining significantly [4, 5]. The use of SAPs is the only approach to protect and strengthen the goal of providing food for the growing population in 2050. The use of SAPs will play a huge role in achieving the reinforced 17 Sustainable Development Goals (SDGs) formulated, especially objective 2 in ending hunger, improving food security, and improving nutrition. However, the use of SAPs by smallholder farmers is constrained by several factors.

Despite government efforts to encourage the development of smallholder agriculturalists to meaningful agrarian worth manacles, the production of smallholder farmers is still lower than the potential for the land [9, 10]. The low yields attained are credited to relying on primeval methods and extraordinary tremors in recent times largely due to climate change, globalization, soil fertility, lack of technology, improper availability of inputs, and degradation of land which usually results in uncertainty in production and establish pressure to yield and welfare of farmers. These challenges are prominent in smallholder farmers in sub-Saharan Africa as they rely on agriculture for living [11]. These challenges have continuously increased the risk of hunger and food insecurity, especially in countries that rely heavily on agriculture for living [12]. Hence, the agricultural sector is yet to reach its full potential to transform the economy of developing countries. The decline and underperformance of the agricultural sector, especially smallholder farmers are credited to the failure to embrace sustainable methods of food production and innovations. Furthermore, apart from agricultural production for food security and job creation, it is observed that agriculture is the key cause of biodiversity loss, overconsumption of water resources, and the lessening of 3% of the world's grazing, where poor smallholder farming communities in Africa are largely affected [13]. However, the negative effect of a decline in yields and rise in unemployment, obsolete agricultural techniques used, the natural environment, and resources have led to the growth and spread of a feature called sustainable agriculture practices.

Sustainable agriculture practice is a type of agriculture that focuses on producing long-term crops and livestock while having minimal effects on the environment [14]. The SAPs attempt to find good stability between the need for food production and the conservation of the environmental system within the location. The adoption and use of sustainable agricultural practices (SAPs) permit farmers and farm workers to discover and gather more acquaintances and skills on how best to attain sustainable agriculture. The adoption of technology in the form of SAPs by farmers is among the most radical and impactful areas of innovation in the agriculture sector as it plays a substantial role in alleviating poverty, lowering per unit costs of production, and improving agricultural output [15]. Hence, SAPs remain the viable option to boost farm productivity among smallholder farmers in developing economies to meet the food demands of a growing population.

The use of SAPs by smallholder farmers has the potential to maximize farm returns and meet the goal of conventional agriculture as well as the preservation of ecological dynamics of agroecosystems and biodiversity [1]. The promotion of SAPs will improve productivity, welfare, and food security across SSA. The use and adoption of SAPs are likely to assist in building and achieving more resilient and productive food systems aimed at enhancing food security and ending hunger and poverty [16]. However, the use and adoption of SAPs by farmers face challenges that vary with countries and regions as a result of alterations in cultural and political principles and natural resource communities. There are still limited studies conducted in the Eastern Cape Province on factors hindering the combination use and adoption of SAPs which is hit high by poverty and

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unemployment rate. Therefore, this paper aimed to examine the level of adoption of multiple SAPs, challenges faced by farmers in the adoption of multiple SAPs, and determinants of multiple SAPs among smallholder farmers in the Eastern Cape Province.

MATERIALS AND METHODS

Study area

The study was conducted in Eastern Cape, South Africa. The districts are Chris Hani and Amatole district municipalities. The choice of these study areas was based on expert opinions (Agricultural Extension and Department of Agriculture) and available statistics which classified these areas as agricultural zones for production and marketing. The study area's climatic condition is favorable for agricultural production as it has a combined average rainfall of 750 mm per annum and thus encourages crop, livestock, citrus, and vegetable farming. The province is dominated by smallholder farmers who are practicing farming as their source of living. The majority of these farming households and smallholder farmers, strictly practice farming for home consumption and surplus for the market as farming is their only strategy to alleviate poverty and reduce food insecurity at the household level.

