Factors influencing the adoption of improved sweet potato varieties: The role of perceived risk in Gaza Province, Mozambique

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ABSTRACT

Adopting improved agricultural technologies is crucial for enhancing food security and agricultural production in regions like Mozambique, where farmers face significant problems, including climate variability and market uncertainties. Despite the potential of improved sweet potato varieties (ISPVs) to boost yields and resilience, adoption rates remain unpredictable, partly due to insufficient understanding of how farmers' risk perceptions influence their decisions. Using the theory of planned behaviour (TPB), this study investigated the factors influencing the adoption of ISPVs in Gaza province, Mozambique, focusing on the role of perceived risks. The study used a cross-sectional survey design, and a multi-stage sampling method was employed to randomly select 382 farmers for interviews, of whom 76% reported adopting ISPVs. Data was collected using questionnaires, and the Logit model was employed to estimate the factors influencing ISPVs adoption. The model results indicated that farmers who diversified their crop production had access to extension services and perceived low risks (reduced yield and market uncertainty) were likelier to adopt ISPVs. The study highlights important policy implications, emphasizing the need to enhance the coverage and effectiveness of extension services, encourage crop diversification, and provide farmers with better access to production and market information, insurance cover, and training programs that reduce uncertainty and boost the adoption of ISPVs.

Keywords: Adoption, Farmers, Gaza Province, Improved Sweet Potatoes Varieties, Mozambique

I. INTRODUCTION

Sweet potato is a relevant staple food crop important in local and international trade (Ben-Chukwu *et al*., 2021). Farmers value sweet potatoes for domestic and commercial purposes, mainly due to their excellent nutritional content (Agoh, 2021). In Mozambique, sweet potatoes are the fifth most important crop and second among root crops after cassava within the smallholder farming systems (Low *et al*., 2017). Despite their popularity, the most grown sweet potato varieties in Mozambique are white-fleshed sweet potatoes, which are characterized by poor yields, high carbohydrate content and low vitamin A levels (Jogo *et al.*, 2021).

In improving the productivity and quality of sweet potatoes, Mozambique dedicated significant research efforts to developing ISPVs. Initial efforts to promote ISPVs began in 1997 with the importation of 38 varieties from Latin America for testing at the Mozambique Institute of Agricultural Research. However, these did not fully adapt to local conditions (Andrade *et al*., 2017). In 2011, the Mozambique Institute of Agricultural Research, in collaboration with the International Potato Center (CIP), released 15 ISPVs bred explicitly for traits such as drought tolerance, high dry matter content, and increased β-carotene, which is important for reducing vitamin A deficiency among children, pregnant women, and breast-feeding women (Brouwer, 2019). Dissemination campaigns accompanied the release of these varieties to raise awareness of their nutritional and agronomic benefits (Brouwer, 2019).

Agricultural research and innovation success is closely tied to how effectively farmers utilize these technologies (Sánchez-Toledano *et al*., 2018). Adopting improved varieties can enhance crop production and productivity, improve incomes, reduce poverty, and increase food and nutrition security (Jogo *et al*., 2021). However, studies on the adoption of sweet potato varieties in Mozambique indicate that ISPVs released before 2000 had an adoption rate of 51% (Mazuze, 2007), which increased to between 61% and 68% in later years (De Brauw *et al*., 2018). While these rates reflect some success in adoption, they also highlight challenges, as adoption was limited by factors such as the varieties' lower resistance to pests and viral diseases, low drought tolerance and low dry matter content (Naico & Lusk, 2010). Understanding the determinants affecting farmers' choices to adopt improved sweet potato varieties is essential for evaluating the efficacy of agricultural research investments and ensuring that scientific advancements correspond with farmers' requirements (Antle *et al*., 2017).

Though current research shows numerous factors affecting adoption, including agronomic, socioeconomic, institutional, psychological, and environmental factors, there is limited exploration of how perceived risk factors, such as uncertainty about yield stability and market behaviour, influence adoption decisions (Acheampong *et al*., 2018; Adekambi *et al*., 2020a; Ago, 2021; Jenkins *et al*., 2018; Jogo *et al*., 2021; Mugumaarhahama *et al*., 2021; Okeke *et al*., 2020). Exceptions to this include the study by Ekwe (2019) highlighting the important role of farmers' risk perceptions in shaping their decisions to new varieties in Nigeria. Ignoring the effect of perceived risks may provide an incomplete understanding of farmers' decision-making process, potentially leading to misguided policy intervention (Adnan *et al*., 2021).

