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Barriers Affecting Sustainable Agricultural Productivity of Smallholder Farmers in the Eastern Free State of South Africa

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Abstract: Sustainable Agricultural Practices (SAPs) are the most promising pathways to enhance the productivity and resilience of agricultural production of smallholder farming systems while conserving the natural resources. This study was undertaken to identify the barriers affecting sustainable agricultural productivity of smallholder farmers in the eastern Free State, South Africa. Data were collected from 359 smallholder farmers using questionnaires and the validity of the collected data was confirmed through focus group discussions with key informants. Descriptive statistics and a binary logistic regression model were used to analyze data. Results indicated that traditional SAPs such as intercropping, mulching and crop rotation were more likely to be adopted by farmers with access to land yet without access to credit (and had low levels of education, although this finding was not significant). In contrast, new SAPs such as cover cropping, minimum-tillage, tied ridging and planting pits were more knowledge (education), capital and labor intensive. Therefore, extension strategies should take these differences into consideration when promoting both the adoption of traditional SAPs and new SAPs. Targeting resource-constrained farmers (in terms of access to credit and education) through raising awareness and building capacity is essential to ensure the adoption of traditional SAPs. In turn, promoting the adoption of new SAPs not only needs awareness raising and capacity building but also must fundamentally address resource constraints of South African smallholder farmers such as knowledge, capital and labor. It is recommended that government should provide resources and infrastructure to improve the quality and outreach of extension services through field demonstration trials and training.

Keywords: adoption; extension services; intensification; smallholder farming; sustainability; rainfed cropping

1. Introduction

Despite past efforts made by agricultural researchers, extension services and government institutions, crop production in South African smallholder farms remains lower than the potential for the land [1–3]. The low yields obtained are attributed to prolonged droughts, longer dry spells, limited water and nutrient availability, degraded soils and inefficient farming practices [4–6]. The predicted increase in incidences of floods, droughts, longer dry spells, rainfall variability and elevated air temperatures posed by climate change threaten the sustainability of rainfed crop production [7–9].

Consequently, climate change will potentially affect food security and the livelihoods of the majority of South African smallholder farmers, who are primarily dependent on rainfed agricultural production and have a narrow adaptation capacity [8,9].

According to Goldblatt [10], the population of South Africa is expected to grow from 57 million to 82 million by the year 2035. In order to feed this rapidly increasing population under social, climate and land use change, food production must be based on sustainable agricultural productivity [10]. This is a viable approach of improving crop yields from the existing land through optimized external inputs and efficient use of available resources while reducing adverse environmental impacts and building resilience, natural capital and the flow of environmental services [11–13]. Therefore, Sustainable Agricultural Practices (SAPs), such as minimum tillage, planting in pits, mulching, intercropping, crop rotation, use of crop cover, green and animal manure, rainwater harvesting and planting on contour and ridges, have been recommended to enhance the productivity and resilience of agricultural production of smallholder farming systems, while conserving the natural resources [6,14–16]. However, the impact of SAPs will only be recognized if most smallholder farmers accept and adopt those practices [17]. In recent years, huge efforts were made by various African research agencies, non-governmental organizations, international organizations and donors to validate, implement and promote these SAPs across the African regions. Despite the well documented yield improvements, nitrogen and water-use efficiency, economic and environmental benefits attributed to these SAPs, adoption levels by South African smallholder farmers are still very low [2,6,16,17].

Previous studies across the African continent indicated that socio-economic factors, farm characteristics and agro-climatic zone characteristics were the main factors influencing adoption of SAPs by smallholder farmers [18–21]. Therefore, factors influencing adoption of SAPs varies with countries and regions as a result of differences in cultural and political ideologies, natural resources community access to education, adequate information on the technical details of the SAPs, extension services, credits and infrastructure [13,22,23]. Given the wide diversity of South African regions, understanding the barriers that influence or hinder adoption of SAPs across the country is essential in order to develop interventions to enhance the adoption process, as targeting those barriers can improve the adoption of SAPs, not only in the study area but also in other regions that face the same barriers. A few studies have been conducted to identify the barriers and major constraints limiting the adoption of the most promising SAPs across South Africa [3,17,24]. However, these studies have only focused on conservation agriculture as one of the SAPs. Consequently, the challenges hindering smallholder farmers from adopting other SAPs have not been investigated in detail in this country. Therefore, the main aim of this study was to identify the barriers affecting sustainable agricultural productivity of smallholder farmers in the eastern Free State, South Africa. Firstly, we describe the effects of demographic and socio-economic characteristics on agricultural productivity of smallholder farmers in the study area. Secondly, we determine the knowledge and extent of adoption of SAPs by those farmers. Thirdly, we determine the key barriers to their adoption of SAPs. Finally, we suggest relevant strategies to increase the sustainable agricultural productivity of the smallholder farmers in the study area.

2. Study Site Description

The study was conducted at Harrismith and Phuthaditjhaba, within the Maluti-a-Phofung municipality, located in the eastern parts of Thabo Mofutsanyana district in the Free State Province of South Africa (Figure 1). Free State is the third-largest province in the country, situated between latitudes 26.6° S and 30.7° S and between longitudes 24.3° E and 29.8° E [25,26]. According to Department of Agriculture, Forestry and Fisheries [25], the main economic activities contributing significantly towards the gross domestic product of the province are community service (24.7%), agriculture (20.1%), trade (10.7%) and mining (9.6%). About 30% of the national maize production is produced in the Free State, thus contributing significantly to the agricultural economy of the country [6]. Most of the agricultural production in the province is under rainfed conditions, with less than 10% of the arable land being under irrigation [5,26–28].

