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Determinants of Bushbuckridge Smallholder Crop Farmers' Participation in Formal Market Channels: A Binary Logistic Regression

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ABSTRACT

In sub-Saharan Africa (SSA), Smallholder Crop Farmers (SCFs) play a vital role in creating job opportunities, providing food, and sustaining rural livelihoods against poverty and improving food security. However, in South Africa, yields remain low due to socio-economic constraints and limited market participation. This restricts SCFs' access to formal market information, affecting SCFs' ability to engage successfully in formal markets and affecting sustainable farming. This study investigated the socio-economic determinants of SCFs' participation in formal market channels in Bushbuckridge Local Municipality, Mpumalanga province. Primary data were collected from 99 SCFs through structured interviews and analyzed using descriptive statistics and binary logistic regression. The results reveal that only 28% of SCFs were sold through formal markets, while the majority (72%) relied on informal channels such as farmgate sales. Interestingly, levels of education ($p = 0.046$) and larger farm sizes ($p = 0.002$) were negatively associated with formal market use, suggesting that more educated and larger-scale farmers often diversify income sources or prefer informal channels. On the contrary, SCFs relying on agriculture as their main source of primary source of income ($p = 0.022$) and those with vehicles ($p = 0.042$) significantly increased the likelihood of formal market participation, with vehicle owners nearly four times more likely to access formal buyers. These findings highlight that transport assets and focusing on farming as a livelihood are crucial enablers of formal market participation, whereas education and land size do not necessarily guarantee integration into structured value chains. The study recommends a holistic approach to better extension services, transport solutions, and access to timely and relevant market information systems to strengthen SCFs' inclusion in formal agricultural markets.

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Introduction

Hunger and food insecurity are pressing issues globally, with significant repercussions for rural livelihoods, sustainable development and economic growth (FAO, 2022). Smallholder Crop Farmers (SCFs) play a crucial role in this complex food landscape, which is expected to feed 9.3 billion people by 2050 (Wickramasinghe et al., 2014; FAO, 2022). Despite the global progress in agricultural innovations, systemic constraints persistently hinder SCF's ability to efficiently produce and distribute food. These constraints include limited access to timely and reliable market channels, inadequate infrastructure, and insufficient agricultural extension support systems (Sinyolo and Mudhara, 2018). FAO (2022) argued that the demand for increased agricultural production puts additional pressure on food systems. This situation highlights an urgent need to improve SCFs' market access and boost their productivity to address ongoing food insecurity (Hlatshwayo et al., 2023).

SCFs are central to the constraints of this global food system and play a vital role in food security, job creation and poverty alleviation (Hlatshwayo et al., 2023). Particularly in developing regions, they contribute 60-80% of locally consumed food while playing a significant role in rural economies (Alemu, 2017, Hare, 2021). Despite their contributions, many SCFs remain among the most food-insecure due to exclusion from profitable value chains and reliance on low-return informal markets (Barrett, 2010). In sub-Saharan Africa, more than 239 million people experience hunger, with the burden disproportionately falling on rural households (FAO, 2022). The struggles of SCFs to access formal/structured markets perpetuate poverty and undermine broader national sustainable development goals of food security and zero hunger (Abdulai and Birachi, 2009).

South Africa's agricultural sector is marked by a dualistic structure, comprising a highly productive commercial farming sector and a less developed smallholder sector (Aliber and Hall, 2012). While commercial farmers are well integrated into formal market channels, SCFs often remain confined to informal markets, constrained by poor infrastructure, lack of transport, and limited access to credit and extension services (Benmehaia, 2019). These constraints restrict their ability to meet quality standards and negotiate favorable terms with buyers, leaving them vulnerable to intermediaries and volatile pricing (Oluwatayo, 2019). The constraints impede SCFs' ability to participate in formal market channels, leaving them vulnerable to market volatility (Buckmaster, 2012). Oluwatayo (2019) reported that the issue is not merely about having market access but about transforming marketing into more comprehensive strategies. The problem lies in the lack of effective marketing, not just in selling. While selling can improve market participation, it is not clearly outlined to improve formal market participation (Agholor et al., 2023, Ndlovu and Masuku, 2021). Most studies have focused on factors influencing market access, constraints and determinants of market channels (Agholor et al., 2023, Mgale and Yunxian, 2020, Tabe-Ojong et al., 2024). However, there are no empirical studies that specifically investigate the determinants of formal market participation among SCFs in Bushbuckridge Local Municipality, South Africa. This underscores the need for tailored extension and policy interventions that address the nuanced determinants of farmers' participation in formal markets rather than relying on generic, one-size-fits-all approaches.

