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The Adoption of Sustainable Farming Practices by Smallholder Crop Farmers: Micro-Level Evidence from North-Eastern South Africa

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Abstract: Sustainable farming practices (SFPs) are often touted as vehicles for improving crop productivity and the livelihoods of many rural households. However, SFP's adoption rates remain persistently low, especially among smallholder farmers in many rural parts of developing countries. Thus, this study aimed to evaluate the adoption of SFPs amongst smallholder crop farmers in Mbombela, South Africa. A simple random sampling procedure was employed to collect data from 294 farmers who were solely specializing in crop production. The data were collected using a structured questionnaire, and the analysis was performed with descriptive statistics. A multivariate probit model was adopted to determine the socio-economic determinants of adopting SFPs. The findings of this study confirm that SFPs are essential for addressing the abiotic and biophysical challenges that impede crop productivity, as farmers view these practices as highly beneficial in their farming activities. Also, the results reveal that crop rotation was the most adopted practice, whereas intercropping and conservation tillage were the least adopted practices in the surveyed area. Furthermore, the study showed that "gender, years of education, off-farm income, annual income, marital status, and satisfaction with extension services" were significant socio-economic attributes that do indeed influence the adoption of SFPs by smallholder crop farmers in the surveyed area. These findings underscore the need for the Ministry of Agriculture and rural development stakeholders to address issues relating to economic incentives, improve farmers' perception of SFPs, provide financial literacy and support programs, and intensify efforts to promote underutilized practices.

Keywords: sustainable agricultural practices; smallholder farmers; simple random sampling procedure; constraints; multivariate probit regression model; South Africa

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1. Introduction

The smallholder farming sector continues to be a sustainable livelihood option for most households, particularly in rural parts of sub-Saharan Africa (SSA), such as South Africa (SA) [1]. According to Ogundiphe et al. [2], smallholder farming remains crucial for reducing poverty and food insecurity and employs a massive proportion of the developing world's labor force. The author further opined that this sector has demonstrated its importance in enhancing household food security by creating additional income that can be used to procure food or other external farming inputs to optimize productivity [2]. Furthermore, in light of the swiftly increasing global population, smallholder farming is recognized as a crucial agricultural sector for realizing the 2030 Agenda for Sustainable Development [3], especially Sustainable Development Goal (SDG) 2, which seeks to eradicate all forms of hunger and poverty while ensuring food sustainability by 2030. This notion is further reinforced by the International Assessment of Agricultural Knowledge, Science and Technology for Development [4], which emphasizes the strong connections between food security and availability, as well as sustainable agriculture, positioning smallholder farmers as central to achieving sustainable food and nutrition security. As postulated by Biermann et al. [5] and Mohamed [6], SDG 2 represents a transformative measure aimed at enhancing the welfare of the most disadvantaged individuals and farming households, especially those residing in rural areas of developing countries like SA. Moreover, according to the Food and Agriculture Organization (FAO) [7], the attainment of the SDGs is intrinsically linked to the smallholder farming sector. This is because smallholder agricultural production is intricately connected to SDG 2 in three distinct ways. Firstly, it ensures food availability via production; next, it lowers the real cost of food, enhancing affordability; and finally, it boosts the incomes of farming households [5,6,8]. Despite the aforementioned benefits linked to smallholder farming, similar to numerous other developing nations, smallholder farmers in South Africa are still vulnerable to abiotic and biophysical challenges that limit crop productivity [9]. These include, among others, a changing and variable climate, droughts, low soil fertility, land degradation, and restricted access to farming inputs and resources [9–11]. Thus, in response to these unprecedented abiotic and biophysical limits, policymakers and rural development stakeholders have advocated interventions aimed at developing, promoting, and disseminating sustainable farming practices (SFPs) [12]. This is because the widespread implementation of SFPs has the potential to improve crop yields and farmers' income while safeguarding the quality of environmental resources [9].

SFPs are management practices that enable farmers to satisfy current and future societal needs for food, fiber, ecosystem services, and health while conserving environmental resources [13]. As stated by Olawuyi [14], sustainable farming is an essential idea for farmers to be aware of, as it is an alternative to conventional farming practices. These practices make it possible to simultaneously achieve the goal of traditional farming, which is to maximize crop yield and farm income while also preserving the natural dynamics of agroecosystems and biodiversity [15]. Consideration for SFPs includes not only the need for future output growth but also the preservation of the quality of the environment, water, and soil. Consequently, the adoption and utilization of SFPs by smallholder farmers, such as mulching, intercropping, conservation tillage crop rotation, use of crop cover, green and animal manure, rainwater harvesting, agro-forestry, and integrated pest management, have been recommended by many scholars [14,16,17]. Scientific evidence demonstrates that these practices increase the productivity and resilience of agricultural production in smallholder farming systems while safeguarding environmental resources within the farming environments. Yet, the effectiveness of SFPs will not be realized unless the majority of smallholder farmers adopt and use these recommended practices [18].

Furthermore, in efforts to realize the mission of the South African Development Plan, which aims to mitigate socio-economic challenges in rural areas of SA by 2030 [6]. Mohamed [6] and Chinseu et al. [19] observed that the promotion, adoption, and diffusion of modern farming practices such as SFPs have become a top priority for the sub-Saharan African development policy agenda, including SA. The adoption and utilization of SFPs will ensure that farmers, mainly smallholders in many rural parts of SA, make the most of their productive environmental resources, thus allowing them to produce more while also supporting the vision of the national development plan (NDP) and attaining SDGs. However, despite the numerous benefits of SFPs, adoption rates remain persistently low, especially among smallholder farmers in the rural agrarian parts of developing nations such as SA [9,16,18]. For instance, despite the significant benefits of SFPs, such as conservation tillage practices (CTPs), their adoption and use in Mozambique have been low due to insufficient skills among farmers and widespread poverty [20]. Similarly, Oni [21] observed that many farmers in Nigeria are believed to exhibit limited enthusiasm for embracing CTPs due to their limited financial resources. In addition, the Ethiopian government has placed significant emphasis on the dissemination of SFPs to enhance the agricultural production of smallholders. However, Haile and Kasa [22] noted that various environmental and socio-economic challenges have constrained the adoption of these practices in the highlands of Ethiopia. Additionally, as pointed out by Makate et al. [13] and Manda et al. [23], research studies documenting the extent of adoption and the causes of low levels of adoption of SFPs in Mpumalanga, South Africa, are very scarce. For instance, a recent study by Bese et al. [16] analyzed "the use of sustainable agricultural practices (SAPs) by smallholder farmers in the Eastern Cape region of South Africa". However, the study did not adequately explore the extent of adoption and the constraints that limit the adoption of these practices. Hence, to fill this research gap, this empirical study evaluated the adoption of sustainable farming practices amongst smallholder crop farmers in South Africa using the Mbombela Local Municipality as a case study. Specifically, the study focused on investigating the socio-economic characteristics of smallholder crop farmers, determining the perceived benefits of SFPs, identified SFPs adopted by smallholder crop farmers, and examining the socio-economic determinants of adopting SFPs in the surveyed area. This is expected to provide useful insight and information that will inform government, policymakers, and rural advisory stakeholders on the adoption level of SFPs and the dominant constraints hindering their adoption in the study area. Additionally, in line with the SDGs, which aim to eliminate all aspects of hunger and poverty by 2030, the study will provide empirically guided policy recommendations that can be utilized in the development of interventions that will speed up the adoption and utilization of SFPs in South Africa.