Sampling procedure, frame, and sample size

A cross-sectional research design survey where the data was collected at one point in time using semi-structured questionnaires was used. This research design was used because it allowed the multiple outcomes (multiple sustainable agricultural practices) to be investigated at once and it measured all factors at a prevalence level as well as is quick to conduct. This design allows the researcher to collect data from a large number of farmers at one point in time and it allows a researcher to construct associations and correlations between the set of variables.

The respondents were 168 smallholder farmers selected through a multistage sampling procedure. The first part was selecting the District Municipalities based on their active participation in agricultural production. Afterward, 2 District Municipalities were selected, Chris Hani and Amatole District Municipalities. The second stage was the selection of 3 Local Municipalities within each District and those municipalities must be involved in farming. In the third and final stage, villages were chosen from the purposively selected municipalities and a total number of 10 villages were selected based on the number of active smallholder farmers and farming households in these villages. Respondents and participants were selected randomly from smallholder farmers from the targeted villages. A

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maximum of 20 villagers for the semi-structured questionnaires in 20 communities in these Districts were used, where the number of farmers from each selected village was proportional to the size of the village. A systematic random sampling at the farm level was done, whereby enumerators picked farmers who adopted SAPs from the first point of entry in a particular village and non-adopters. A total of 168 farmers where 120 adopted SAPs while 48 were non-adopters. These farmers were randomly selected in each village, based on farmer lists provided by government extension officers and farm organization facilitators in the respective wards where the study was conducted.

Data collection

This study employed descriptive research techniques that involved the collection of data through semi-structured personal interviews with farmers.

Data analysis

The descriptive statistics method of data analysis was employed. Particularly, mean, standard deviation, frequencies, and percentages were used while the multivariate probit model was used to estimate determinants of sustainable agricultural practices.

Analytical Framework

This study adopted the multivariate Probit model to estimate determinants of the adoption of sustainable agricultural practices by smallholder farmers in the Eastern Cape Province. The method has been used because it recognizes the correlation in the error terms of adoption equations and estimates a set of multivariate probit models [18,19]. The MVP model consists of 7 binary choice equations, namely improved variety of crops, use of organic manure, integrated pest management, and irrigation. The MVP model is specified as:

$$Y^*_{im} = \beta_{im} + X_{im} + \varepsilon_{im} \qquad m = 1,2,3 \ldots\ldots\ldots .7 \ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$Y_{im} \; (\, 1 \text{ if } Y^*_{im} > 0, 0 \text{ otherwise}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where

$y^* \, im$ is a dormant variable that captures the unobserved preferences related to the choice of practice m. This latent variable is supposed to be linear, the combination of observed characteristics, Xim, and unobserved characteristics apprehended by the stochastic error term, εim. The vector of parameters to be estimated is denoted by βm. Given the latent nature of $y^* \, im$, estimation is based on observable binary variables yim, which indicate whether or not a farmer used a

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particular technology in the reference year. The MVP model for this study was as followed:
Y^{*}_{im} represents the adoption practices of SAPs by farmers. This was binary as 1 represents those who adopted the SAPs practices and 0, those who did not adopt SAPs practices.

The error terms εim, m = 1, 2 … …,5 are distributed multivariate normal each with a mean of 0 and a variance-covariance matrix V, where V has 1 on the leading diagonal, and correlations ρjk = ρkj as off-diagonal elements.

$$V = \begin{pmatrix} 1 & \rho_{12} & \cdot & \cdot & \cdot & \rho_{1k} \\ \rho_{21} & 1 & \cdot & \cdot & \vdots & \rho_{2k} \\ \rho_{31} & \rho_{32} & 1 & \cdot & \cdot & \rho_{3k} \end{pmatrix} \text{..............(3)}$$

where ρ (rho) denotes the pairwise correlation coefficient of the error terms corresponding to any five SAP adoption equations to be estimated in the model. In the presence of error terms correlation (ρ), the off-diagonal elements in the variance–covariance matrix of adoption equations become non-zero and Eq. (2) becomes an MVP model. In this model, ρ is not just a correlation coefficient and carries more information. A positive correlation is interpreted as a complementary relationship, while a negative correlation is interpreted as a substitute.