Hence, the study investigated the socio-economic determinants of SCFs' participation in formal market channels in Bushbuckridge Local Municipality, Mpumalanga province. By examining factors such as education, farm size, vehicle ownership, and primary source of farm income, the study contributes to a deeper understanding of the constraints and enablers of formal market participation. The findings provide evidence-based insights for policymakers, extension practitioners, and development partners on designing interventions that strengthen SCFs' integration into inclusive agri-food systems. The study is intended to contribute to ongoing debates on rural transformation, food security, and sustainable agricultural development in South Africa. This paper is organized into five sections. Following this is the methodology, which outlines the study area, sampling method, research design, data collection, and analysis. Ethical considerations, reliability, and validity of the study are discussed in the last part of the methodology section. Section 3 analyses the findings, focusing on the

socio-economic characteristics of the farmers in formal market channels. Section 4 outlines the conclusion and recommendations. Section 5 explores the broader implications and potential directions for future research, as well as the study's limitations.

Methodology

Study area

The study was conducted in the rural region of Bushbuckridge, located in Mpumalanga Province, South Africa. Data was collected from the following rural communities: Hluvukani, New Forest, Thulamashe, and Mkhuhlu. Bushbuckridge Local Municipality is part of the Ehlanzeni District, located at geographic coordinates 24°50'06.0"S and 31°04'14.2"E, and is a vibrant community with a population of approximately 546,000 (Kahn et al., 2012). One notable feature of Bushbuckridge is its New Forest Irrigation scheme in New Forest Village (Fisher et al., 2012). This scheme relies on gravity to draw water from the Orinocco dam, which is fed by the Mutlumuvhi River, which flows consistently throughout the year. The irrigation scheme consists of nine storage dams, eight of which are currently operational. This irrigation network is a testament to the ingenuity in utilizing canals and reservoirs, ensuring a robust and steady water supply (Mbedzi, 2024).

This advantageous infrastructure encourages local SCFs to actively engage in crop farming. The area receives substantial rainfall throughout the year (700-900 mm), ensuring an adequate water supply for agricultural activities (Mbedzi, 2024). In addition to these favorable conditions, the average temperature in Bushbuckridge is suitable for a variety of crops, thereby promoting healthy growth and development (Fisher et al., 2012). Bushbuckridge LM is well-suited for crop cultivation due to its favorable climate (Mbedzi, 2024). The municipality is home to the majority of SCFs, who play a vital role in the local economy.

Research design

In this study, a quantitative research approach was utilized to systematically explore a specific phenomenon. This approach focuses on collecting measurable data and employing statistical techniques to analyze it. By leveraging sampling methods, surveys, and questionnaires, quantitative research effectively gathers information from current and potential clients (Mohajan, 2020, Sahu, 2013). Such research designs are well-regarded for their objectivity, thoroughness, and reliability. They are particularly valuable in situations that require an investigative approach, offering valid insights that can be used for making informed decisions and fostering a deeper understanding of the studied phenomenon (Bauer et al., 2021).

Sampling method and Target population

The researcher used convenience sampling to select participants for the study. This approach was chosen for its practicality, allowing participants to be selected based on ease of accessibility and convenience, without following a predetermined pattern (Sahu, 2013). The method's simplicity offers considerable advantages over other approaches that may require more complex procedures and additional resources (Mohajan, 2020). In this study, the target population consisted of registered SCFs within the Bushbuckridge Local Municipality. The participants were chosen as they have a significant impact on agricultural productivity and income generation. To qualify, participants needed to be at least 18 years old, have access to agricultural land (whether owned, leased, or shared), and be able to provide accurate information about market channels as well as possess various socio-economic attributes relevant to the study.