The study structure consists of six sections, including this introductory section. Section 2 discusses the methodology used for this study, which includes a description of the study area, sampling procedure, data collection and analysis methods, model specification, and ethical considerations. Section 3 summarizes the research findings, focusing on the socio-economic attributes of the farmers, the perceived benefits of SFPs, the adoption of SFPs by smallholder crop farmers, constraints hindering the adoption of SFPs, and socio-economic determinants of the adoption of SFPs. Section 4 presents a discussion of the results. After this, Section 5 presents the theoretical implications of the study, and lastly, conclusions and recommendations are presented in Section 6.

2. Materials and Methods

2.1. Description of the Study Area

The data utilized in this study were obtained from a randomly selected sample of smallholder crop-growing farmers in Mbombela Local Municipality (MLM), SA (Figure 1). The choice of MLM for this study comes because of its climatic contrasts with the other drier districts that are located in the highveld region of the province. MLM is located in the north-eastern area of SA, specifically within the Lowveld sub-region of Mpumalanga province [24], and experiences a cold winter and hot, humid climatic conditions that facilitate diverse agricultural activities. The municipality's minimum average temperatures range from approximately 2 °C in the mountainous western areas to over 8 °C in the Kruger National Park. Meanwhile, the maximum temperatures range from 25 °C in the western regions to 35 °C in the eastern parts [24]. As stated by Agholor [25], this municipality is conducive to the growth and development of sub-tropical fruits, including but not limited to mangoes, oranges, lemons, and bananas. Moreover, the MLM ranks among the top crop-producing municipalities in Ehlanzeni District Municipality [26]. Additionally, the research site is dominated by smallholder farmers engaged in the cultivation of grains, vegetables, and livestock.

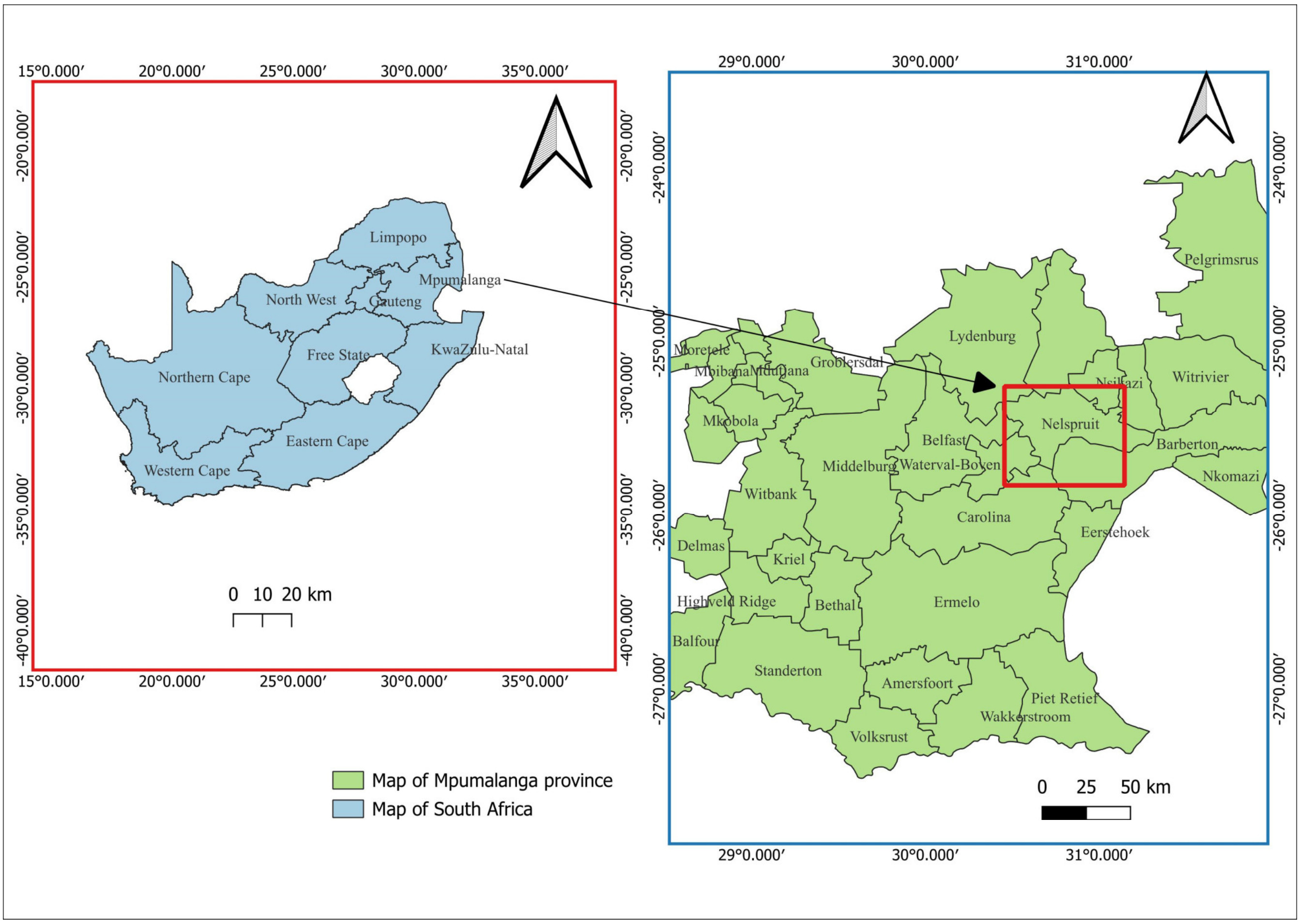

Figure 1. Location of Mbombela Local Municipality, within the Mpumalanga Province in north-eastern South Africa.

2.2. Sampling Procedure and Sample Size

The study employed a quantitative research approach utilizing a descriptive survey research design. The research design was utilized in accordance with the approach of Bese et al. [8] and Kamarudeen [27], who implemented this design in a comparable adoption-related study. Bless et al. [28] pointed out that descriptive and quantitative research focuses on the beliefs and attitudes held, as well as emerging patterns. A list of smallholder crop farmers registered with the Department of Agriculture in Mbombela was obtained with the help of an extension officer. Moreover, the list (Mbombela Farmer Database), which comprises smallholder farmers sourced from the Department of Agriculture in the province, provided the sampling framework for this study. The population of smallholder crop farmers comprised 1134 individuals. To participate in the study, the smallholder farmer had to be registered with the Department of Agriculture within the province and had to specialize in crop production. The Slovin's formula was then employed to ascertain the suitable sample size from the identified population of farmers in the study area. Slovin's method, developed by Michael Slovin, ensures the neutrality of statistically selected samples. The Slovin formula is presented below, calculated using a 95% confidence level and a 5% margin of error. A total of 294 smallholder crop farmers were randomly selected for participation in the study, as determined by the computation from the formula. The simple random sampling technique employed in respondent selection ensured that each individual in the population had an equal probability of selection. The following calculation illustrates the method used to determine the suitable sample size.

$$n = \frac{N}{1+Ne^2} \quad = n = \frac{1134}{1+1134(0.05)^2} = 294$$

where n = sample size (294);

N = population size of smallholder farmers (1134);

e = desired margin of error (0.05).