Measurement of variables
Table 1 presents the measurements of variables used in this study.

RESULTS AND DISCUSSION

Demographic characteristics of farming households
Of the 168 smallholder growers, 64% of respondents reported adopting sustainable agricultural practices as a strategy to enhance productivity as well as improve their livelihoods in the province. The study results revealed that the majority of smallholder farmers were female farmers with a proportion of 70% while the remaining 30% were male farmers. The average age of smallholder farmers was 47 years. These results were in line with Bese *et al.* [20], As-sunny *et al.* [21], Nigussie *et al.* [22] and Cheteni *et al.* [23] that the majority of smallholder farmers were young farmers, and still in their active age, thus helps in adopting sustainable agricultural practices. This showed superior participation of young farmers in farm production, which tells that farming in the province is on the rise and can adopt enhanced technologies for the betterment of the farm and farm productivity. The average family size was 6 people per household and that played a huge part in

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availing the family labour especially. Family size was used as a proxy for family labour. Smallholder farmers spent 10 years in school which makes them literate and able to read as well as analyze innovative information. The result is in line with Oyewole and Sennunga [1] that educational attainment is very high among the farmers which are very crucial for adopting improved farming techniques. The average farm size was 6 Ha which they used for farming purposes and 12 years was an average farming experience. This was the case as they grow up in a farming household which exposed them to farming.

The study results revealed that about 64% of smallholder farmers earned household income from farming operations as 55% of farmers indicated that they were full-time farmers. Smallholder farmers were land owners (65%) and had access to extension services (68%) which played an imperative role in adopting sustainable agricultural practices by providing information to farmers and farming households. The majority of farmers were members of farm organizations (60%) which assisted them in attaining training and information about sustainable agricultural practices. The study found that farmers grew and used cultural practices they were comfortable with and hence lessened production risk associated with crop failure or yield reductions. They used social grant security and farm income as a source of credit for farm operations.

Level of adoption of sustainable agricultural practices by farmers
Table 2 indicates the rate of adoption of sustainable agricultural practices by farmers in the study area. The first adopted and used SAPs is the use of organic manure (36%) by farmers. This was the case because organic manure is a soil modification strategy that recovers physical possessions and soil loss [20, 24]. The use of an improved variety of crops was the second SAP adopted by farmers in the study area with 20% and the main reason farmers adopted this SAP is due to changing climatic conditions as well as prolonged drought in the province. These results were in line with those of Oyewole and Sennuga [1] who found that SAPs are used due to their importance attached to increased productivity for smallholder farmers. Farmers also adopted intercropping practices (18%), irrigation (14%), and integrated pest management (12%). The use and adoption of these SAPs have played a huge and imperative role in enhancing agricultural productivity and output. These SAPs increased agricultural yields which resulted in improved livelihoods for farmers and farming households given the prolonged drought in the province and the global pandemic of Covid-19 which affected the agricultural sector negatively. The results suggest that the smallholders interviewed were involved in various sustainable farming practices. This could be enlightened by the detail that traditional farming practices also form part of sustainable farming

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practices. This generally means that farmers have knowledge of SAPs and have implemented them in their farming practices to enhance agricultural productivity and income generation.

Barriers to sustainable agricultural practices by smallholder farmers and farming households

The smallholder farming sector is faced with numerous challenges which affect their farming practices. These challenges resulted in farmers experiencing a decline in production and decided to transform their farming by adopting sustainable agricultural practices as an approach to enhance productivity. However, as much as Sustainable agricultural practices are contributing immensely to improving agricultural productivity but farmers face some challenges in using them.