This paper fills this gap by analyzing the role of perceived risks in influencing the adoption of ISPVs in Gaza province, Mozambique. Outlined in the TPB, it explores how farmers' perceptions of risks, such as yield uncertainty and market uncertainty, influence their adoption decisions. The results aim to contribute to designing strategies that mitigate perceived risks and foster broader adoption of ISPVs. Focusing on perceived risks, this paper seeks to deepen our understanding of the barriers to adopting agricultural technology and provide actionable insights for enhancing agricultural productivity and food security.

1.1 Research objective

To investigate the factors affecting the adoption of ISPVs in Gaza province, Mozambique, focusing on the role of perceived risks.

II. LITERATURE REVIEW

2.1 Theoretical Review

The adoption of innovation in agriculture has been extensively studied using various theoretical models, offering insights into the factors that influence decision-making among farmers (Adnan *et al*., 2019). One such framework is the Theory of Planned Behavior, which has been widely applied in understanding how individuals make decisions about adopting new agricultural technologies (Eliya *et al*., 2019). In the TPB, a person's intention to act is determined by three major sources: attitude toward behavior, social pressure and perceived behavioral control (Conner, 2020). Each of these factors contributes to the formation of either a positive or negative intention, which ultimately influences whether the behavior is performed. Lalani *et al*. (2016) assert that these three dimensions not only shape a farmer's willingness to adopt an innovation but also their long-term commitment to maintaining the innovation.

This study draws on the TPB to analyze the adoption decisions of farming households in Gaza province, Mozambique. The focus is on the role of perceived risk factors such as yield uncertainty and market uncertainty on adoption decisions and behavioral intentions related to ISPVs. By accounting for these perceived risk factors, the TPB provides insights into how farmers evaluate the risks associated with adopting ISPVs. Understanding these dynamics helps explain why farmers may be willing or hesitant to adopt ISPVs, as their intentions are shaped by how they evaluate the risks and benefits (Tama *et al*., 2021). Additionally, analyzing farmers' perceptions is crucial for identifying the main characteristics of technologies that should be targeted for improvement to encourage adoption (Sánchez-Toledano *et al*., 2018).

2.2 Empirical Review

Several research works have attempted to explain farmers' acceptance of improved agricultural technologies (Takahashi *et al*., 2020). The adoption choices at the household level are primarily influenced by the farmers' socio-economic circumstances and the content of agricultural technology (Ahmed & Anang, 2019). Farmers' adoption choice towards agricultural innovation can be affected by factors like farmers' age, farm size, asset ownership, access to formal education, access to credit, household size, access to extension services, and belonging to farmer associations (Ahmed & Anang, 2019). Mazuze (2007) showed that farmers'' decision to adopt ISPVs introduced before 2000 in Mozambique was influenced by the experience with varieties, frequency of vines distribution, household's sweet potato cultivated area, participation in field days and demonstration activities. The study found limited adoption in two districts of Gaza province due to poor drought resistance and dry matter content of the varieties (Naico & Lusk, 2010). A study in Sierra Leone indicated that the adoption of these varieties was significantly inhibited by limited finance and a lack of high-yielding and disease-free planting material tolerable by both the producers and consumers. The study further found that farmers' religion, sex, marital status, collaboration in on-farm research, and income sources outside agriculture were essential in influencing adoption (Sandy-Margao *et al*., 2007).

Adekambi *et al*. (2020) in Northern Ghana found that taste, sweetness and dry matter significantly affect adoption of an improved sweet potato variety. The optimal adoption of new varieties requires training in good agronomic practices, understanding the characteristics of the new variety, and using the right marketing strategies (Amengor *et al*., 2017). Wabwile (2016) revealed that adopting ISPVs among farmers in Kenya was positively and significantly influenced by extension contact and educational level. The study concentrated on sweet potato varieties that were recently introduced and were bred explicitly for critical characteristics such as high dry matter content and drought resistance. Likewise, Jenkins *et al*. (2018) demonstrated that the adoption and maintenance of ISPVs by farmers in Mozambique were influenced by taste preferences, agronomic traits, access to planting material, availability of capital for inputs and labour, environmental conditions, access to information, stability of markets and availability of planting material across farmer networks. The study focused on three provinces: Maputo, Manica, and Zambezia. Xie and Huang (2021) reported that the influence of independent variables and interactions among them on farmer's technology adoption varies from area to area. Thus, location-specific studies are necessary to understand the factors influencing the adoption of new agricultural technology in each region. However, existing research indicates several factors influencing the adoption of improved agricultural technologies, but there is limited evidence of how perceived risk factors influence adoption decisions.