2.3. Data Collection and Analysis

An interview-administered, semi-structured questionnaire was employed to gather data from the smallholder crop farmers in the study area. Questionnaires were developed and distributed through a farmer-to-farmer approach. Translations were provided to farmers with limited proficiency in English. Before finalizing the questionnaire, it underwent pre-testing to enhance its quality and assess critical factors, including the time required for completion and the relevance of the questions posed. Prior to the initiation of the data collection process, three enumerators received training to facilitate the data collection process. The questionnaire was organized into sections corresponding to the study's objectives. All objective variables were defined and evaluated at the nominal, ordinal, and interval levels as appropriate.

The data that were gathered with the questionnaire was first coded, then imputed into Microsoft Excel, and then analyzed using IBM SPSS software version 29.0. The survey data were descriptively analyzed (e.g., frequencies, percentages, means, and ranks). The descriptive statistics utilized were applied to examine all the research objectives. The analyzed data were visualized and presented in the form of tables, pie charts, and bar graphs. Moreover, the multivariate probit regression model was used as an inferential statistic to examine the socio-economic determinants of adopting SFPs in the surveyed area.

2.4. Model Specification

A farming household is presumed to adopt various practices and combinations thereof for sustainable farming, contingent upon the benefits linked to these practices. These practices are adopted simultaneously and/or sequentially because they complement each other [29]. Thus, the combination of the practices and the adoption decision are multivariate [29]. Building on the works of Ehiakpor et al. [1] and Teklewold [30], we utilized a multivariate probit model (MVP) approach to examine the socio-economic determinants of adopting SFPs by smallholder crop farmers in the area. In contrast to other dichotomous models, the MVP model effectively accounts for unobservable factors that influence smallholder crop farmers' adoption decisions by permitting correlation across error terms of latent equations [31]. The identified correlations allow for error terms that indicate positive correlation (complementarity) and negative correlation (substitutability) among the different SFPs [32]. In this study, the MVP model consists of seven binary choice equations, namely crop rotation, cover cropping, mulching, intercropping, integrated pest management (IPM), conservation tillage, and the application of animal and green manure. Hence, we specified the study model as:

$$Y_{im}^{*} = \beta_{im} + x_{im} + \varepsilon_{im} \qquad (m = 1, 2, 3, \ldots, 7)$$

Y_{im} {1 if $Y^{*}_{im} > 0$ and 0 otherwise

The above Equation is developed based on the assumption that a rational i-th farm household has a latent variable Y^*_{im} that captures unobserved factors related to the m-th choice of sustainable farming practices (m = 7 SFPs) utilized by the farming household during the year under consideration. X_{im} comprises exogenous variables that determine SFPs' adoption, such as households' socio-economic attributes (Table 1). The coefficients β_m quantify the effects of the vector of dependent variables. ε_{im} represent error terms following a multivariate normal distribution, each with a mean of zero and a variance–covariance matrix with values of 1 on diagonal and non-zero correlations as off-diagonal elements. The socio-economic attributes included in the model are shown in Table 1.

Table 1. Description of the socio-economic attributes used in this study.

Variables	Description	Variable Type	Hypothesized Sign
Gender	1 = male, 0 if otherwise	Categorical	Positive/negative
Marital status	1 = married, 0, if otherwise	Categorical	Positive/negative
Household size	Number of members in the household	Continuous	Positive/negative
Formal education	Years spend in school	Continuous	Positive
Farming experience	Number of farming in years	Continuous	Positive/negative
Source of income	Other sources of income, aside from farming	Categorical	Positive
Annual income	Average annual income, including farm income	Continuous	Positive
Source of water	Sources of water for crop farming	Categorical	Positive/negative
Off-farm income	Average annual off-farm income	Continuous	Positive
Satisfaction with extension services	1 = if satisfied with the services, 0 if otherwise	Categorical	Positive/negative
Farmer group	1 = if a farmer is a member of the farmer group, 0 if otherwise	Categorical	Positive

Source: author's elaboration.

2.5. Ethical Consideration

The researcher obtained ethical clearance for this research from the University of Mpumalanga Ethics Committee, facilitated by the Faculty of Agriculture and Natural Sciences, under the reference number UMP/Sithole/201940558/MAGR/2023. During the questionnaire administration, the researcher requested the participants' consent and guaranteed them the utmost confidentiality. The questionnaires were administered at times and locations (farm fields) that were convenient for the participants. Prior to completing the questionnaire, the participants were informed of the study's scope, and their anonymity was maintained by not disclosing any identities. Throughout the investigation, the well-being of the participants was prioritized by ensuring that they were not subjected to any form of harm. Additionally, all participants were recognized and thanked for the time they dedicated to completing the questionnaires.

3. Results

3.1. Socio-Economic Attributes of the Smallholder Crop Farmers

The findings in Table 2 reveal the socio-economic attributes of the smallholder crop farmers in the surveyed area. The results indicate that the majority (57.1%) of the respondents were between 36 and 65 years old, 37.4% were between the ages of 66 and above, followed by 4.8% of smallholder crop farmers who were between 26 and 35 years of age, and a minority (0.7%) were less than 25 years of age. The average mean age of the respondents was 59.12 years, with a standard deviation of 13.13. About two-thirds (65.0%) of the smallholder crop farmers were females, while males accounted for only (35.0%).

The marital status reveals that a significant proportion (75.0%) of the farmers were married, while only a few (25.0%) were unmarried. The findings from Table 2 further reveal that a little above average (51.0%) of the farmers in the area had a household size of between 5 and 9 persons, 41.2% had between 1 and 4 persons, while only a handful had 10 or above persons living together under the same roof, with an overall mean household size for the surveyed area being six (6) individuals. Also, the results further reveal that a little above average (57.5%) of the respondents had 7 years or less of formal education, and 38.1% had a formal education that ranges from 8 to 12 years, while only a few (4.4%) of the farmers had 13 years or more of formal education. In addition, a significant proportion (83.3%) of the farmers belonged to a particular farmer group, while only a few (16.7%) of the farmers did not belong to any farmer group or organization.

Table 2. Frequency distribution respondents according to age, gender, marital status, household size, years of formal education, membership group, average monthly off-farm income, income-paying job, sources of water for irrigation, SFP training, and satisfaction with services rendered by extension officers.