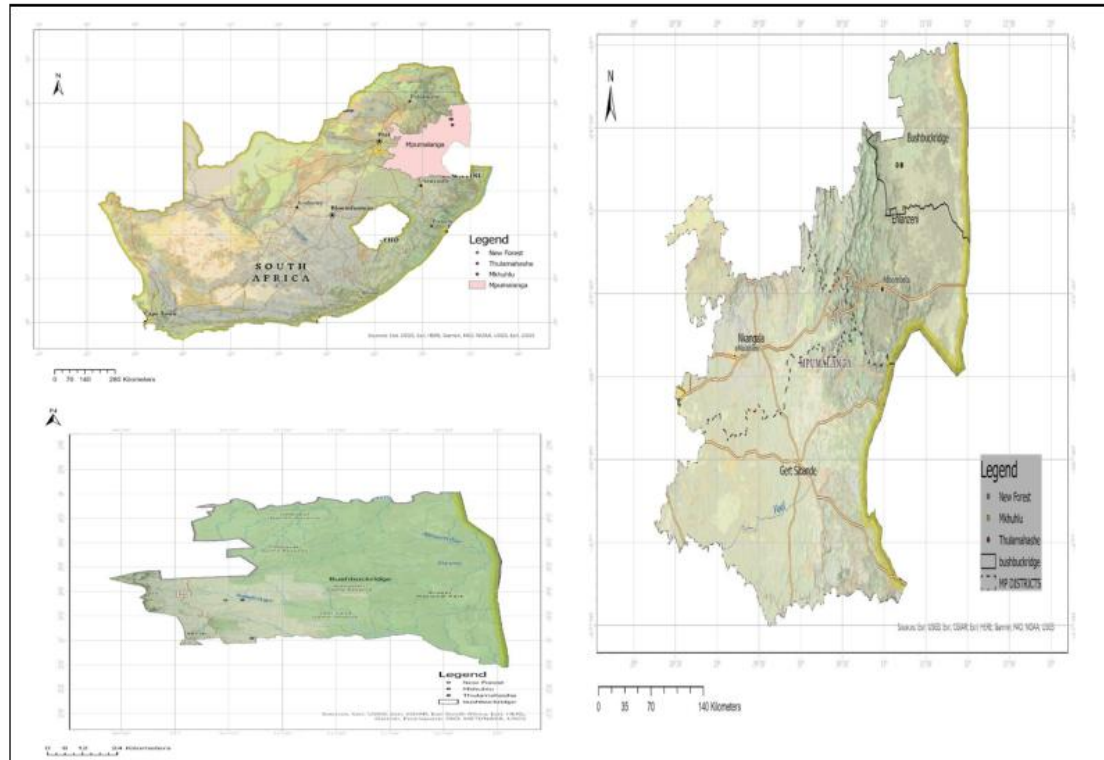


Figure 1. Map of the study area

Source: (Author, 2023)

Sampling size

Determining the right sample size is crucial for any research, as it ensures the findings represent the broader population. A sample size refers to the number of elements or units that comprise a sample (Mohajan, 2020). In this study, Slovin's formula was used to determine the sample size, which is calculated using the equation: $n = N / [1 + N(e)^2]$

$$\begin{aligned}
 &= 400 / [1 + 400(0.0025)^2] \\
 &= 200
 \end{aligned}$$

Where (n) represents the sample size, (N) represents the finite population, (e) represents the significance level or acceptable error limit, and (1) is a constant (Sahu, 2013).