Table 3 illustrates barriers faced by farmers and farming households in practicing sustainable agricultural practices. Farmers specified that these practices were too costly for them as they depended solely on social security for living and farm operations as they did not have financial support. As a result, economic reflections and enticements must be encouraged to change to a different farming system. Most farmers lacked knowledge or skill in practicing sustainable agricultural practices on their farms. This is a barrier as most households opt for non-farm activities which are being adversely impacted by shocks, pandemics, and disasters. The last barrier was natural hazards which affected farmers' adoption and use of sustainable agricultural practices as they lacked information about them. Additionally, climate hazards adversely affected their land management practices (for example changes in rainfall patterns as rainfall no longer comes at the usual time framework which affects their land and manure application which depends on the rainfall). The majority of the farmers stated that they did not receive extension services and that no extension agent in contact with them would in understanding these sustainable agricultural practices.

Estimate of factors influencing the adoption of sustainable agricultural practices (SAPs) by smallholder farmers and farming households

The study estimated the MVP model generated with maximum likelihood estimation on factors influencing the adoption of sustainable agricultural practices among smallholder farmers. The results are presented below in Table 4. The study results demonstrate model fitness for the data with the Wald test [χ^2 (124) = 173.39, p = 0.0000)] of the hypothesis that all regression coefficients in each equation are jointly equal to zero is rejected. The result supports the application of the MVP model. The study utilized multivariate probit regression while controlling for demographic characteristics, cultural issues, and institutional policies. The coefficients that explain how each variable influences the probability of adopting each of these technologies are explained.

The age of farming households had a positive coefficient and was statistically significant at a 5% level. This means that there is a positive relationship between age and sustainable agricultural practices. This suggests that a unit increase of 1 year in the age of the households will induce an increase in the adoption use of sustainable agricultural practices by farmers and farming households. This implies that the younger the farming households are, the more open they are to the idea of adopting sustainable agriculture as well as building sustainable farming. The estimated marginal effect of this variable signposts that the probability of adopting and building sustainable agriculture increases by 18% if a farmer is younger. These results are in line with Oyetunde *et al.* [11] that number of SAPs adopted by farmers increases with the age of the farmer's head and is due to the experience accumulated over the farming years, especially with SAPs.

Years spent in school had a positive coefficient and were statistically significant at 5% and 1%. This implies that a unit increase in years spent in school led to an increase in the adoption of sustainable agricultural practices by farmers. This suggests that the more years spent in school, the more innovative farmers become in adopting sustainable agricultural practices. This result is in line with Oyetunde *et al.* [11] and Hagos and Hadush [25] that farmers who spent years in school appear to have higher propensities to adopt sustainable agricultural practices and technologies compared to less educated farming households.

Membership in farm organizations had a positive spillover for smallholder farmers to adopt more and various sustainable agricultural practices as was significant at 1% and 5%, respectively. This implies that a unit of one additional member of the farm organization will induce an increase in the adoption of sustainable agricultural practices. This suggests that being a member of a farming organization increases the adoption of sustainable agricultural practices by farming households. These results correlate with Mutyasira *et al.* [26], Zeweld *et al.* [27], and Cheteni's [28] assertion that being a member of a farm organization increases the adoption rate of sustainable agricultural practices by farmers. Farmer groups and associations act as platforms for social networking and learning where farmers can share their knowledge, know-how, and experiences with SAPs, which can positively influence perceptions and therefore adoption of these practices.

Household labor had a positive coefficient and was statistically significant at a 5% level. This implies that a unit increase of 1 additional member of household labor will induce an increase in the adoption of sustainable agricultural practices. The availability of household labor resources positively influenced the sustainable agricultural facilities to be adopted by farming households and farmers. This result is consistent with Mutyarisa *et al.* [26] that have shown how labor constraints impede the adoption of sustainable agricultural technologies in improving food availability in households.