Characteristics	Frequency (%)	Mean (SD)
Age (Years)		
≤25	2 (0.7)	59.12 (13.13)
26–35	14 (4.8)	
36–65	168 (57.1)	
66 and above	110 (37.4)	
Gender		
Male	102 (35.0)	
Female	192 (65.0)	
Marital Status		
Married	221 (75.0)	
Unmarried	73 (25.5)	
Household Size		
1–4	121 (41.2)	6 (2)
5–9	150 (51.0)	
10 and above	23 (7.8)	
Years of Formal Education		
≤7	169 (57.5)	6.07 (5.13)
8–12	112 (38.1)	
13 and above	13 (4.4)	
Membership Group		
Yes	245 (83.3)	
No	49 (16.7)	
Average Monthly Off-Farm Income (Rand)		
≤5999	218 (74.1)	4107.31 (4105.98)
6000–10,999	54 (18.4)	
11,000–15,999	12 (4.1)	
16,000 and above	10 (3.4)	
Income-Paying Job		
Yes	40 (13.6)	
No	254 (86.4)	
Sources of Water for Irrigation		
Rain	115 (39.1)	
Irrigation	0 (0)	
Both	179 (60.9)	

SFP Training	
Yes	236 (80.2)
No	58 (19.8)
Are the Services from Extension Officers Satisfactory?	
Yes	89 (30.3)
No	205 (69.7)

Furthermore, the results in Table 2 reveal that a significant proportion (74.1%) of the farmers in the area live on an average monthly off-farm income of R5999 or less, while (18.4%) live on an average monthly off-farm income of R6000–R10,999, and 4.1% live on an average monthly off-farm income of R11,000–R15,999. Only a few (3.4%) of smallholder crop farmers live on an average monthly off-farm income of R16,000 and above. Smallholder crop farmers' average monthly off-farm income in the surveyed area was R4107.31. Moreover, the study found that a significant proportion (86.4%) of the farmers in the area did not have an income-paying job aside from farming, and only a few (13.6%) of the farmers had an income-paying job. The results further reveal that the majority (60.9%) of the farmers in the area relied both on rainfall and irrigation as the primary source of water for farming. Conversely, a minority (39.1%) of the farmers relied exclusively on rainfall as the primary source of water for irrigation. The results in Table 2 further reveal that a significant proportion (80.2%) of the respondents stated that they have participated in one form of sustainable farming practices-related training. In comparison, only a few (19.8%) of smallholder crop farmers stated that they had not been exposed to any form of SFP training. In addition, over two-thirds (69.7%) of the respondents indicated that the services received from extension officers were not satisfactory, and only a few (30.3) of the farmers were satisfied with the services rendered by the extension officers.

3.2. Perceived Benefits of Sustainable Farming Practices Among Smallholder Crop Farmers

Utilizing the mean score to rank the perceived benefits of sustainable farming practices among smallholder crop farmers, all statements regarding the potential benefits of SFPs were perceived as highly beneficial by the farmers in the study area. All statements scored an overall mean rating of greater than 3. As shown in Table 3, the top 5 ranked statements that were prominently perceived as beneficial by the farmers were "Crop rotation plays a crucial role in enhancing the utilization of sunlight, nutrients and water" (MS = 4.24) was ranked first, "SFPs play an important role in preserving the quality of the environment, water and soil" (MS = 4.20) was ranked second, "animal and green manure play an important role in building soil organic matter" (MS = 4.18) was ranked third, and "Crop rotation cannot suppress weeds, diseases and pests" (MS = 4.12) was ranked fourth "SFPs remain an important strategy to improve farm production" (MS = 4.11) was ranked fifth. In conclusion, the findings in Table 3 reveal that a significant proportion of the smallholder crop farmers indicated that SFPs, such as crop rotation, were effective in enhancing the utilization of various environmental resources such as sunlight, nutrients, and water, as this was ranked first.

Table 3. Perceived benefits of SFPs among smallholder crop farmers.

Statements	Mean	Rank
Sustainable farming practices remain an important strategy to improve farm production	4.11	5th
SFPs play an important role in preserving the quality of the environment, water and soil	4.20	2nd
Soil fertility can never be improved by the use of SFPs	4.10	6th
The depletion of environmental resources such as water, soil and nutrients cannot be reduced by the use of SFPs	4.10	7th
Crop rotation cannot suppress weeds, diseases, and pests	4.12	4th
The implementation of cover crops plays an important role in suppressing weeds	3.97	10th

Cover crops helps to enhance soil organic matter content and increase the availability of soil nutrients	4.01	9th
Crop rotation plays a crucial role in enhancing the utilization of sunlight, nutrients, and water	4.24	1st
The application of manure plays an important role in building soil organic matter and structure	4.18	3rd
Applying integrated pest management helps to keep diseases and pests under control with minimal impact on people and environment	4.01	8th

Mean score derived from strongly agree = 5, agree = 4, undecided = 3, disagree = 2, strongly agree = 1.

3.3. Adoption of Sustainable Farming Practices by Smallholder Crop Farmers

The results in Table 4 provide an analysis of the SFPs adopted by smallholder crop farmers in the surveyed area. The study found that a significant proportion (97.6%) of the farmers adopted crop rotation, and it was ranked first among the SFPs adopted by the farmers in the study area. IPM (82.3%), cover crops and mulching (79.9%), animal and green manure (59.5%), intercropping (53.4%), and conservation tillage (23.1%) were ranked 2nd, 3rd, 4th, 5th, and 6th, respectively.

Table 4. Frequency distribution of sustainable farming practices adopted by smallholder crop farmers in study area.

Sustainable Farming Practices	Adopted	Not Adopted	Rank
Crop rotation	287 (97.6)	7 (2.4)	1st
Cover Crops and mulching	235 (79.9)	59 (20.1)	3rd
Intercropping	157 (53.4)	137 (46.6)	5th
Conservation tillage	68 (23.1)	226 (76.9)	6th
Use of Animal and green manure	175 (59.5)	119 (40.5)	4th
Applying integrated pest management	248 (82.3)	52 (17.7)	2nd

Value in parenthesis signifies percentages.

3.4. Constraints Hindering the Adoption of Sustainable Farming Practices

The findings in Table 5 reveal that "high cost of SFPs inputs and resources" (MS = 3.82), "affordability of SFPs associated technologies" (MS = 3.74), "lack of government support and subsidies" (MS3.66) were viewed as the topmost constraints hindering the adoption and use of SFPs by the smallholders. "Lack of access to credit facilities" (MS = 3.57), and "inadequate access to farm machineries for SFPs adoption" (MS = 3.43) were both ranked fourth and fifth most severe constraints. While both "inadequate access to farm inputs" (MS = 3.35) and "inadequate access to training and workshops on SFPs" (MS = 3.31) were ranked sixth and seventh as the most severe constraints. "Unpredictable weather patterns/extreme events" (MS = 3.26), "high risks associated with technologies utilized during SFPs adoption" (MS = 3.24), "inadequate dissemination of clear and reliable information by change agents" (MS = 3.16), "inadequate access to extension services" (MS = 3.05), and "inadequate stakeholders support on SFPs adoption" (MS = 2.94) were ranked 8th, 9th, 10th, 11th, and 12th, respectively.