III. METHODOLOGY

3.1. Research Design

A cross-sectional study design, recognized for collecting data at a single point in time (Wang & Cheng, 2020), was employed in this research. This design was chosen for its effectiveness in collecting comprehensive data over a specific time frame and its ability to explore relationships between variables efficiently. It also facilitates the incorporation of mixed techniques, encompassing qualitative and quantitative elements, rendering it appropriate for this study (Cummings, 2018).

3.2. Data and Description of Variables

Data for the present study was collected from a survey conducted in Gaza province between April and December 2023 by interviewing 382 farmers in six districts. A multi-stage sampling procedure was implemented from the population in the study area. In the first stage, Gaza province was selected because it was ranked the topmost province in Southern Mozambique with a high number of beneficiaries of the recently released ISPVs. In the second stage, six districts out of 12 districts from four zones were purposively selected using the previously mentioned criteria. The six districts were: Chokwe, Guija and Chibuto, in the south of the province, Mabalane, in the center of the province, Chigubo, in the east of the province, and Massangena in the north of the province. The survey included all farmers who received ISPVs planting material in the six districts in 2018. In the third stage, a list of farmers who received planting material of ISPVs released between 2011 and 2020 was obtained from the Agricultural Research Institute of Mozambique, from which a stratified sample was determined based on the total number of beneficiaries in each district. The final stage was devoted to the random selection of farmers which were interviewed in each district with the help of agricultural extension officers. The sample size of 382 households was determined using Slovin's equation (1) as proposed by Siyum *et al*. (2022) at 95% of confidence.

$$n = \frac{N}{1 + Ne^2} \tag{1}$$

Where n = sample size, N = total number of farmers who received new sweet potato vines in 2018 (N=9200), e = maximum variability which is 5% (e =0.05), and one stands for the probability of the event occurring. Data were collected with the assistance of three research assistants who had knowledge of the local language (Portuguese or Changana), depending on the respondent's preference. The research assistants were trained in the context of the interview schedule, method of data collection, using a pretested questionnaire. Table 1 shows the definitions or measurements and hypothesized variables.

Table 1
Variable with their Definitions/Measurement

Variables	Definition/ Measurement
Adoption of ISPVs	Dummy:1 if yes, 0 otherwise
Gender of household head	Dummy:1 if male, 0 otherwise (+)
Education of household head	Dummy:1 if educated, 0 otherwise (+)
Farm size (hectares)	Continuous: Number of hectares used for sweet potato (+)
Household size	Continuous: Number of people living and eating together (+)
Farming experience	Continuous: Number of years in sweet potato cultivation (+/-)
Livestock ownership	Dummy:1 if own livestock, 0 otherwise (+)
Distance to market (minutes)	Continuous: Distance from homestead to the market (-)
Group member	Dummy:1 if group member, 0 otherwise (+)
Crop diversification	Dummy:1 if practices crop diversification, 0 otherwise (+)
Access to extension service	Dummy:1 if access extension service, 0 otherwise (+)
Yield uncertainty	Dummy:1 if concerned about performance, 0 otherwise (-)
Market uncertainty	Dummy:1 if concerned about lack of market, 0 otherwise (-)

3.3. Empirical framework

Qualitative response regression models, such as Switching Regression Models, Probit, Logit, and the Linear Probability Model, are used to evaluate the parameters of qualitative variables. The dependent variable in all these models is a binary outcome, such choices of "yes" or "no", with Probit and Logit being the most popular of these models (Tarekegn & Yosefe, 2017). For example, Udimal *et al.* (2017) used both Probit and Logit models to explain the factors affecting adoption of improved rice varieties in Ghana. The empirical results obtained from Probit and Logit models are often similar. The primary distinction is that the conditional probability (pi) approaches zero or one at a slower rate in the Logit model than in Probit model (Tarekegn & Yosefe, 2017). Therefore, the choice on the models is left to the researcher and depends on their experience, the availability of software, and the assumption made about the error term (Tarekegn & Yosefe, 2017; Udimal *et al.*, 2017). This study used a Logit model to identify factors influencing adoption of ISPVs. The model equation was specified as follows:

$$log\ (Pi) = ln\left(\frac{Pi}{1-Pi}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_n + u \quad (2)$$