Farm size had a negative coefficient and was statistically significant at 1% and 5%. This implies that a unit increase in farm size will induce a decrease in the adoption of sustainable agricultural facilities. The results indicate that farmers and farming households who have smaller farm sizes have a higher probability of limiting the adoption of sustainable agricultural practices. These results agree with Bese *et al.* [20], Tegegne [5], and Lowder *et al.* [29] that larger farms have a greater propensity to implement sustainable agricultural practices.

Income level had a positive coefficient and was statistically significant at 1% and 5%. This implies that a unit increase of 1% in income level will induce an increase in the adoption of sustainable agricultural practices by farmers. This suggests that the higher the income level, the more farming households willing to adopt and invest in sustainable agricultural practices to enhance farm output and returns. These results are in line with Myeni *et al.* [9] and Musungwini [30] that farmers and farming households with higher off-farm income are likely to adopt SAPs because they come through the enhanced farm fluidity, which farmers use to hire labor, purchase inputs, and equipment which is required by some of the SAPs. Cultural norms had positive and negative impacts on the adoption of sustainable agricultural practices. This implies that some cultural norms prevent farmers from adopting sustainable agricultural practices as they are against their customs such as improved crop variety. The increase in belief in cultural customs might increase the adoption of inorganic manure as they normally use and have no problem using it for farming.

Correlation coefficients for MVP regression equations

The binary correlations between the error terms of the four adoption equations are presented in Table 5. These coefficients measure the correlation between the four adoption decisions after the influence of the observed factors is accounted for. The results reveal that some practices are complements, while others are substitutes (meaning that they compete for the same scarce resources). The correlation coefficients are statistically different from zero in 5 of the 21 cases, confirming the appropriateness of the multivariate probit model and technology adoption is not mutually independent.

The highest positive correlation (48%) is between an improved variety of crops and the use of irrigation. The use of a variety of crops is very beneficial in resisting the changing and adapting to climate change, while irrigation increases the water content and maturity of crops, so the combining of both could lead to synergies. The use of an improved variety of crops is positively associated with integrated pest management. Both technologies are aimed at maximizing soil efficiency and complementing each other. The use of organic manure also breaks pest and disease cycles. The use of organic manure is positively associated with irrigation. This is plausible as both technologies involve managing and enhancing crop productivity. There are also several negative associations between adoption decisions, indicating technological substitutes. The use of organic manure is negatively associated with integrated pest management. The study results reveal that integrated pest management was negatively associated with irrigation are found to be a substitute. Overall, the study results show that the use of an improved variety of crops complements irrigation, integrated pest management, and manure application. The study concludes that agricultural extension personnel must encourage farmers to make use of an improved variety of crops and use organic manure, irrigation, and integrated pest management technologies.

CONCLUSION

The paper aimed to investigate the challenges faced and factors influencing the adoption of SAPs by smallholder farmers in the Eastern Cape Province. The general lack of impulsive adoption of SAPs and technologies among smallholder farmers has been a major concern in Africa, especially in South Africa. The study results reported that about 54% of farmers adopted SAPs and experienced some improvement in their farm outputs and farm returns. Farming was female-dominated in the study with an average age of 47 years and an average family size of 6 people in the household. Smallholder farmers adopted improved variety, use of organic manure, mixed cropping practices, crop rotation, irrigation, and intercropping. Farmers were constrained in adopting SAPs due to a lack of financial support, lack of knowledge or skill, lack of extension services, and natural hazards. The study concludes that the adoption of sustainable agricultural practices by smallholder farmers in the study depends on cultural issues and socioeconomic, institutional, and technical factors. Therefore, the study recommends that policymakers, NGOs, and government must facilitate innovative technology adoption based on agricultural programs so that they can bring improvement. The implication of this study to agricultural extension service conveyance is that extension agents need to focus their attention on disseminating information and technologies that are accepted and feasible in farming communities.

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Conflict of interest
The authors declare no conflict of interest.