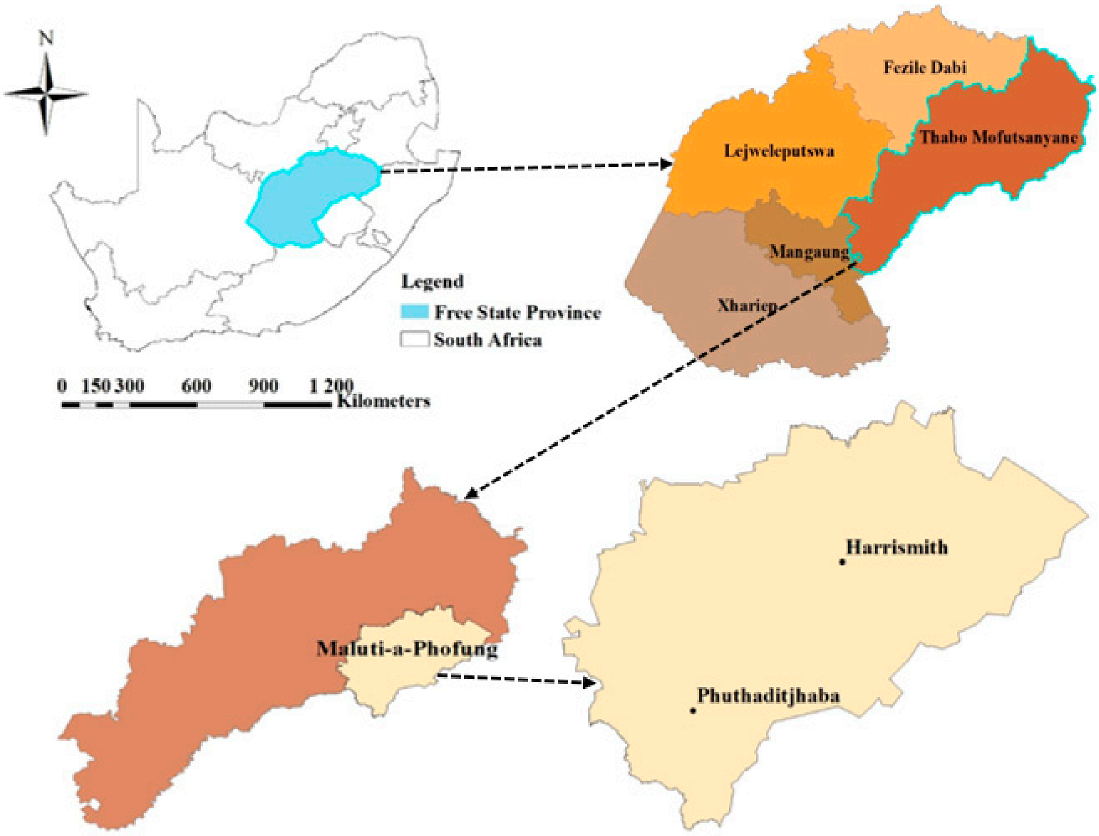

Figure 1. Location of Harrismith and Phuthaditjhaba, within the Maluti-a-Phofung municipality of Thabo Mofutsanyana district in eastern Free State, South Africa.

The climate in the Maluti-a-Phofung municipality is characterized by hot, humid summers and cold winters [29]. The municipality experiences frequent snowfalls during winter, especially on the higher mountain ranges [29]. Rainfall in this area occurs mainly in summer as brief afternoon thunderstorms [30]. Moeletsi and Walker [5] reported the high spatial rainfall variability which is influenced by orographic patterns this region. According to Moeletsi and Walker [5], there are early onset (before the second dekad of November) and relatively late cessation (after the second dekad of May) of rains at Thabo Mofutsanyana and the rest of eastern Free State compared to western parts of the province. Annual rainfall in the western and southern parts of the province often remains below 400 mm, whereas much of the eastern parts receives between 500 and 600 mm of rainfall per annum [5]. Therefore, eastern parts of Free State are highly suitable for dryland crop production compared to dry areas in the western and southern parts of the province [5]. Longer dry spells and droughts which often occur during summer months (December to February) are amongst the major agro-climatological hazards which affect agricultural production in Free State [26,31]. This makes soil-water conservation and efficient use of soil moisture very important for sustainable agricultural production in this region. According to Moeletsi et al. [31], eastern, northern and south-eastern parts have a shorter growing period of less than 240 days as a result of early onset (mid-March) and late cessation (mid-October) of frost in these regions. Therefore, early and ultra-early cultivars are recommended in the eastern, northern and south-eastern parts of this province to reduce vulnerability to the frosts [21].