Where Pi is the probability of occurrence, and 1-Pi is the probability of non-occurrence. The dependent variable is binary and assumes two values: Y = 0 (otherwise) and Y = 1 (if there is adoption). Adopters are defined as farmers who planted at least one of the ISPVs during the 2022/23 wet season, while non-adopters are those farmers who previously received ISPVs but did not grow them during the 2022/23 wet season. X_1 *and* X_n are independent variables; β_1 *and* β_4 are the regression coefficients; β_0 is constant, and *u* is the error term. Before including the selected variable in the model, it was essential to check for multi-collinearity among the variables using the Variance Inflation Factor (VIF). The formula for calculating VIF is as follows:

$$VIF\ (Xi) = (1 - Ri^2)^{-1} \quad (3)$$

Where Ri^2 is multiple correlation coefficient between Xi and other explanatory variables.

IV. FINDINGS & DISCUSSION

4.1 Response Rate

Table 2 presents some descriptive statistics for key continuous variables from surveyed farmers across six districts. The results show that adopters have significantly larger farm sizes compared to non-adopters. Households with large farms may provide additional resources or capacity to engage in new practices, such as adopting improved varieties, while households with smaller farms may face more constraints (Atinafu *et al.*, 2022). Similarly, the mean household size of adopters is slightly larger than that of non-adopters, although this difference is not statistically significant.

The average farming experience shows a slight variation between the two groups, with non-adopters reporting marginally more years of farming experience. However, this difference is not statistically significant, suggesting that the two groups have comparable levels of farming experience. Finally, the mean distance to the market is marginally shorter for adopters compared to non-adopters. Though this difference is not statistically significant, and thus no definitive conclusions can be drawn about the role of market proximity in facilitating access to farm inputs and reducing transportation challenges for farm products (Adekambi *et al.*, 2020a).

Table 2

Descriptive Statistics of Continuous Variables

Variable	All sample		Adopter		Non-adopter		t-value
	Min	Max	Mean	Std. Dev.	Mean	Std. Dev.	
Farm size	0.01	4.00	0.26	0.32	0.17	0.15	-2.59***
Household size	1.00	22.00	7.74	3.58	7.69	3.65	-0.10
Farming experience	3.00	70.00	31.07	13.79	31.44	13.81	0.22
Distance to market	10.00	240.00	56.61	37.06	58.79	34.34	0.50
Observations	382		291		91		

Note: *** = significant at 1% level

The results in Table 3 indicate that the proportion of male adopters is slightly lower than that of non-adopter, though the difference is statistically not significant. Furthermore, results show that adopters are more likely to be educated compared to non-adopters, but this difference is statistically not significant. Education has been widely recognized as a facilitator of technology adoption due to its role in improving farmers' ability to understand and implement new agricultural practices (Onyeneke *et al.*, 2020).

Table 3
Descriptive Statistics of Discrete Variables

Variable	Response	Adopter		Non-adopter		Total		X^2
		n	%	n	%	n	%	
Gender	Male	166	57.04	57	62.64	223	58.38	0.89
	Female	125	42.96	34	37.36	159	41.62	
Education level	Educated	183	62.89	48	52.75	231	60.47	2.98
	Otherwise	108	37.11	43	47.25	151	39.53	
Livestock ownership	Own livestock	233	80.07	59	64.84	292	76.44	8.93***
	Otherwise	58	19.93	32	35.16	90	23.56	
Group member	Member group	199	68.38	49	53.85	248	64.92	6.43
	Otherwise	92	31.62	42	46.15	134	35.08	
Crop diversification	Crop diversification	250	85.91	54	59.34	304	79.58	30.12***
	Otherwise	41	14.09	37	40.66	78	20.42	
Access to extension	Access extension	240	82.47	44	48.35	284	74.35	42.32***
	Otherwise	51	17.53	47	51.65	98	25.65	
Yield uncertainty	Concerned	123	42.27	88	96.70	211	55.24	83.08***
	Otherwise	168	57.73	03	03.30	171	44.76	
Market uncertainty	Concerned	59	20.27	5	73.63	126	32.98	89.26***
	Otherwise	232	79.73	86	26.37	256	67.02	
Observation		291		91		382		

Note: *** = significant at 1% level; ** = significant at 5% level.