Table 1: Hypothesised influential factors of sustainable agricultural practices

Variable	**Description/Measurement**	**Variable type**	**Expected Sign**
Adoption of SAPs	Adoption of multiple SAPs by smallholder farmers (Yes=1, No=0)		
Independent variable	**Description/measurement**		**Expected sign**
Age	Actual years of the farmers	Continuous	+
Sex	1 = male, 0 if otherwise	Category	-
Farm experience	Actual years of farming	Continuous	+
Farm size	Actual arable hectares	Continuous	-
Family size	The actual number of people in the house	Continuous	+
Membership in the farm organization	1= if a member of a farm organization, 0 if otherwise	Category	+
Access to extension services	1= access to extension services, 0 otherwise	Category	+
Years spent in school	Actual years spent in school	Continuous	+
Access to credit facilities	1= access to credit facilities, 0 otherwise	Continuous	-
Use of technologies on the farm (improved seed, fertilizers, machinery)	1= use technology, 0 = otherwise	Category	-
Distance to marketplace	Actual km to the marketplace	Continuous	-
Marital status	1= married, 2= single, 0 otherwise	Category	+
Total Household income	The actual amount of money	Continuous	+
Farmers' Attitudes to Innovation	1= positive attitude, 0 = otherwise	Category	+
Off-farm income	Whether the household has a side business to earn extra income or not	Category	+
Livestock ownership	1= livestock ownership, 0 = otherwise	Category	+

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Table 2: Rate of adoption of sustainable agricultural practices by farmers

Adopted SAPs	Frequency	Percentage (%)	Ranking
Improved variety crops	34	20	2
Use of organic manure	60	36	1
Integrated pest management	20	12	5
Irrigation	24	14	4
Intercropping	30	18	3

Table 3: Barriers to sustainable agricultural practice use by rural households

Variable	Mean scores	Rank
Financial support	2.8	1
Lack of knowledge or skill	2.3	2
Access to extension services	1.3	4
Natural Hazards (climate change, shocks)	1.5	3

Table 4: Coefficient estimates of the multivariate probit model

Explanatory variables	Improved variety crops	Use of organic manure	Integrated pest management	Irrigation
Age	(0.0430) 0.015**	(0.0809) 0.042**	(0.0200) -0.018**	(2.089) 0.189
Years spent in school	(0.0870)0.015**	(0.0762) 0,008***	(0.0610) 0.004***	(0.0590) 0.028**
Income level	(0.0761) -0.040**	(0.0489) 0.167	(0.0508) 0.001***	(0.0363) 0.023**
Farm size	(0.076) -0.189	(0.065) 0.007***	(0.089) 0.028**	(0.0240) 0.000***
Member of farm association	(0.082) 0.010**	(0.042) 0.008***	(0.078) 0.043**	0.093) 0.015**
Household labor	(.0.087) 0.013**	(1.034) 0.1782	(0.065) 0.008***	(0.062) 0.020**
Cultural norms	(0.076) -0.015**	(0.0504) 0.023**	(0.097) 0.180	(0.0608) 0.089
N	168			
Wald χ^2 (124)	173.39***			
Log-likelihood	-355.19			

Note: ** represents 5% ($p < 0.05$), and *** 1% ($p < 0.01$), significance levels

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Table 5: Correlation coefficients for MVP regression equations

	P^{IVC}	P^{UOM}	P^{IPM}	P^{IRR}
P^{IVC}	1			
P^{UOM}	0.350*** (0.287)	1		
P^{IPM}	0.318** (0.284)	-0.033 (0.176)	1	
P^{IRR}	0.482** (0.236)	0.466** (0.200)	-0.029 (0.188)	1

, * significant at 5%, and 1% levels, respectively. Standard errors are in parentheses. IVC=improved variety crops, UOM= use of organic manure, IPM= integrated pest management, IRR= irrigation
Likelihood ratio test for the overall correlation of error terms: chi^2 (21) = 48.53 Prob > chi^2 = 0.000

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