3. Materials and Methods

3.1. Data Collection

Data for this study was collected from the smallholder farmers located in the eastern Free State as part of the InnovAfrica project (http://www.innovafrica.eu/). The aim of this multi-country international project was to validate the most promising innovative SAPs and Extension Advisory Systems (EASs) through farmer-led implementation supported by Multi-Actor Platforms (MAPs) for wider adoption by smallholder farmers in eastern and southern Africa. One of the aims of this project was to understand the demographic and socio-economic characteristics of households at initial stage of the project. Data from eastern Free State were collected using online software in the year 2018 by the Agricultural Research Council (ARC) through a pretested, structured questionnaire survey (https://service.ki-ag.com/innovafrica/#!). This study used a systematic random sampling procedure targeting smallholder farmers in Maluti-a-Phofung municipality for primary data collection. In selecting a representative sample of the study area, all local extension officers provided lists of smallholder farmers in their wards. As the majority of smallholder farmers were not registered with local extension officers, in addition to the list provided, all smallholder farmers from each ward that had backyard gardens and willing to participate were included. A total of 359 smallholder farmers from different villages in the Harrismith and Phuthaditjhaba areas were interviewed to examine the factors affecting sustainable agricultural production in this region. The main characteristics of the household head such as age, gender, level of education, major occupation, total income, access to land, hired labor, agricultural extension and agricultural credit, ownership of equipment and livestock, as well knowledge and practices of different SAPs, were investigated. Prior to the data collection process, a total of 10 enumerators from the study area were trained to assist with data collection. Enumerators interviewed a household head or any other senior family member in case where the household head was not available at the time for interview. The questionnaire was translated to the native Sesotho language. Collected data were compiled in Microsoft Excel spreadsheets for cleaning process to identify missing data, errors and suspect data. Focus group discussion meetings were held with extension officers, MAPs and farmers as key informants to confirm the validity of the collected data.

3.2. Data Analysis

3.2.1. Demographic and Socio-Economic Characterization of Smallholder Farmers

The collected data from the questionnaires were coded by assigning a numerical value for easier analysis. The descriptive statistics were used to analyze continuous variables such as age, gender, education, occupation, income, access to land, extension services and credit, hired labor, ownership of equipment and livestock. Statistical Package for the Social Sciences (SPSS) version 23.0 was used to process data and for statistical analysis.

3.2.2. Explanatory Variables for a Binary Logistic Regression Model

Binary logistic regression model with a dependent variable (adoption of SAPs) against demographic, socio-economic and farm characteristics as explanatory variables was used to analyze the factors influencing the adoption of SAPs. The major demographic, socio-economic and farm characteristics factors that influenced adoption of SAPs in this study area were hypothesized to be age, gender, education, occupation, off-farm income, on-farm income, ownership of farm equipment, ownership of livestock, access to hired labor, awareness of SAPs, access to land, access to credit and access to extension services based on literature [3,17,24,32–34].

For ownership of farm equipment, the response variable was whether or not the farmer owned at least two of the technical farm equipment such as irrigation equipment, planter, tractor, pray pump and water tanks. For ownership of livestock, the response variable was whether or not the farmer owned any livestock. For access to hired labor, the response variable was whether or not the farmer had ever hired labor either during land preparation, planting, weeding or harvesting. For awareness of SAPs, the response variable was whether or not the farmer knew at least three of SAPs. For access to land, the response variable was the size of land parcel the farmer owned. For access to credit, the response variable was whether or not the farmer had took any credit for crop production within the last 12 months. For access to extension service, the response variable was whether or not the farmer had received any advisories regarding crop production from local extension officers within the last 12 months.

Responses on dependent variable were categorized into two groups, i.e., traditional SAPs and new SAPs. The traditional SAPs consisted of less knowledge-intensive practices that require minimal external inputs such as intercropping, mulching and crop rotation while new SAPs consisted of labor and knowledge-intensive practices such as cover cropping, minimum-tillage, tied ridging and planting pits which were not common in the study area. For the traditional SAPs as dependent variable, the response variable was whether or not the farmer had adopted at least two practices from traditional SAPs. For the new SAPs as dependent variable, the response variable was whether or not the farmer had adopted at least two practices from new SAPs.

4. Results and Discussion

4.1. Demographic and Socio-Economic Characterization of Smallholder Farmers

Demographic and socio-economic characterization of households is essential to understand the factors influencing or hindering sustainable agricultural productivity of smallholder famers at household level [35,36]. Demographic and socio-economic data obtained from the household survey are presented in Table 1.

Table 1. Demographic and socio-economic characteristics of smallholder farmers in the study area.