Livestock ownership is significantly lower among non-adopters compared to adopters. These results support the view that livestock ownership, as an indicator of household wealth, may enable farmers to experiment with improved varieties. Livestock farming provides economic stability and potential resources to offset the risks of adopting new agricultural technologies (Yokamo, 2020). Adopters were more likely to belong to farmer groups compared to non-adopters. Although the difference is statistically not significant, group membership is known to improve access to critical resources such as shared tools, information, and social support. These benefits may reduce the perceived risks associated with improved agricultural technologies, as emphasized by (Opata *et al*., 2021).

Adopters demonstrate significantly higher rates of crop diversification compared to non-adopters. Most adopters grow multiple crops, including cassava, sweet potato, beans, rice, corn, peanuts, sorghum, wheat, and various vegetables. Crop diversification is a risk mitigation method, placing potential trade-offs between multiple crops. It also shows that adopters may be more prepared to evaluate and accept ISPVs, given that growing diversified crops likely fosters broader agricultural knowledge and reduces the risks associated with adoption (Adnan *et al*., 2021). Adopters were more likely to interact with agricultural extension service agents than non-adopters. Continuous access to information through extension services is an important facilitator for adopting agricultural technologies, as these agents provide the necessary technical guidance and advice for implementing agricultural innovations (Adekambi *et al*., 2020a). The variable yield uncertainty is a significant concern for non-adopters, suggesting that risk aversion may contribute to decision-making. Market uncertainty is more pronounced among non-adopters, showing that concerns related to access and stability of markets for ISPVs may limit adoption. As noted by Abebe *et al.* (2013), farmers often continue to grow traditional varieties in the absence of certainty regarding the performance or market prospects of improved varieties.

The empirical results of the Logit model, including the marginal effect results and the VIF values of the independent variables, are illustrated in Table 4. All VIF values are below the generally accepted threshold of 10, supporting the lack of significant multicollinearity issues. The coefficient of crop diversification is positive and statistically significant at 1%, showing that farmers who engage in multi-crop production are more likely to adopt ISPVs. These findings highlight how diversified farming systems enable farmers to minimize the potential risk inherent in adopting improved crop varieties, as income from other crops can cushion adoption-associated uncertainties. These results are consistent with Adnan *et al*. (2021) and Muthini (2018), who noted that diversified farming practices increased the likelihood of adopting improved crop varieties.

Table 4

Logit Results of Factors Influencing Adoption of ISPVs

Variables	Coefficient	Standard Error	Marginal effect	VIF
Gender	-0.46	0.39	-0.04	1.13
Education level	0.19	0.37	0.02	1.07
Farming experience	-0.01	0.01	0.00	1.07
Household size	0.02	0.05	0.00	1.08
Farmer size	1.24	1.02	0.11	1.09
Livestock ownership	0.47	0.42	0.04	1.08
Distance to market	-0.01	0.00	0.00	1.06
Group member	-0.06	0.39	-0.01	1.11
Crop diversification	1.11**	0.47	0.10**	1.25
Access to extension	1.08**	0.43	0.09**	1.36
Yield uncertainty	-4.47***	0.70	-0.39***	1.04
Market uncertainty	-1.88***	0.39	-0.16***	1.53
Constant	3.89***	1.06		
Observations	382			
Pseudo R-squared	0.48			

Note: *** = significant at 1% level; ** = significant at 5% level; mean VIF = 1.16

The variable access to extension service also positively and significantly influences the adoption of ISPVs, indicating that sweet potato growers with access to extension facilities are more likely to adopt ISPVs due to technical knowledge, increased awareness and confidence in the technology extension agents provide. This finding is consistent with the studies by Onyeneke *et al*. (2020), Opata *et al*. (2021), and Li *et al*. (2022), who recognized extension as a key enabler of agricultural technology adoption.

Finally, the variables ‘yield uncertainty' and 'market uncertainty' negatively influence the probability of adopting ISPVs. The findings indicate that those who perceive greater risks associated with unpredictable yield (e.g., susceptibility to disease or weather conditions) and unstable markets (e.g., fluctuating demand and unpredictable input costs) are less likely to adopt these varieties. These findings support the critical role of perceived risks as a psychological and contextual constraint to adopting new technologies. Divergent socioeconomic factors that provide the capacity or resources to adopt risk perceptions reflect farmers' uncertainties regarding the consistency and benefits of ISPVs. This aligns with Ekwe (2019), who found that negative perceptions about crop varieties' susceptibility to disease, theft, and low yields discouraged adoption. Likewise, Llones and Suwanmaneepong (2021) found that farmers often resist substantial changes in traditional practices due to perceived risks associated with unfamiliar technologies. Similarly, Abebe *et al*. (2013) reported that farmers persisted in cultivating old varieties due to uncertainty about the performance, marketability, and production costs of new varieties. These findings suggest that perceived risks are not merely secondary considerations but are at the core of farmers’ adoption decisions. Farmers’ perceptions often diverge from researchers’ assessments, as they are informed by experience, peer influence, and contextual realities such as local market dynamics (Kyire *et al*., 2023).