With a total population of 400 SCFs registered with the Department of Agriculture and an error margin set at 0.0025, Slovin's formula indicated a required sample size of 200. While this ensured access to active SCFs, it may have introduced selection bias by excluding unregistered SCFs, potentially limiting the generalisability of the study's findings. Due to practical considerations, including time and budget constraints, the study proceeded with 99 SCFs. To ensure the questionnaire's effectiveness and gauge potential challenges, a pilot study was conducted with 20 SCFs.

Data collection

For the data collection a structured questionnaire was administered. This approach allowed direct interaction and facilitated accurate data gathering from the SCFs. The questionnaire was organized into two key sections: the farmers' socioeconomic determinants and the formal market channels they utilized. As detailed by Creswell and Creswell (2017), structured questionnaires, with their predetermined questions and consistent format, offer clear advantages. A structured questionnaire ensures a systematic approach to data collection, yielding reliable and easily comparable results, and are both time-efficient and cost-effective. The structured nature of these questionnaires facilitates statistical analysis and comparison across different studies or populations, enhancing research efficiency (Sahu, 2013).

Data Analysis Methods

To ensure the integrity of the data analysis, the collected datasets were meticulously reviewed for errors, coded, and entered into the Statistical Package for the Social Sciences (SPSS) Version 27. Data analysis, a systematic approach to collecting, evaluating, and interpreting data, uses various statistical methods, particularly for numerical data in quantitative analyses (Creswell and Creswell, 2017). This study used binary logistic regression and descriptive statistics to examine the formal market channels used by SCFs. Descriptive statistics, through frequencies and percentages, provided insight into the socioeconomic characteristics of participants. Binary logistic regression was applied to explore the relationship between these determinant characteristics and the formal market channels used by the SCFs.

The binary logistic regression model was key in this study, with the dependent variable being the "formal market channel used." This was operationalized to reflect whether a farmer engaged with formal market channels: farmers who reported using such channels were coded as 1, while those who did not were coded as 0. This analysis aimed to determine if the socioeconomic characteristics of SCFs significantly affect their choice of formal market channel. Logistic regression is considered the most appropriate when categorical and continuous variables are present (Mohajan, 2020).

The logistic regression function was structured to predict the probability of using market channels, where various socioeconomic predictor variables informed the outcome of interest. These were gender, age, educational level, farm experience, farm distance to the marketplace, farm size, type of farm enterprise, primary income source, vehicle ownership, type of land, and cooperative membership. Each predictor variable was carefully selected to ensure it genuinely contributed to understanding the dynamics of market channel choices among SCFs. The regression coefficients indicated the degree of influence each variable exerted on the likelihood of using market channels.

Logistic Function

$$P(Y = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n)}}$$

Where:

$P(Y = 1)$ is the probability of the outcome (using market channels)

β_0 is the intercept term

$\beta_1, \beta_2, \dots, \beta_n$ are the coefficient for the predictor variable

The following method was used to identify significant independent variables that influence the outcome:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_{11} X_{11} + \mu$$

Where the variables are represented as follows:

Y = use of market channels by smallholder crop farmers (1= use, 0= do not use)

X1–X11 = predictor variables demarcated as:

X1 = Gender (Male = 1, Female = 0)

X2 = Age (Years)

X3 = Educational level (No formal education = 0, ABET = 1, Primary school = 2, Secondary = 3, Matriculated = 4, Tertiary = 5)

X4 = Farm experience (Years)

X5 = Farm distance to the marketplace (Km)

X6 = Farm size (Ha)

X7 = Type of farm enterprise (Vegetables = 0, Field crops = 1, Horticulture = 2)

X8 = Main source of income (Farming = 0, Employed = 1, Self-employed = 2, Pension = 3)

X9 = Vehicle ownership (Yes = 0, No = 1)

X10 = Type of land (Own = 0, Renting = 1, Communal = 2)

X11 = Cooperative membership (Yes = 0, No = 1)

β_0 = Constant

β_1 – β_{11} = Regression coefficients

μ = Error term

Despite the comprehensive data collection, not all variables were included in the final model. Some variables, such as marital status, household size, and primary income source from vegetables, were excluded to avoid multicollinearity and reduce the model's complexity. For example, marital status showed potential overlap with household size. Similarly, farm experience was strongly correlated with age and was retained as the more comprehensive variable for analysis. Retaining only variables with theoretical and statistical significance helped create a parsimonious model, essential for producing reliable, interpretable results free of overfitting or erroneous conclusions. This strategic selection of variables underscored a focused, well-considered approach to uncovering the relevant factors that determine formal market channel use among SCFs.