Table 5. Constraints hindering the adoption of sustainable farming practices.

Constraints	Mean	Rank
Inadequate knowledge and information on sustainable farming practices (SFPs)	2.54	15th
Lack of access to credit facilities	3.57	4th
High cost of SFP inputs and resources	3.82	1st
Inadequate access to farm inputs	3.35	6th
Insufficient sustainable agriculture subject matter specialist	2.37	16th

Inadequate stakeholder support on SFP adoption	2.94	12th
Unstable government policies on SFP adoption	2.02	18th
Inadequate access to extension services	3.05	11th
Inadequate access to training and workshops on SFPs	3.31	7th
Inadequate dissemination of clear and reliable information by change agents	3.16	10th
Lack of government support and subsidies	3.66	3rd
Insufficient technical know-how on the use of SFP-related farm technologies	2.69	14th
Inadequate access to farm machineries for SFP adoption	3.43	5th
The perceived complexity of utilizing SFP-associated technologies	2.32	17th
Affordability of SFP-associated technologies	3.74	2nd
High risks associated with technologies utilized during SFP adoption	3.24	9th
Limited access to water	2.93	13th
Unpredictable pest and diseases incidence	1.98	19th
Unpredictable weather patterns/extreme events	3.26	8th

Mean derived from very severe = 4, severe = 3, moderately severe = 2, a little severe = 1.

3.5. Smallholder Crop Farmers' Socio-Economic Determinants of Adoption of Sustainable Farming Practices in the Surveyed Area

The results presented in Table 6 revealed the estimates of socio-economic attributes influencing the adoption of SFPs by smallholder crop farmers using a multivariate probit regression model. The Wald test (chi2 (75) = 220.24, Prob > chi2 = (0.0000) is strongly significant at a 1% significant level, suggesting that the error terms across the adoption equations are correlated. The significance of this lies in the fact that applying an MVP regression model was suitable for identifying the smallholder crop farmers' socio-economic attributes influencing the adoption of SFPs. These significant socio-economic attributes include gender, marital status (MS), household size (HS), years of formal education (YFE), source of income (SI), annual income (AI), off-farm income (FFI), farmer group (FG), sources of water (SW), and satisfaction with extension services (SExtn). The significant variables that were positively related to the adoption of cover crops and mulching include YFE ($p < 0.05$) and SExtn ($p < 0.05$). The significant variables associated with intercropping were YFE ($p < 0.05$), AI ($p< 0.05$), and FG ($p < 0.05$). YFE ($p < 0.01$), AI ($p < 0.00$), and SI ($p < 0.01$) were positively related to the adoption of conservation tillage, and only the farmer group (<0.05) was positively associated with the adoption of animal and green manure. Furthermore, variables such as gender ($p < 0.10$), MS ($p < 0.10$), HS ($p < 0.10$), YFE ($p < 0.05$), AI ($p < 0.01$), SW ($p < 0.05$), and SExtn ($p < 0.05$) were positively related to the adoption of IPM.

Table 6. Smallholder crop farmers' socio-economic determinants of adoption of SFPs.

Variables	CC and Mulching		Intercropping		CA		A&G Manure		IPM	
	Coeff.	Std.Err	Coeff.	Std.Err	Coeff.	Std.Err	Coeff.	Std.Err	Coeff.	Std.Err
Gender	−0.014	0.209	0.294	0.179	−0.206	0.235	−0.117	0.174	−0.431 *	0.251
Marital status	−0.253	0.218	0.258	0.194	−0.175	0.281	0.053	0.193	0.429 *	0.242
Household size	−0.027	0.037	0.012	0.032	−0.064	0.052	0.002	0.033	−0.069 *	0.036
Years of formal education	0.060 **	0.264	0.050 **	0.021	0.128 ***	0.031	0.024	0.021	0.082 ***	0.029
Farming experience	0.021	0.016	−0.017	0.013	0.014	0.019	−0.021	0.131	0.002	0.015
Sources of income	0.007	0.077	0.055	0.068	0.299 ***	0.114	−0.080	0.069	−0.069	0.088
Average annual income	−3.29	2.81	6.02 **	2.51	0.000 ***	0.304	1.36	2.39	0.000 ***	3.91
Average off-farm income	−2.84	0.00	−0.000	0.000	0.000	0.000	0.000	0.000	−6.33	0.000

Farmer group/organization	−0.622 *	0.340	0.624 **	0.285	0.297	0.388	0.571 **	0.289	0.273	0.334
Satisfaction with extension services	0.589 **	0.253	−0.039	0.194	−0.043	0.265	0.096	0.194	0.577 **	0.82
Sources of water	−0.298	0.105	−0.019	0.092	0.163	0.123	−0.056	0.091	0.232 **	0.109
Constant	0.669	1.159	−2.495	0.988	−2.005	1.329	0.487	0.967	−0.535	1.270
N	294									
Wald chi (75)	220.24									
Log-likelihood	−675.113									
Prob > chi2	0.000									

*, **, and *** indicate statistical significance at $p < 0.1$, $p < 0.05$ and $p < 0.01$ levels, respectively. CCs = cover crops, A&G manure = animal and green manure, IPM = integrated pest management. Source: Author's calculation.

4. Discussion

4.1. Smallholder Crop Farmers' Socio-Economic Attributes

The respondents' average mean age (59.12 years) suggests that most smallholder crop farmers participating in crop production in the surveyed area are aging and approaching the pinnacle of their years. This has the potential to affect the adoption of SFPs adversely. As stated by Ntshangase [18], young people are more inclined to adopt modern farming practices like SFPs and related technologies, which are crucial for advancing agriculture. These findings are consistent with those of Oyetunde-Usman et al. [12], who discovered that young people are not actively engaging in agricultural-related activities. The research found that a notable percentage (65%) of smallholder crop farmers involved in crop production within the study area were females. This finding aligns with previous research studies that have established women as a significant workforce in crop production, surpassing men [33]. However, Baffoe-Asare et al. [34] opined that male smallholder farmers are generally more resource-rich than their female counterparts. This is because women are frequently limited in terms of resources, such as land, because of the values upheld by their social and cultural institutions. Therefore, this might probably hinder female farmers from adopting modern farming practices due to a lack of necessary capital resources [35,36]. In addition, a majority (75%) of the smallholder crop farmers reported being married, which may be attributed to the fact that these farmers are older and more family oriented, as highlighted in the household size analysis and the farmers' ages.