Results in Table 5 show that Mabalane District has the highest adoption rate, likely due to better extension services and support from agricultural organizations that help farmers adopt new agricultural technologies effectively. De Brauw *et al*. (2018) support this finding, noting that 79% of farmers adopting improved varieties in Mozambique were in areas where the technology was actively promoted. In contrast, Massangena District has the lowest adoption rate, which may be attributed to several factors, including limited awareness about the benefits of ISPVs, hesitation toward new technology, and negative experiences from previous adoption attempts. Farmers' perceptions of certain risks, such as susceptibility to disease and lower yields, also discourage the adoption of agricultural technologies (Ekwe, 2019).

Table 5

Adoption Rates of Improved Sweet Potato Varieties

Districts	n=291	Adoption rate (%)
Chokwe	51	72.86
Guija	61	88.41
Chibuto	100	83.33
Mabalane	43	93.48
Chigubo	21	61.76
Massangena	15	34.88

The main reasons mentioned by the farmers for adopting ISPVs, as reported in Table 6, are high yield, early maturity, high nutritive value, taste, high dry matter content, drought resistance, and resistance to pests and diseases. Studies by Mudombi (2013), Adekambi *et al.* (2020a), and Adekambi *et al.* (2020b) also confirmed that yield, early maturity, dry matter content, drought resistance, and disease resistance were critical factors influencing the adoption of ISPVs. Conversely, a scarcity of planting material, low yields, low nutritional value, and susceptibility to pests and diseases were the main reasons for dropping old varieties. This finding is consistent with the findings of Mbanaso *et al.* (2011), and Zawedde *et al.* (2014).

Table 6
Reasons for Adopting Improved Varieties or Discontinuing Old Varieties

Reasons for adopting improved varieties			**Reasons for discontinuing old varieties**		
Variable	**n=291**	**(%)**	**Variable**	**n=74**	**(%)**
High yield	114	39.18	Low yields	19	25.68
Good Taste	45	15.46	Lack of planting material	51	68.92
High dry matter	4	1.37	Pest/disease susceptibility	1	1.35
Drought resistance	3	1.03	Low nutritional value	3	4.05
Early maturity	65	22.34			
Pest/disease resistant	3	1.03			
High nutritive value	57	19.58			

V. CONCLUSION & RECOMMENDATIONS

5.1. Conclusion

This study assessed the factors influencing the adoption of improved sweet potato varieties in Gaza province, located in southern Mozambique, with a primary focus on the under-researched role of farmers' risk perceptions. The results showed that perceived risk factors, specifically yield and market uncertainties, are critical constraints to ISPVs adoption. These perceptions significantly outweigh traditional socioeconomic factors in adoption decision-making, emphasizing the need for a paradigm shift in how adoption research and interventions are designed. Although socioeconomic factors such as crop diversification and access to extension services were shown to play a key role in adoption decisions in this study, factors such as gender, education, livestock ownership, farming experience, distance to market, household size, farmer size, and group membership did not significantly influence ISPVs adoption. This shows that addressing perceived risks is critical and possibly more urgent than relying solely on socioeconomic policies to promote ISPVs adoption.

5.2. Recommendations

The study findings call for fostering the adoption of ISPVs, which requires addressing farmers' perceived risks and increasing their confidence in the reliability and benefits of the crop. Main recommendations include introducing crop insurance schemes tailored to smallholder farmers' circumstances to mitigate productivity variability risks and strengthen predictable market systems, including demand and prices for ISPVs. Also, efforts should focus on improving access to extension services and promoting crop diversification, positively and significantly influencing adoption decisions. Furthermore, future research should expand this scope by integrating comprehensive frameworks such as the TPB to analyze the differentiated interplay between perceived risks, perceived benefits, subjective norms, and behavioural control in the adoption of ISPVs. Finally, future studies should consider how these dynamics differ across socioeconomic and agroecological contexts to formulate region-specific policy recommendations. By integrating these strategies, policymakers can create an enabling environment that supports the adoption of ISPVs and increases food security in the region.

Declaration of Competing Interest

The authors declare no conflict of interest.

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