Ethical Considerations

Ethical considerations were paramount in our study, ensuring adherence to key principles for research involving human participants. Before participating, all individuals received a comprehensive briefing about the study's objectives, methodologies, and potential risks or benefits. They provided written consent, affirming their voluntary participation. To uphold beneficence, we focused on generating valuable knowledge while minimizing risks to participants. Justice was upheld by treating everyone fairly and offering equal opportunities for participation without discrimination. In keeping with nonmaleficence, we designed the study to prevent distress and allow participants to withdraw at any time without consequences. Consent forms confirmed their willingness to participate, and we safeguarded their information with secure storage and limited access. Our protocol was approved by the School of Agricultural Sciences Research Ethics Committee under reference number UMP/Ndoro/1/2022 (Approval Date: 01/2022).

Reliability and validity of the questionnaire

Evaluating the reliability and validity of the questionnaire was crucial for ensuring accurate research findings. Reliability was examined by the School of Agricultural Ethics Research Committee and supervisor to ensure the questionnaire consistently measured the intended hypotheses, emphasizing the importance of participant comprehension and a well-crafted tool. Pretesting was integral in identifying issues prior to the main data collection, enhancing dependability. For validity, we assessed the questionnaire's ability to capture the study variables and to align research concepts with outcomes. Validity was categorized into content, principle-correlated, and hypothesis validity. Conducting a pilot test was essential, allowing us to anticipate and address potential problems in the instrument's functionality, particularly important given the absence of a universal design applicable to all scenarios.

Results and Discussions

Demographics

Age Distribution

The data revealed a pronounced age imbalance among SCFs in Bushbuckridge, with a substantial 32.3% aged 50-59 years and another 28.3% aged 60 and over. A scarce 7.1% are under 29 years, while just 10.1% fall in the 30-39 age range. This distribution highlights an aging demographic actively engaged in farming, consistent with broader trends seen in South Africa and across sub-Saharan Africa. Younger individuals often migrate to urban areas seeking employment opportunities, leaving the agricultural sector largely to older generations (Dyanty et al., 2025, Hlatshwayo et al., 2023). While older SCFs bring valuable experience, this reliance on an older workforce constrains the sustainability of smallholder agriculture, as younger farmers are generally more receptive to innovation and modern market strategies (Omiti et al., 2009). Thus, agriculture in Bushbuckridge remains seen mainly as a fallback occupation for older individuals, lacking appeal for the youth.

Gender

The findings highlight that women make up 55.6% of respondents, compared to 44.4% men, affirming that women predominantly manage farming in Bushbuckridge. This aligns with renowned global and regional trends showing women's critical role in sustaining rural livelihoods and food security. Women often comprise most of the agricultural labor force in rural settings and significantly contribute to agricultural productivity (Agholor et al., 2023; Dyanty et al., 2025). However, despite their prominent role, women face systemic barriers, including restricted access to essential resources like land, credit, and agricultural extension services (Asciutti et al., 2016, Sinyolo and Mudhara, 2018). These constraints can hinder their market engagement. This study's predominance of female SCFs underscores the need for policies that empower women by enhancing their access to assets and institutional support.

Education

The educational attainment among the farmers is notably high, with 29.3% having matriculated and 24.2% holding tertiary qualifications. Only a small fraction (8.1%) reported no formal schooling, with modest proportions in the ABET, primary, or secondary education categories. This reflects the positive impact of national initiatives to broaden educational opportunities, even in rural areas (Aliber and Hall, 2012). Higher education is expected to foster better decision-making, improve access to market information, and promote value chain participation among farmers (Mmbando et al., 2015). However, despite their educational achievements, many remain in smallholder production, possibly due to limited non-farm job prospects in Bushbuckridge. Thus, educational advancements must be paired with policies that leverage human capital into greater agricultural profitability.