Variables	Description	Mean	Std. Dev	Min	Max
Household Head Characteristics					
Age	20–35 (years)	0.080	0.271	20	35
	36–51 (years)	0.245	0.430	36	51
	52–66 (years)	0.410	0.492	52	66
	>67 (years)	0.264	0.441	67	95
Gender	Male (1/0)	0.520	0.500	0	1
Education	No formal education (years)	0.282	0.500	0	0
	Adult education (years)	0.020	0.140	1	12
	Primary education (years)	0.292	0.455	1	11
	Secondary education (years)	0.365	0.481	8	16
	Tertiary education (years)	0.035	0.183	15	20
Occupation	Own or family farming (1/0)	0.742	0.438	0	1
	Self-employed (1/0)	0.067	0.249	0	1
	Employed in other sector (1/0)	0.191	0.393	0	1
Monthly on-farm income	0 South African Rand (ZAR)	0.785	0.411	0	0
	10–500 (ZAR)	0.127	0.332	100	500
	5010–2000 (ZAR)	0.063	0.243	700	2000
	>2010 (ZAR)	0.022	0.147	2400	5000
Monthly off-farm income	<500 (ZAR)	0.082	0.275	0	380
	500–1000 (ZAR)	0.140	0.348	500	1000
	1010–2000 (ZAR)	0.581	0.493	1140	2000
	2010–5000 (ZAR)	0.165	0.371	2080	5000
	5010–10,000 (ZAR)	0.022	0.147	6000	8500
	>10,000 (ZAR)	0.008	0.091	11,000	20,000
Hired labor	Hired labor (1/0)	0.159	0.365	0	1
Total area owned	<0.25 (ha)	0.144	0.352	0.03	0.25
	0.25–0.5 (ha)	0.361	0.480	0.3	0.50
	0.51–1.0 (ha)	0.383	0.486	0.6	1
	1.1–2.0 (ha)	0.078	0.238	1.2	2
	>2 (ha)	0.031	0.172	2.5	4

Table 1. *Cont.*

Variables	Description	Mean	Std. Dev	Min	Max
Farm equipment owned	Irrigation equipment (1/0)	0.178	0.382	0	1
	Planter (1/0)	0.002	0.045	0	1
	Tractor (1/0)	0.014	0.117	0	1
	Spray pump (1/0)	0.146	0.353	0	1
	Water tanks (1/0)	0.020	0.140	0	1
Livestock owned	Cattle (1/0)	0.121	0.326	0	1
	Sheep (1/0)	0.015	0.121	0	1
	Goat (1/0)	0.010	0.099	0	1
	Poultry (1/0)	0.043	0.203	0	1
	Pig (1/0)	0.007	0.081	0	1
Extension services	Access to extension services (1/0)	0.008	0.091	0	1
Credit	Access to credit (1/0)	0.017	0.128	0	1

4.1.1. Age

Responses on age of the household head were categorized into four groups from 20 to above 67 years. The results revealed that 41% of farmers were between 52–66 years, 26% were above 67 years and only 8% of farmers were between 20-35 years. These findings confirmed that most of the farmers in the Maluti-a-Phofung municipality are above 51 years as reported by [37]. According to Brown [38], youth in South Africa (<35 years) are less involved in farming even with the high unemployment rate (>70%). This is a concern that needs to be addressed at high-level as future agricultural productivity will be hampered if there is low involvement of youth in agriculture, who are often more likely to adopt new technologies [17,39]. In some areas, this is evident as the area of fallow land is increasing with time [40]. The low involvement in farming by youth could be attributed to their emigration from rural to urban areas in search for better opportunities and lifestyles [38].

Previous studies have indicated that older farmers are less likely to adopt new sustainable practices and often rely on their indigenous knowledge to manage their farms [18,35,41]. However, their indigenous knowledge is becoming unreliable due to climate change and variability [42,43]. Therefore, integration of indigenous knowledge and scientific agricultural management practices seems to be a key for sustainable agricultural productivity of smallholder farmers [44].

4.1.2. Gender

The study results revealed that 52% of the household farms were headed by men. These findings do not coincide with previous studies which identified women as the predominant working force in crop production over men [33,37,44]. The findings could be attributed to the emigration of retired males (>65 years) from urban areas to rural homelands [45]. The retired male could be involved in farming to supplement their retirement packages, consequently increasing the male expected percentage of respondents. Furthermore, the unexpectedly greater number of male respondents could also be attributed to the cultural ideology that males are the heads of the families and are often the ones answering the questions in the survey despite the possibility of a wife being the main working force of the household farm [46]. Cultural ideologies of men being superior to women has resulted to gender inequalities that has left majority of black women without land and not involved in major decision-making at household level, even after 25 years of democracy [47]. In practice, women in rural communities can only acquire land from Traditional Authority if they are linked to a man through marriage or family linkages [48].

4.1.3. Education

Responses on education were categorized into five groups indicating the level of education of farmers from no formal education (no certificate attained for particular training) to tertiary level. Results revealed that about 37% of farmers had attained secondary education, 29% had attained primary education, 28% had no formal education, 4% had attained tertiary education and only 2% had attained adult education. These findings confirmed that the majority of South African smallholder farmers have limited education [49,50]. Low literacy levels in the region have an indirect impact on agricultural productivity as new technological advancements and information require a certain level of formal education and training [2,42]. Most SAPs are often presented in complex academic language, which makes it difficult for illiterate farmers to make use of them [51,52]. Therefore, farmers with higher levels of formal education are likely to adopt new sustainable agricultural management practices [33,34,53,54]. They have the ability to search, process, interpret and respond to new information on the SAPs much faster than their counterparts with no formal education or training. In contrast, farmers with higher levels of formal education and training are more likely to adopt these practices [54].

4.1.4. Occupation

The study results revealed that own or family farming was the main occupation for the majority of household heads at about 74%. Others were employed in farm work as casual labor (seasonal), public or private sector and non-governmental organization (19%) while only 7% were self-employed. These findings confirmed that the majority of South African communities in rural areas depend mainly on agriculture for their food security and livelihoods as a result of the high unemployment rate [2,24,55–57]. Consequently, smallholder farming systems have been identified by several authors as the vehicle through which poverty alleviation and rural development can be achieved [2,57,58]. National development plan [57] stressed the need for investment in smallholder agriculture to ensure food security and alleviate poverty in South Africa.