Moreover, an average household size of six individuals suggests that most of the farmers have quite a large size. Hence, it is pertinent for them to adopt and utilize SFPs and related technologies to enhance their crop productivity, thereby ensuring an adequate food supply for their families [37]. The overall mean average of 6 years of formal education indicates that many of the respondents in the study area have not completed primary school, which generally lasts for seven years in SA. This situation is concerning, as a higher level of education is thought to enhance farmers' comprehension of instructions and increase their chances of adopting modern farming practices, including SFPs. For instance, in their study, Nyambose and Jumbe [38] found that farmers with higher levels of education are more inclined to adopt no-till conservation agriculture than farmers with lower education levels. In addition, a significant proportion (80.3%) of the farmers belonged to a particular farmer group or organization. As stated by Cheteni [39], farmers' associations serve as a fertile platform for exchanging and disseminating new ideas, including information related to sustainable farming, thereby keeping farmers informed about these practices. Also, the average monthly off-farm income of R4107.31 indicates that the farmers' monthly off-farm income is far below the stipulated monthly minimum national wage of R4854.08 [40], placing them in an unfavorable position to keep up with the current economic trends and agricultural market inflation.

Furthermore, the results reveal that a significant proportion (86.4%) of the respondents in the study area did not have an income-paying job aside from farming. The lack of income-paying jobs could be attributed to the fact that a significant proportion of the farmers in the area are already in their early 60s, suggesting that they might have retired and devoted most of their time to farming as the primary source of livelihood. This finding agrees with the results of Cheteni [39], who reported that a significant number of farming households in many rural parts of developing countries rely on subsistence farming as their primary source of income. The results further reveal that the majority (60.9%) of the farmers in the area relied both on rainfall and irrigation as the primary source of water for farming. None of the 294 participants chose irrigation as the primary source of water for crop production. Based on these findings, one can assume that the smallholder crop farmers in the area are still susceptible to water source fluctuations, as rainfall is a prominent source of water used solely or sometimes in conjunction with irrigation for crop farming. These findings are consistent with the results of Bachewe et al. [41], who reported that among the challenges facing rural African countries regarding endeavors to increase crop production is restricted access to water. Also, a majority (80.2%) of the respondents indicated that they have participated in one form of SFP-related training, which implies that these farmers possess basic knowledge of various SFPs, their application, and their associated benefits [42]. In addition, over two-thirds (69.7%) of the farmers indicated that the services rendered by extension officers were not satisfactory. These results confirm that most of the smallholder crop farmers in the area had limited access to effective extension services delivery. As reported by Aliber and Hall [43], the dissatisfaction expressed by these farmers regarding effective extension service delivery could possibly be because of a shortage of extension personnel and a lack of resources.

4.2. Perceived Benefits of Sustainable Farming Practices Among Smallholder Crop Farmers

The study's findings show that most of the farmers agreed that "crop rotation plays a crucial role in enhancing the utilization of sunlight, nutrients and water" as this variable was ranked first. This agrees with the findings of Turyahabwe et al. [44], who observed that crop rotation is the most common practice among farmers in Eastern Uganda, with 51% of them indicating that they regularly rotate crops by planting different ones on the same plot of land throughout successive seasons. Furthermore, the farmers also agreed that "sustainable farming practices play an important role in preserving the quality of the environment, water and soil", as this was ranked second. This demonstrates that the majority of the respondents in the surveyed area were aware that sustainable farming not only boosts crop productivity but also plays a vital role in safeguarding the quality of the soil and other essential environmental resources. This finding concurs with the findings of Semuroh and Sumin [45], who found that a significant proportion of smallholders believed that adopting and using SFPs would help mitigate negative environmental impacts. Also, the farmers agreed that the "application of animal and green manure plays an important role in building soil organic matter and soil structure", as this was ranked third. This indicates that smallholders are cognizant and recognize the importance of maintaining the soil in a high-quality condition through the utilization of manure, which has been scientifically demonstrated to enhance the quality and nutrient content of the soil to enable optimal crop development. In addition, the farmers disagreed with the statement that says, "crop rotation cannot suppress weeds, diseases and pests", as this variable was ranked fourth, with a mean of 4.12. This aligns with the findings of Mohler [46], which suggested that crop rotation is an essential component of all organic cropping systems due to its pivotal role in cultivating fertile soils, effectively managing pests, and yielding a range of additional advantages. Lastly, the farmers agreed that SFPs remain an important strategy to improve farm production, as this variable was ranked fifth. This underscores the vital role of various sustainable practices in boosting crop productivity, thus increasing the overall farm profitability [15].

4.3. Adoption of Sustainable Farming Practices by Smallholder Crop Farmers

The results reveal that a significant proportion (97.6%) of the respondents adopted crop rotation, which ranked first among the SFPs adopted by the farmers in the surveyed area. The involvement of most smallholder crop farmers in crop rotation can be attributed to its cost-effectiveness and potential to boost yields and soil quality if implemented correctly. This may further suggest that farmers possessed an understanding of the significant impact of this practice in farming [39,47]. In addition, the majority (82.3%) of the smallholder crop farmers adopted IPM, as it was ranked second. This may be attributed to the susceptibility of vegetable crops to a range of plant diseases that hinder their growth and development. This corroborates the results of Chepchirchir et al. [48], who postulated that IPM practices can effectively reduce the harm inflicted by diverse plant diseases, thereby promoting their crops' robust growth and development. Thus, the farmers leverage this practice to enhance their crop productivity and overall farm profit. The results further reveal that cover crops and mulching were ranked third and were adopted by 79.9% of the farmers. This finding is not surprising given that after harvesting, smallholder farmers often leave behind a residue of crops such as maize and cabbage in the soil beds to provide coverage to the soil surface [49] while safeguarding the quality of the top-fertile soil.

Furthermore, the findings show that over half (59.5%) of the respondents adopted animal and green manure and were ranked fourth. This finding corroborates the results of Tittonell et al. [50], who opined that manure has been scientifically proven to improve soil properties while enhancing crop growth. Thus, smallholder crop farmers leverage this practice to boost their crop productivity. Moreover, the results reveal that a little above average (53.4%) of farmers adopted intercropping, and it was the second-last adopted practice. Despite its potential to increase food production and enhance household income, the findings confirm that intercropping was among the least adopted sustainable practices in the area. This finding is consistent with the results of Myeni et al. [37], who, in their investigation, observed that 77% of the sampled farmers knew about intercropping. However, only 59% of the farmers were practicing it. Lastly, the results also show that only a few (23.1%) of the farmers adopted conservation tillage, and it was ranked last (sixth), thus confirming that conservation tillage was the least adopted practice among all the practices that were presented to the farmers. The low level of involvement of farmers in the adoption of conservation tillage could be ascribed to the financial constraints that limit farmers from purchasing conservation tillage inputs and associated technologies. This finding corroborates the findings of Umeh and Igwe [51], who found that rural farmers in many parts of developing countries faced financial difficulties in adopting advanced technologies such as irrigation technologies.

4.4. Constraints Hindering the Adoption of Sustainable Farming Practices

The results reveal that the high cost of SFP inputs and resources and the affordability of SFP-associated technologies were viewed as the topmost constraints faced by the farmers [51–53]. These results concur with the results of Michalscheck et al. [52], who observed that high costs associated with agricultural technologies often hinder the adoption of modern farming practices. Consequently, Olayemi et al. [53] noted that smallholder farmers from Shika and Bassawa ranked financial constraints as the significant barrier to the implementation of modern farming practices, followed by high costs of fertilizers. Also, the lack of government support and subsidies was another severe constraint, which implies that the government should acknowledge the fact that a significant proportion of smallholders lack the financial capacity to purchase and implement certain modern farming practices to scale up the adoption of SFPs. Consequently, the provision of input vouchers and subsidies will be crucial in accelerating the adoption of these practices.