Table 1. Socio-economic and demographic data of SCFs

Farmers characteristics	Categories of farmers	Frequency and Percentage	
		N	%
Age	18 to 29	7	7.1
	30 -39	10	10.1
	40 - 49	22	22.2
	50 - 59	32	32.3
	60 and above	28	28.3
Gender	Female	55	55.6
	Male	44	44.4
Highest educational level	No formal education	8	8.1
	ABET	6	6.1
	Primary level	16	16.2
	Secondary level	16	16.2
	Matriculated	29	29.3
	Tertiary	24	24.2
Farming experience	Less than 5	21	21.2
	6-15	49	49.5
	16 and above	29	29.2
Distance to market	Less than 5km	12	12.0
	6-15km	15	15.0
	16 and above	72	73.0
Type of produce	Vegetables, e.g., cabbage, spinach	71	71.71
	Field crops, e.g., maize, soybean	25	25.25
	Horticulture	3	3.03
Own vehicle	Yes	55	55.6
	No	44	44.4

Farming Experience

A sizable portion of respondents (49.5%) have amassed 6-15 years of farming experience, with another 29.2% possessing over 16 years. On the contrary, only 21.2% have less than five years. This indicates a farming community rich in accumulated knowledge and skill. Long-term involvement in agriculture equips these farmers with resilience, local know-how, and technical skills (Corsi et al., 2017). Such experience is invaluable in managing risks, optimizing production, and sustaining agricultural practices (Jebessa et al., 2024). However, without robust extension support and infrastructure, this experience may not always translate into enhanced commercialization (Barrett, 2010). The predominance of experience among Bushbuckridge SCFs suggests a dedicated farming foundation, yet to fully realize productivity gains, formal market access, and enhanced institutional support is integral.

Distance to Market

The results show that 73% of farmers must travel more than 16 km to reach markets, with only 12% within 5 km. This highlights distance as a substantial obstacle for most Bushbuckridge SCFs. These results concur with earlier studies (Buckmaster, 2012, Jagwe et al., 2010), who argued that extended travel times increase transport costs and diminish the competitiveness of especially perishable produce like vegetables. Poor infrastructure and long distances discourage SCFs' participation in formal markets (Agholor et al., 2023). These findings demonstrate the persistent issue of spatial isolation in this municipality, necessitating strategic infrastructure development, improved road networks, and market decentralization to alleviate these constraints (Tabe-Ojong et al., 2024).

Type of Produce

The majority (71.7%) of SCFs focus on vegetables, with 25.2% growing field crops such as maize and soybeans, and just 3% growing horticultural crops. This trend illustrates the region's agro-ecological support for short-season vegetables, which are favored by irrigation and rainfall conditions (Hlatshwayo et al., 2023). The predominance of vegetables concurs with findings from other studies in South Africa that show smallholders often favor crops with shorter cycles and consistent demand (Hlatshwayo et al., 2023). Vegetable farming offers income potential through frequent harvests but poses risks of post-harvest losses and market volatility where logistics are lacking (Hlomendlini, 2015). Although vegetable production presents a competitive advantage, supporting storage, transport, and aggregation infrastructure is crucial to maximizing benefits for SCFs.

Vehicle Ownership

A total of 55.6% of the respondent's own vehicles, while 44.4% do not. This indicates reasonably common access to transport, although a notable minority remains without access to a vehicle. This concurs with Christian et al. (2024), vehicle ownership is pivotal in lowering transaction costs and reducing intermediaries' reliance, enhancing farmers' capability to access distant markets, deliver products promptly, and secure better trade terms. However, the near-even split indicates ongoing disparities, with those without vehicles at a disadvantage. The findings highlight a critical need for improved transport access, through ownership or collective solutions, to enable effective participation in formal markets for SCFs.