4.1.5. Monthly Income

Total monthly income of households included both on-farm and off-farm sources of income. Response of on-farm monthly income was categorized into four groups indicating the rate of income of the farmer from ZAR 0.00 to above ZAR 2 010.00 (USD 140.31) per month. The study results revealed that majority of the farmers (79%) were not making any income from their farms and 13% earned between ZAR 10.00–500.00 (USD 0.70–34.90), followed by 6% who earn between ZAR 510.00–2 000.00 (USD 34.90–139.62), while only 2% of the farmers earned above ZAR 2 010 00.00 (USD 140.31) per month from their farms. Response on off-farm monthly income was categorized into six groups indicating the rate of income of the farmer from less than ZAR 500.00 (USD 34.90) to above ZAR 10 000.00 (USD 698.08) per month. About 58% of the farmers earned between ZAR 1 010.00–2 000.00 (USD 70.51–139.62), followed by 24% of farmers who earned between ZAR 500.00–1000.00 (USD 34.90–69.81), while only 1% of farmers earned above ZAR 10 000.00 (USD 698.08) per month. This study indicated that the mean for off-farm income in the study area was R1 901.78, which is less than the average of R2 732.00 (USD 190.72) per month reported by Pienaar and Traub [59] for South African smallholder farmers.

These results revealed that although farming was the major occupation in the study area, off-farm income was the main source of income for most households. These findings suggested that the majority of the smallholder farmers produce for subsistence under rainfed farming systems and a very small number of their produce reach the market, as reported by Pienaar and Traub [59]. Consequently, the main sources of income were old age and child-support social grants while very few farmers received remittances [59]. These findings also confirmed that most of the older South African smallholder farmers (>60 years) supplement their social grants income by subsistence farming [50,60]. These findings further confirmed that most of the South African smallholder farmers have limited income, which hinders them from adopting labor-intensive SAPs that require sophisticated equipment and financial investment [49,53]. Moreover, limited income could hinders smallholder farmers from adopting SAPs such as conservation agriculture, which relies on relative expensive herbicide for weed control [34,61].

4.1.6. Hired Labor

The study results revealed that only 15% of the household farms had hired labor, while majority (85%) of the farmers had never hired labor in their farms as a result of their limited total income.

The limited labor could hinders smallholder farmers from adopting labor-intensive SAPs such as conservation agriculture, rainwater harvesting, planting on contour and ridges [61,62].

4.1.7. Total area Owned

Responses on total area owned by a farmer were categorized into five groups indicating the sizes of the farms from less than 0.25 ha to greater than 2 ha. About 38% of the farmers have farm sizes between 0.51 and 1.0 ha, followed by 36% of farmers who have farm sizes between 0.25 and 0.51 ha; only 3% have farm sizes of greater than 2 ha per household. These findings correspond with previous studies which reported that most of the South African smallholder farmers own less than 2 ha of land [3,24,58]. These findings confirmed that most of the South African smallholder farming community, which is dominated by resource-poor black farmers and who are mainly farming on former homeland areas, own about 13% of the total agricultural land [47,49,55,58]. In contrast, the well-developed commercial farming community, which is dominated by white farmers, own about 87% of the total agricultural land [55]. The dualistic nature and division between the commercial farming and smallholder farming systems can be attributed to the past laws and injustices associated with apartheid in South Africa [63]. Moreover, apartheid resulted in inequalities in the population that left the majority of the black population landless and sinking into continual poverty and food insecurity, even after more than 25 years of democracy [2,47,64]. Most of the South African land available to the rural communities for farming purposes is communally owned and administered by a Traditional Authority [65]. The communal ownership of land limits the adoption of SAPs which requires sophisticated equipment and financial investment as a result of huge uncertainties associated with this kind of land ownership. Farmers who own large land plots are more likely to invest in their farms and adopt SAPs [66].

4.1.8. Farm Equipment Owned

The study results revealed that the most technical farm equipment owned by farmers were irrigation equipment (18%), spray pumps (15%), tractors (2%) and water tanks (2%), while only 1% owned planters. Consequently, the majority of farmers relies on hand hoes for their farming activities such as planting and weeding. These findings confirmed that the majority of South African smallholder farmers lack farm equipment as reported by [34]. Limited access and lack of farming equipment such as tractors, rippers and planters as a result of financial constrains often delays and limit the use of appropriate equipment for sustainable crop productivity during land preparing and planting [17,44].

4.1.9. Livestock Owned

The results indicated that only 20% of farmers owned livestock, while the majority (80%) of the farmers had no livestock. The study results revealed that the most of the livestock owned by farmers were cattle (12%), poultry (4%), sheep (2%), goats (1%) and pigs (1%). These findings suggested that crop production was the main farming activity in the study area. Low livestock ownership could be attributed to the peri-urban nature of the study area and high theft of livestock [67]. Low livestock ownership could hinder smallholder farmers from adopting SAPs such as application of animal manure as an organic fertilizer to enhance soil fertility. Moreover, the low ownership of livestock could limit the use of livestock for draught power enabling smallholder farmers to animal-drawn planters for conservation tillage and easy transportation of farms inputs [68].