Additionally, the "lack of access to credit facilities" corroborates the findings of Akinnagbe and John [54], who pointed out that access to credit facilities is an essential factor in effectively using conservation practices on farmland because farmers need financial resources to buy inputs and materials needed to practice conservation techniques in their farming environments. In addition, inadequate access to farm machineries for SFP adoption and inadequate access to farm inputs were the most severe constraints. This underscores the importance of the provision of farm inputs and resources to smallholders, as these resources aid in the adoption of SFPs. Moreover, inadequate access to training and workshops on SFPs was ranked seventh. It corroborated the results of Nakawuka et al. [55], who opined that for smallholders to embrace a particular modern farming practice such as SFPs, a significant amount of time should be dedicated to farmers' awareness, learning, and demonstration to ensure that farmers possess sufficient knowledge about the practices and related technologies. For instance, Jayasooriya and Aheeyar [56] observed that farmers' understanding of integrated pest management significantly impacted their implementation of related measures.

Furthermore, unpredictable weather patterns/extreme events and high risks associated with technologies utilized during SFP adoption were ranked eighth and ninth and collaborate with the findings of Kassie et al. [57], who observed that abundant rainfall can promote the growth of weeds and lead to increased water logging, which could have a detrimental impact on the adoption and use of inputs and technologies linked to conservation tillage. Moreover, inadequate dissemination of clear and reliable information by change agents was ranked tenth, while inadequate access to extension services and inadequate stakeholder support on SFP adoption were ranked eleventh and twelfth. These results support the apparent tendency that farmers accessing extension services increases their likelihood of adopting various modern farming practices. As stated by Mwangi and Kariuki [58], change agents and other relevant stakeholders play a vital role in helping farmers learn about the presence of modern farming practices as well as their practical usage, which increases the likelihood of their adoption. These findings are consistent with the results of Muriithi et al. [59], who observed that access to rural advisory services positively impacted the adoption of IPM practices in the suppression of mango-infesting fruit flies.

4.5. Smallholder Crop Farmers' Socio-Economic Determinants of Adoption of Sustainable Farming Practices in the Surveyed Area

The study's findings regarding socio-economic attributes affecting the adoption of SFPs by smallholder crop farmers analyzed through a multivariate probit regression model revealed that the farmer's gender was statistically significant at $p < 0.10$, with a coefficient of −0.431, demonstrating a negative correlation with the adoption of IPM practices. This indicates that male farmers were more inclined to adopt IPM methods than their female counterparts. This further suggests that female farmers are behind in adopting SFPs and related technologies, likely due to the gender disparities present in many rural areas of developing countries [60]. This result agrees with the findings of Mulwa et al. [61], who reported that gender significantly influences the adoption of "improved agricultural technologies". Moreover, a positive and significant ($p < 0.10$) relationship was found between the coefficient of marital status (0.429) and IPM adoption, suggesting that the marital status of the farmers influences the likelihood of adopting IPM. Marriage results in a larger household, subsequently leading to increased responsibilities for the farmers. Consequently, farmers are more likely to utilize SFPs, such as IPM, to combat pest infections, thereby increasing crop productivity and financial gains, which in turn helps to provide basic needs for their dependents. As pointed out by Verschelde et al. [62], an increased number of household members could serve as proxies for farm labor that could aid in carrying out various IPM methods. This result is corroborated by Kolapo et al. [63], who also found a significant correlation between marital status and the adoption of improved land management practices by smallholder maize farmers in Nigeria.

Years of formal education had a positive coefficient (0.060, 0.050, 0.128, and 0.082) and was statistically significantly associated with the adoption of cover crops ($p < 0.05$), intercropping ($p < 0.05$), conservation tillage ($p < 0.01$), and IPM ($p < 0.05$). This suggests that the likelihood of adopting these SFPs increases as the years of formal education increase. This is consistent with a priority expectation, as farmers with greater levels of formal education are expected to be able to make sound decisions about the financial risks and benefits of adopting SFPs and related technologies. This, thus, suggests that higher educational status increases farmers' awareness of the benefits associated with various SFPs, thus facilitating their decision on whether to leverage these practices. Similarly, Gido et al. [64] opined that farmers with higher education levels are more likely to be innovative and take calculated risks for effective farm adjustments, including the adoption of SFPs. Also, the results revealed that the household size of the respondents was statistically significant at $p < 0.10$ and with a coefficient of −0.069, indicating a negative relationship with the adoption of IPM. The negative coefficient obtained for household size implies that a unit increase of one (1) additional member of a farming household is more likely to induce a decrease in the adoption of IPM by 0.069. Farmers with large household sizes are faced with additional responsibilities, such as providing for their dependents. The limited funds that they generate from both farming and non-farming activities are primarily used to provide basic needs for their families. Consequently, they face challenges in allocating funds towards specific IPM methods, such as acquiring pesticides, which are considered costly to purchase. These findings corroborate the results of Kassie et al. [65], who reported that household size significantly affects the adoption of improved farming practices such as SFPs.

Furthermore, the average annual income generated by the smallholder crop farmers had a significant and positive influence on the adoption of intercropping (6.02: $p < 0.05$), conservation tillage (0.000: $p < 0.00$), and IPM (0.00: $p < 0.01$). This suggests that an increase in average annual household income will result in increased adoption of various SFPs and related technologies [66]. In addition, satisfaction with the services rendered by extension agents was seen to positively and significantly influence the adoption of cover cropping and mulching (0.589: $p < 0.05$) and IPM (0.578: $p < 0.05$). As posited by Bryan et al. [67], farming households that perceive the sustainable practices-related information rendered by extension agents as satisfactory are more likely to adopt SFPs. Conversely, those who perceive the services as unsatisfactory are less likely to adopt these practices. This is because extension agents are vital to the dissemination and adoption of SFPs, particularly in providing training and demonstrations of sustainable practices and related technologies. These findings are in line with the findings of Chalise et al. [68]. The coefficient of membership of farmer organizations was seen to positively and significantly influence the adoption of intercropping (0.624: $p < 0.05$) and animal and green manure (0.571: $p < 0.05$). These corroborate the results of Kassie et al. [65], who opined that this could be ascribed to the fact that members of farmer groups can share vital information and educate one another on new modern farming practices that are available in the agricultural markets.

These results agree with the findings of Oyewole and Sennuga [15], who also observed a positive correlation between the adoption of SFPs and membership of farmer groups.