Table 2. Binary Logistic Regression results

Variables in the Equation		B	S.E.	Wald	Df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1 ^a	Gender	-.959	.647	2.198	1	.138	.383	.108	1.362
	Age	-.099	.315	.098	1	.755	.906	.489	1.681
	Highest education level	-.512	.257	3.972	1	.046**	.599	.362	.992
	Years in farming	.195	.294	.440	1	.507	1.216	.683	2.165
	Farm distance to the marketplace	-.296	.214	1.908	1	.167	.744	.489	1.132
	The size of your farmland	-1.549	.494	9.822	1	.002**	.213	.081	.560
	Vegetables are produced as the primary source of income	-.272	.165	2.715	1	.099*	.762	.551	1.053
	Main source of income	.643	.282	5.213	1	.022**	1.902	1.095	3.304
	I own a vehicle	1.382	.681	4.120	1	.042**	3.981	1.049	15.114
	Type of land ownership	-.546	.404	1.824	1	.177	.580	.263	1.279
	I belong to a cooperative.	-.506	.824	.377	1	.539	.603	.120	3.031
	Constant	4.729	1.999	5.596	1	.018	113.174		

-2Log-likelihood = 84.852 and Wald = 17.386 Cox and Snell R-square = 0.284 Nagelkerke R-squared = 0.408, Hosmer and Lemeshow Test Chi-Square = 7.038, df = 8, and p = 0.532.

B-value = coefficient, Std. Err. = Standard error Wald= Wald, (P-value) = probability value.

Note that *, ** denotes statistically significant at 10% and 5% respectively.

Binary Logistic Regression

A binary logistic regression model was employed to explore the factors influencing smallholder crop farmers' choice to sell through formal market channels. The model demonstrated a robust fit, as reflected by the Hosmer and Lemeshow test results ($\chi^2 = 7.038$, df = 8, p = 0.532). This outcome indicates no substantial discrepancy between the classifications observed in the data and those predicted by the model. The pseudo-R-squares, with a Cox and Snell R^2 of 0.284 and Nagelkerke R^2 of 0.408, suggest that the independent variables could account for approximately 28% to 41% of the variation in farmers' market channel selection. The model's overall statistical significance (Wald = 17.386; -2 Log-likelihood = 84.852) further corroborates the reliability of the predictors used in the analysis.

Of the 99 SCFs examined, 28 opted for formal market channels, such as contract channels, while the remaining 71 farmers chose informal markets, such as selling directly at the farmgate. This distribution underscores a significant inclination among SCFs to rely on informal markets. The outcomes of this analysis provide valuable insights into the marketing preferences and behaviors of SCFs, which can be critical for policy formulation to enhance market accessibility and choice for smallholder agricultural producers. By understanding these determinants, strategies can be developed to encourage a shift towards more formalized market engagement, potentially benefiting both the farmers and the market ecosystem.

Highest education level

Education has a notable negative coefficient ($B = -0.512$; $SE = 0.257$; $Wald = 3.972$; $p = 0.046$; $\text{Exp}(B) = 0.599$), indicating that higher education levels are associated with reduced odds of engaging in formal market channels, about a 40% decrease per unit increase, controlling for other factors. The significance level ($p = 0.046$) suggests this finding is unlikely to be random. Chikawo (2024) and Hou (2023) propose two mechanisms consistent with this negative relationship: more educated household members may diversify into non-farm jobs, reducing reliance on farming, and education can entail opportunity costs that deter investment in the fixed costs of formalization. These mechanisms explain why higher education could lower the likelihood of formal agricultural sales in specific contexts.

The size of your farmland

Farm size exhibits a significant negative coefficient ($B = -1.549$; $SE = 0.494$; $Wald = 9.822$; $p = 0.002$; $\text{Exp}(B) = 0.213$), indicating that larger landholdings significantly reduce the odds of formal market use, with an approximately 79% decrease per unit increase. This indicates a statistically significant result ($p = 0.002$). In some contexts, larger holdings do not equate with formal access, particularly if larger holdings are still relatively small or if flexibility with informal buyers is preferred for liquidity (Barrett, 2010, Chikhawo et al., 2024, Dlamini and Huang, 2019, Jagwe et al., 2010).