4.1.10. Extension Services

The study results revealed that the majority of farmers (99%) did not have access to extension services, with only 1% having access to extension advisory on crop production. The results confirmed that smallholder farmers receive limited access to extension services through formal organizations and Department of Agriculture extension advisory [69]. For example, Ortmann and King [70] reported that government extension advisors only visit smallholder farmers once a year in KwaZulu-Natal and their levels of education are very low. Diale [33] noted that local extension officers often had contact with individual farmer and most of the contacts with farmers were during farmers' mass meetings. Moreover, access to extension services is highly skewed towards certain farmers over others [71]. The low outreach of the extension officers may be attributed to shortages of staff, lack of resources and poor use of resources [71]. Most South African smallholder farmers prefer visits from local extension officers as their main source of information regarding SAPs, which are often presented in complex academic language and therefore difficult to use [52]. Previous studies have reported that farmers having access to good quality extension service are more likely to adopt SAPs [72,73]. In contrast, lack of technical information on how to effectively implement SAPs could limit adoption of practices by smallholder [53].

4.1.11. Credit

The study results revealed that only 2% of farmers had access to farm credit while the majority of farmers (98%) had never received credit for crop production. These results confirmed that South African smallholder farmers have very limited access to credit as a result of low income, old age and low level of education which hinders them to meet basic credit requirements [74,75]. Most credit institutions prefer lending money to farmers within economically active age groups and who have proof of reliable income stream [76]. Most South African smallholder farmers have no title deeds for their farms which hinders them from applying for loans to invest on their farms as a result of the lack of collateral [74]. The modeling study of Von Loeper [58] revealed that improved access to credit from banks has the potential to improve productivity of the smallholder farmers and allow them to participate in the modern South African economic agricultural value chains. Therefore, access to credit allows farmers to have enough capital to overcome the financial constraints that hinder them from adopting SAPs, which requires financial investment in expensive equipment and technology [49,53].

4.2. Knowledge and Extent of Adoption of the SAPs

4.2.1. Farmer's Knowledge on Sustainable Agricultural Practices

Knowledge is one of the most vital variables that could significantly influence or hinder adoption of different SAPs by smallholder farmers [17,72]. Data of knowledge on SAPs by smallholder farmers obtained from the household survey are presented in Table 2. The study results revealed that crop rotation and intercropping were the practices best known by farmers (both at 77%) while the least known practices were cover cropping (38%), minimum tillage (48%) and planting pits (49%). These findings confirmed that intercropping and crop rotation are the most common practices used to improve productivity of the area while sustaining the environment by smallholder farmers in the eastern Free State [77,78].

Table 2. Summary statistics on farmers who knew about Sustainable Agricultural Practices (SAPs).

SAPs	Mean	Standard Deviation	Min	Max
Cover cropping (1/0)	0.382	0.486	0	1
Crop rotation (1/0)	0.767	0.423	0	1
Intercropping (1/0)	0.767	0.423	0	1
Minimum tillage (1/0)	0.480	0.500	0	1
Mulching (1/0)	0.598	0.490	0	1
Planting pits (1/0)	0.485	0.500	0	1
Tied ridging (1/0)	0.611	0.487	0	1

4.2.2. Extent of Adoption of SAPs

After obtaining the percentage of farmers who knew about the different SAPs, data were further analyzed to obtain information on the percentage of farmers who were actually practicing these

SAPs (Table 3). Out of the 77% of respondents who knew about crop rotation, only 63% were actually practicing it. This study also indicated that out of the 77% of respondents who knew about intercropping, only 59% were actually practicing it. Furthermore, only 27% of the 38% of respondents who knew about cover cropping were actually practicing it. The study revealed that farmers adopt SAPs for various reasons. For example, most the farmers believed that crop rotation and intercropping increase crop yield and improve soil fertility. These findings confirmed that although farmers knew about these SAPs, the adoption level is still low as reported by previous studies [2,6,16,17].

Table 3. Summary statistics on number of SAPs practised by smallholder farmers.

SAPs	Mean	Std. Dev	Min	Max
Cover cropping (1/0)	0.271	0.445	0	1
Crop rotation (1/0)	0.627	0.483	0	1
Intercropping (1/0)	0.585	0.493	0	1
Minimum tillage (1/0)	0.525	0.499	0	1
Mulching (1/0)	0.407	0.491	0	1
Planting pits (1/0)	0.329	0.470	0	1
Tied ridging (1/0)	0.525	0.499	0	1

4.3. Barriers to Adoption of SAPs by Smallholder Farmers

4.3.1. Barriers to Adoption of Traditional SAPs by Smallholder Farmers

Results from a binary logistic regression model revealed that access to hired labor, awareness of traditional SAPs, access to land and access to credit were the main factors that had a significant effect ($p < 0.05$) on the adoption of traditional SAPs by smallholder farmers in the eastern Free State (Table 4). Although variables such as gender, age, level education, occupation, off-farm income, on-farm income, ownership of farm equipment, ownership of livestock and access to extension services were hypothesized to have an influence, they actually had no significant effect on the adoption of traditional SAPs in the study area.

Table 4. Estimation results on the adoption of traditional SAPs.