Sources of income aside from farming (0.299) had a significant ($p < 0.01$) influence on the adoption of conservation tillage. This indicates that a unit increase in additional sources of income aside from farming activities is more likely to induce a 0.299 increase in the adoption of conservation tillage. This corroborates the results of Ojo and Baiyegunhi [69], who postulated that having off-farm income sources provides the farmers with increased capital to hire labor and procure machinery and inputs related to conservation tillage. The study also found that the source of water for irrigation (0.232) was statistically significant at $p < 0.05$ and positively influenced the adoption of IPM. This implies that smallholder crop farmers with access to quality clean water for irrigation are more likely to adopt SFPs, such as IPM. This is because access to readily available and sufficient water for crop farming has a crucial impact on the development of crops. This agrees with the finding of SA Grain [70], who opined that having sufficient water supply to enable field flooding is essential for reducing insect infestations, such as cutworms.

5. Theoretical Implications of the Study

This study significantly enhances the theoretical understanding of sustainable farming practices (SFPs) by highlighting how socio-economic attributes influence smallholder farmers' adoption decisions. The findings align with established theories of technology adoption and rural development, particularly the theory of planned behavior (TPB), innovation diffusion theory (IDT), and the sustainable livelihood framework. They demonstrate that farmers' decisions are not solely driven by environmental considerations but are also shaped by socio-economic conditions. The discovery that aspects such as education, gender, income levels, and household composition are pivotal suggests that the adoption of SFPs is deeply entrenched in the community's unique socio-cultural and economic fabric. This underscores the need for context-specific agricultural extension and rural advisory strategies. According to the TPB, which posits that behavior is guided by attitudes, social norms, and perceived behavioral control, the findings show that farmers' educational backgrounds and economic capacities enhance their control and ability to adopt SFPs. For example, higher levels of education positively correlate with SFP adoption, indicating that educated farmers are more likely to recognize the long-term benefits of these practices. Consequently, interventions promoting SFPs among smallholder farmers may be more effective if they include educational components tailored to the farmers' literacy levels.

Additionally, the study finds that off-farm income and other alternative revenue sources facilitate SFP adoption, suggesting that economic stability could increase farmers' confidence in embracing sustainable practices. This supports the TPB's notion that perceived behavioral control is influenced by resource availability. The study also aligns with the IDT by revealing varying adoption rates among different SFPs, such as the high adoption of crop rotation compared to the lower rates of intercropping and conservation tillage. This discrepancy indicates that certain innovations may be more appealing to farmers based on their perceived relative advantage, compatibility with existing practices, and complexity. For instance, crop rotation may be considered easier to integrate into current cropping systems, while conservation tillage may appear more resource-intensive or misaligned with local agricultural routines. This nuanced understanding of innovation adoption calls for strategies that consider the socio-economic and cultural dynamics affecting farmers' perceptions and choices regarding SFPs. Furthermore, in line with the sustainable livelihood framework (SLF), farmers' decisions to adopt SFPs as a livelihood strategy are influenced by their available resources and expectations of the resulting outcomes.

The decision to adopt or not adopt is shaped by various potential benefits, including increased yield, improved soil fertility, and enhanced farm revenue. The framework also emphasizes the importance of recognizing that various contextual elements, including environmental, socio-economic, and institutional factors, influence farmers' decisions to adopt sustainable farming practices. This study highlights the complex interaction between socio-economic attributes and adoption behavior, advocating for a comprehensive approach to scaling up SFPs that considers both the realities faced by smallholder farmers and the distinct characteristics of specific practices. By doing so, it contributes to a more holistic understanding of the adoption of SFPs and lays a good foundation for future research exploring multi-dimensional strategies that address the interconnected motivations and constraints influencing smallholder farmers' decisions in diverse agricultural settings.

6. Conclusions, Recommendations and Research Directions

This study evaluated the adoption of sustainable farming practices amongst smallholder crop farmers in South Africa, focusing on the Mbombela Local Municipality as the case study. A simple random sampling procedure was employed to elicit data from 294 smallholder crop farmers specializing in crop production. The data were collected using a structured questionnaire, and the analysis was performed using descriptive statistics and an inferential model. In line with previous research studies documenting the adoption and benefits associated with sustainable practices, this study confirms that SFPs are crucial for addressing the abiotic and biophysical challenges that hinder crop productivity in SSA. However, the adoption of these practices among smallholder farmers is still low and uneven in various rural parts of developing countries, such as MLM. Sustainable farming practices such as crop rotation, cover cropping, mulching, and IPM were the top-ranked adopted SFPs in the surveyed area. The smallholder crop farmers perceived these practices as beneficial in their farming environment in the following ways: "crop rotation plays a crucial role in enhancing the utilization of sunlight, nutrients and water, SFPs play an important role in preserving the quality of the environment, water, and soil; animal and green manure plays an important role in building soil organic matter, SFPs remain an important strategy to improve farm production. Nonetheless, practices such as intercropping and conservation tillage were least adopted by the farmers, and the low adoption could be attributed to some of the severe constraints that the study exposed. These severe constraints include but are not limited to high cost of SFPs inputs and resources, lack of access to credit facilities, inadequate access to farm inputs, inadequate access to training and workshops on SFPs, unpredictable weather patterns/extreme events, high risks associated with technologies utilized during SFPs adoption, inadequate dissemination of clear and reliable information by change agents and inadequate access to extension services". The study further revealed that farmers' socio-economic attributes such as "gender, marital status, household size, years of formal education, source of income, annual income, off-farm income, farmer group, satisfaction with extension services, and sources of water" play a significant role in influencing the adoption of SFPs among smallholder crop farmers in the surveyed area.

In light of these conclusions, the subsequent policy recommendations are proposed to enhance the adoption of SFPs among smallholder crop farmers while also safeguarding the sustainability of these practices. Firstly, the government and rural development stakeholders need to focus on interventions and strategies that ameliorate the prominent constraints highlighted by farmers that impede the adoption of sustainable farming practices (SFPs). Consequently, it is essential for the government to provide farmer-friendly initiatives, as well as credit and subsidy schemes, to reduce the financial burdens associated with the utilization of SFPs, thereby enhancing their affordability. Additionally, extension and rural advisory stakeholders need to pay more attention to ensuring that farmers' knowledge and perceptions regarding various SFPs and related technologies are improved, as this significantly influences their adoption decisions. Furthermore, extension agencies and advisors should intensify efforts to disseminate less-adopted sustainable farming practices among smallholder crop farmers to increase their adoption. This can be achieved by creating programs to monitor the adoption rates of various SFPs, identifying factors that contribute to low adoption levels, and collaborating with farmers to identify viable solutions to the challenges associated with the low adoption of these practices.

The study primarily examined smallholder farmers specializing in crop production during the study year under consideration, and it was not within the scope of this study to sample smallholder farmers who focused exclusively on livestock production. Furthermore, the outcomes of this study were based on data gathered exclusively from smallholder farmers specializing in crop production in Mbombela, SA. The study is further limited by the fact that the majority of the smallholders did not speak English fluently. Hence, translation to their native language took up the majority of the time, leading to the presumption that the provided answers were accurate. Future research should also be conducted to empirically examine the perceived effectiveness of sustainable farming practices in improving the livelihoods of smallholder crop farmers in the study area, thereby ensuring the sustainable development of smallholders and the sustainability of these practices.

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