Vegetables are produced as the leading enterprise

Producing vegetables yields a negative coefficient ($B = -0.272$; $SE = 0.165$; $Wald = 2.715$; $p = 0.099$; $\text{Exp}(B) = 0.762$), suggesting vegetable producers are somewhat less inclined toward formal channels. This finding is statistically significant at 10% ($p = 0.099$). Vegetables entail higher logistics and quality demands, discouraging formalization without aggregation or cold-chain support, and a nearly substantial negative coefficient aligns with recent vegetable market studies (Dey and Singh, 2023).

Main source of income

Relying mainly on farming as an income source has a positive and significant coefficient ($B = 0.643$; $SE = 0.282$; $Wald = 5.213$; $p = 0.022$; $\text{Exp}(B) = 1.902$), indicating nearly double the odds of formal market channel sales for those highly dependent on agriculture compared to those dependent on non-farm income. The result ($p = 0.022$) indicates that greater reliance on farm income incentivizes the pursuit of structured, potentially higher-value channels. This pattern aligns with literature showing market-driven households actively seek formal buyers to stabilize income and manage risk (Chikhawo et al., 2024, Hlatshwayo et al., 2021).

Vehicle ownership

Owning a vehicle strongly increases the odds of using formal channels ($B = 1.382$; $SE = 0.681$; $Wald = 4.120$; $p = 0.042$; $\text{Exp}(B) = 3.981$), with owners having nearly fourfold the odds compared to non-owners. The result ($p = 0.042$) indicates that transport access significantly enhances the feasibility of formalization by reducing transaction costs and losses. This concurs with Christian et al. (2024), which highlights the importance of reliable transport in formal market frameworks and underscores vehicle access as a critical constraint.

Conclusion

In conclusion, this study underscores the significant role that household characteristics and resource endowments play in shaping SCFs' participation in formal markets. Interestingly, higher levels of education and larger farm sizes were associated with lower levels of formal market engagement, suggesting that these farmers might prefer the flexibility and immediacy of informal channels. Similarly, those whose primary income source is farming and who have access to vehicles are more likely to participate in formal markets, revealing the critical role of livelihood reliance and transport capabilities in connecting farmers to structured value chains.

The implications of these findings for agricultural extension and policy are profound. Extension services should be geared towards offering tailored support to farmers with limited resources, especially those lacking transportation means, to better align them with formal market demands. Furthermore, recognizing that education and land size alone do not guarantee formal market involvement, interventions should focus on local market dynamics and farmers' strategic preferences.

Policymakers are encouraged to invest in collective transportation solutions, strengthen farmer cooperatives, and develop infrastructure to ease entry barriers into formal markets. Ultimately, enhancing institutional support and minimizing transaction costs are vital for better integrating smallholders into established value chains.

Enhancing extension training is critical to address these challenges. This involves educating farmers on the specific requirements of formal markets, such as quality standards and contract terms, to equip them for participation better. Supporting transport access can be achieved through collective schemes run by cooperatives, which diminish reliance on intermediaries and facilitate direct market access. Building stronger farmer organizations, such as cooperatives, can empower farmers by enabling collective bargaining, pooling resources, and reducing transaction costs. Investing in infrastructure, like rural roads and market centers, will alleviate logistical challenges for formal market engagement. Targeting resource-limited farmers with tailored support, such as credit or equipment subsidies, is crucial for helping them overcome entry barriers. Addressing market information gaps by creating platforms for real-time market data can guide farmers' decision-making between formal and informal channels. Lastly, leveraging public-private partnerships can foster inclusive value chains that intentionally integrate SCFs, ensuring they have a fair share in market opportunities.

Competing Interest

The authors declare no conflict of interest

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