Explanatory Variables	Coefficients	Odds Ratios	Standard Error.	z	P > z
Gender	0.445	1.561	0.270	2.708	0.100
Age	0.004	1.004	0.012	0.114	0.736
Level of education	−0.013	0.987	0.036	0.131	0.718
Occupation	0.599	1.820	0.340	3.096	0.078
Off-farm income	0.000	1.000	0.000	1.744	0.187
On-farm income	0.000	1.000	0.000	0.336	0.562
Ownership of farm equipment	−0.076	0.927	0.280	0.074	0.320
Ownership of livestock	−0.336	0.715	0.338	0.990	0.320
Access to hired labor	0.880 *	2.411	0.404	4.738	0.030
Awareness of traditional SAPs	2.872 ***	17.675	0.366	61.532	0.000
Access to land	0.651 *	1.918	0.258	6.351	0.012
Access to credit	−2.737 *	0.065	1.229	4.960	0.026
Access to extension services	0.669	1.952	1.591	0.177	0.674
		Number of observations = 359			

Standard errors in parentheses (* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$).

4.3.2. Barriers to Adoption of New SAPs by Smallholder Farmers

Results from a binary logistic regression model revealed that age, level of education, off-farm income, ownership of livestock, access to hired labor and awareness of new SAPs were the main factors that had a significant effect ($p < 0.05$) on the adoption of new SAPs by smallholder farmers in the eastern Free State (Table 5). Although variables such as gender, occupation, on-farm income, ownership of farm equipment, access to land, access to credit and access to extension services were hypothesized to have an influence, they actually had no significant effect on the adoption of SAPs in the study area.

Table 5. Estimation results on the adoption of new SAPs.

Explanatory Variables	Coefficients	Odds Ratios	Std. Err.	z	P > z
Gender	0.347	1.415	0.281	1.522	0.217
Age	0.046 ***	1.048	0.013	12.599	0.000
Level of education	0.139 ***	1.149	0.039	12.580	0.000
Occupation	−0.436	0.647	0.355	1.503	0.220
Off-farm income	0.000 **	1.000	0.000	8.453	0.004
On-farm income	0.000	1.000	0.000	0.044	0.833
Ownership of farm equipment	1.392	0.559	0.298	3.820	0.051
Ownership of livestock	1.392 ***	4.024	0.340	16.794	0.000
Access to hired labor	1.165 **	0.312	0.417	7.782	0.005
Awareness of new SAPs	2.474 ***	11.876	0.484	26.118	0.000
Access to land	0.181	1.199	0.235	0.594	0.441
Access to credit	−0.358	0.699	0.970	0.136	0.712
Access to extension services	−0.667	0.513	1.592	0.176	0.675
		Number of observations = 359			

Standard errors in parentheses (* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$).

4.3.3. Overall Discussions

Only those variables that had a significant effect on the adoption of either traditional or new SAPs were discussed in this section.

Access to Hired Labor

The variable access to hired labor significantly and positively influences the adoption of both traditional SAPs (0.880) and new SAPs (1.392). For unit increase in access to hired labor, the odds of a farmer to adopt become 2.411 for traditional SAPs and 0.312 for new SAPs. These results suggested that farmers that have access to hired labor are more likely to adopt SAPs. Most of these SAPs are labor-intensive; therefore, farmers who are able to hire laborers are likely to adopt these practices. These findings are consistent with previous studies that have reported a positively influenced of access to hired labor in adoption of SAPs by smallholder farmers [62,68].

Awareness of SAPs

The variable awareness of SAPs was the most significant factor which positively influences the adoption of both traditional SAPs (2.872) and new SAPs (2.474). For unit increase in the awareness of these practices, the odds of a farmer to adopt are 17.675 for traditional SAPs and 11.876 for new SAPs. These results suggested that farmers are most likely to adopt the SAPs if they have knowledge about them. From the focus group discussion that was held in support of the questionnaires, lack of information remains the biggest barrier that farmers are facing in the study area. Considering that farming is a knowledge-intensive industry, many farmers do not have a single channel that serves as a comprehensive source for all their information needs [61,68]. Therefore, most of the farmers were unaware of the different agricultural practices they could adopt to sustain their crop productivity in the study area. Consequently, most of them rely on their indigenous knowledge of crop production, which they believe is more accurate and simpler to understand as opposed to the complex nature of scientific SAPs that require formal education and training [2]. These findings are consistent with previous studies that have stressed the importance of access to information and awareness for adoption of SAPs [34,68].

Access to Land

The variable access to land significantly and positively (0.651) influences only the adoption of traditional SAPs. For unit increase in access to land, the odds of a farmer to adopt are 1.918 for traditional SAPs. These results suggested that farmers having access to land are more likely to adopt traditional SAPs. In practice, most of the land in the study area is owned by older farmers who are less likely to adopt new SAPs and often rely on their traditional SAPs [18,35,41]. Farmers who own large land plots are more likely to invest in their farmers and adopt SAPs [33,62,66]. Land ownership provide collateral which enables farmers to acquire loans, which they could use to invest on their farms [74]. For farmers practicing integrated crop-livestock farming systems, access to land could provide large grazing land and enables them to retain crop residues, and hence improve the adoption of mulching as one of the SAPs [61].

Access to Credit

The variable access to credit significantly and negatively (−2.737) influences only the adoption of traditional SAPs. For unit increase in access to credit, the odds of a farmer to adopt are 0.065. These results suggested that farmers having access to credit are less likely to adopt traditional SAPs. These findings do not coincide with previous studies, which reported that farmers having access to credit are more likely to adopt SAPs to improve their productivity [17,58]. Most of the farmers in the study area have very limited access to credit as a result of their low income, old age and low level of education, while those who meet basic credit requirements are more likely to invest their money on other businesses, such as tuckshops, than agriculture. This could be attributed to the high level of uncertainties agricultural production as a result of poor crop yields associated with land degradation and climate change [4–6]. The communal ownership of land could also limits the financial investment in agriculture as a result of huge uncertainties associated with this kind of land ownership [66].

Age

The variable age significantly and positively (0.046) influences only the adoption of new SAPs. For unit increase in age, the odds of a farmer to adopt are 1.048. These results suggested that older farmers are more likely to adopt new SAPs, as also reported by [17]. These findings could be attributed to knowledge and experience that older farmers have gained over time, which allows them to adopt these SAPs, compared to their counterparts, which are young, lack experience and have poor access to resources such as land [17]. The receptiveness toward new SAPs among the older farmers is more likely to be attributed to the unreliability of their indigenous knowledge on crop production as a result of climate change and variability [42,43].

Level Education

The variable level of education significantly and positively (0.139) influences only the adoption of new SAPs. For unit increase in level of education, the odds of a farmer to adopt new SAPs are 1.149. These results suggested that farmers with higher level of education are likely to adopt these new SAPs, which are knowledge-intensive, as also reported by [17,54]. Most of the farmers with higher level of formal education and trainings have the ability to understand these new SAPs, which require a certain level of formal education and training [2,42].

Off-Farm Income

The variable off-farm income significantly and positively (0.000) influences only the adoption of new SAPs. For unit increase in off-farm income, the odds of a farmer to adopt new SAPs are 1.000. These results suggested that farmers with higher off-farm income are likely to adopt new SAPs. The positive contribution of off-farm income to adoption of new SAPs most probably comes through the improved farm liquidity, which they can use to hire labor, purchase inputs and sophisticated equipment required by some of these new SAPs [53,61].

Ownership of Livestock

The variable ownership of livestock significantly and positively (1.392) influences only the adoption of new SAPs. For unit increase in the ownership of livestock, the odds of a farmer to adopt new SAPs are 4.024. The positive contribution of livestock to adoption of new SAPs most probably comes through the increased availability of animal manure, which is often used by farmers to enhance soil fertility as a result of financial constrains, which limit them from buying organic fertilizers. Ownership of livestock enables farmers to generate extra income from sales of livestock, which they can use to purchase inputs, implements and hire the laborers required for SAPs, as also noted by Mutyasira et al. [68]. Farmers owning livestock are likely to adopt SAPs, which improve crop production, to secure feed for their livestock, especially during dry seasons.

5. Conclusions and Recommendations

The main aim of this study was to identify the barriers affecting sustainable agricultural productivity of smallholder farmers in the eastern Free State, South Africa. The study indicated that although farmers knew about Sustainable Agricultural Practices (SAPs), the level of adoption is still low. The results further highlighted the contracting factors affecting traditional SAPs and new SAPs. Results indicated that traditional SAPs such as intercropping, mulching and crop rotation were more likely to be adopted by farmers with access to land yet without access to credit (and had low levels of education, although this finding was not significant). In contrast, new SAPs such as cover cropping, minimum-tillage, tied ridging and planting pits were more knowledge (education), capital and labor intensive. Therefore, extension strategies should take these differences into consideration when promoting both the adoption of traditional SAPs and new SAPs. Targeting resource-constrained farmers (in terms of access to credit and education) through raising awareness and building capacity is essential to ensure the adoption of traditional SAPs. In turn, promoting the adoption of new SAPs not only needs awareness raising and capacity building but also must fundamentally address resource constraints of South African smallholder farmers such as knowledge, capital and labor.

The findings of this study suggested that extension services have a crucial role to play in sustainable agricultural productivity through awareness raising, capacity building and the provision of up-to-date information on SAPs, input supply, early warnings on droughts, climate change adaptation strategies, weather forecasts, access to markets and credits. Therefore, there is a significant need to improve the quality and outreach of extension services. Most of the information used by South African smallholder farmers, who are generally illiterate and lack skills, is through verbal and personal experience. Consequently, they need to be exposed to field demonstration trials and training. Therefore, it is recommended that future interventions on promoting SAPs should demonstrate the economic, social and environmental benefits of adopting SAPs at the local level. Moreover, it is recommended that extension services should conduct farmer-led trials for meaningful farmer involvement, learning, adoption and adaptation of the SAPs at local level.

Access to extension services is the vehicle through which sustainable agricultural productivity can be achieved. Therefore, it is recommended that government should provide resources and infrastructure to improve the quality of extension services accessed by smallholder farmers in the study area. It is also suggested that government policies should encourage farmers groups to ease the outreach of extension services for wider dissemination of information to ensure agricultural sustainability. Land ownership provides collateral and enables farmers to acquire loans which they could use to invest on their farms and adopt SAPs. Therefore, it is also suggested that government policies should address the issue of land redistribution and ownership to enable poverty alleviation and rural development through sustainable agricultural productivity.

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