

Research

Farmer perceptions and their implications for adoption of sustainable agricultural intensification practices

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Abstract

Although extensive research has assessed the role of perceptions in technology adoption, their role in facilitating the adoption of sustainable agricultural intensification practices (SAIPs) among small-scale farmers has received limited attention. The purpose of the research was to assess the effect of perceptions on the adoption of SAIPs. Data were gathered from 320 smallholder maize farmers in Eastern Uganda using a cross-sectional survey. Chi-square was used to compare perceptions of SAIPs among adopters and non-adopters. A binary logistic model was used to compute the effect of perception and institutional and socio-economic factors on farmers' adoption of SAIPs. Results revealed that adopters had higher perceptions of benefits associated with SAIPs than non-adopters, while non-adopters perceived SAIPs as more risky and costly than adopters. Econometric results show that perceived benefits, access to extension services, credit, and market nearness positively affected the adoption of SAIPs. Perceived risks and costs influenced SAIPs' adoption negatively. The study recommends strengthening extension services and farmers' training programs to create awareness of SAIPs' benefits. Extension services should focus on demystifying negative perceptions harbored by smallholder farmers towards SAIPs about costs and risks through frugal and hands-on extension techniques. Policies and development programs should consider farmers' perceptions to foster the adoption of SAIPs.

Keywords Perceptions · Sustainable agricultural intensification practices · Adoption · Institutional factors · Socio-economic factors

1 Introduction

Low crop productivity has remained one of the key constraints to agricultural development, especially in developing countries [64]. Large yield gaps exist in Sub-Saharan Africa (SSA), with average yields of rain-fed agriculture representing only 15–25% of the mean yield potential for most countries [20]. These yield gaps have been exacerbated by the continued use of conventional agricultural practices. According to Gomiero [22], these practices are discouraged because they contribute to the continuous degradation of land, forests, and water, culminating in low agricultural production and productivity.

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Consequently, several efforts have been put into the generation, growth, and propagation of agricultural practices that enhance production and productivity [32]. Key among the interventions is the promotion of sustainable agricultural intensification practices (SAIPs) [71]. Crucial among the SAIPs are conservation tillage, improved crop varieties, agroforestry, integrated pest management (IPM), organic farming, integrated soil fertility management (ISFM), etc. [26, 74]. The benefits of SAIPs include conserving soil and water, boosting soil nutrients, enhancing soil organic matter, and improving crop yields [26]. Furthermore, SAIPs improve the likelihood of farms becoming carbon sinks and enhance food security and biodiversity conservation [23]. These benefits are the critical reasons for their promotion in smallholder farmers' settings. Despite their advantages, SAIPs' adoption has been very slow in several developing countries [64]. For example, research done by Njenga et al. [48] in Kenya revealed that merely 46% of smallholder farmers had adopted ISFM practices. Another investigation in Ghana by Anang et al. [7] on the uptake of soil fertility improvement practices found that only 43% of the farmers had taken up inoculants to improve soil fertility.

Perception defined as farmers' opinions, beliefs, and attitudes about agricultural technologies is a key determinant of adoption [65]. Scholars, Meijer et al. [36] and Meshesha et al. [37] argue that the failure to take up certain farming techniques may be attributed to limited attention given to farmers' perceptions during the agricultural extension process. Likewise, Mulyono et al. [43] and Omara et al. [52], revealed that the rate and speed of adoption of disseminated technologies are dependent on the farmers' perceptions of the technology including, risk, cost, and benefit perceptions. This is because a farmer's insights into the potential outcome of a certain farming technique affect the decision to embrace or discard the technique Ajzen [4]. Similarly, farmers' subjective rating of a new farming technique compared to the old one could inform their resolution to embrace or discard it [2, 58]. For instance, Meshesha et al. [37] revealed that farmers' positive perceptions of the advantage of climate-smart agricultural practices i.e., enhancing agricultural productivity, increased adoption in Ethiopia. Another study by Jha et al. [24] on the effect of farmers' perceptions on the adoption of agriculture technologies in Tanzania, found the technology (improved seeds) that was perceived as sustainable, was highly adopted by smallholder farmers. On the contrary, farmers' lack of technical advice was the most limiting factor to the adoption of agriculture technologies.

Although several studies have been done on the effect of perceptions on the adoption of agricultural technologies [44, 50, 52], research on the effect of perceptions on the adoption of SAIPs is still limited. This research therefore aims to assess the implications of perceptions on adoption of SAIPs among smallholder maize farmers in Eastern Uganda. In addition, the study will analyze the complementary role played by institutional and socio-economic factors in facilitating the adoption of SAIPs. The findings from this work will support the government by recommending policies that can increase the extent of adoption of the SAIPs to improve maize production. This study also adds to the international discussions on SAIPs, one of the current global topics.

1.1 Theoretical perspectives

This study is anchored on the adopter-perception (AP) framework [29]. The AP postulates that perceived attributes of technologies condition adoption behavior. According to this model, prospective adopters accept or reject an emerging technology based on its perceived attributes. As per Owusu [54], the perceived attributes that may influence farmers to embrace or reject technologies can be distinguished as perceived costs, risks, and benefits.

In the AP model, the interrelationships among predictor variables that influence farmers' decisions to take up or reject SAIPs are presented in the conceptual framework below. Whereby adoption of SAIPs such as; improved maize variety, ISFM, conservation tillage, IPM, and legume intercrop is influenced by farmers' perceptions of the practices (perceived benefits, risks, and costs), and institutional and socioeconomic conditions as illustrated below (Fig. 1).

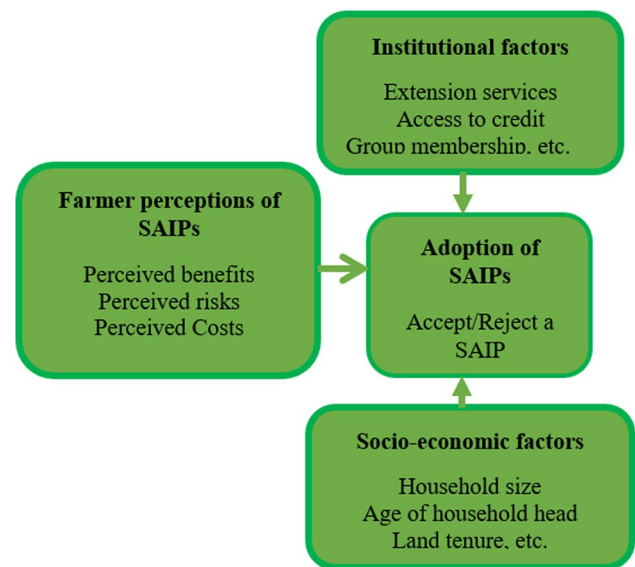
Concerning SAIPs, the perceived benefits may include yield improvement, soil and water conservation, production cost reduction, biodiversity conservation, rehabilitation of degraded lands, and improving soil fertility among others [11, 60, 61]. Risks associated with SAIPs may include loss of biodiversity; pollution of the soil, water, and air; and harm to users [12, 62]. In terms of costs, SAIPs may present costs associated with transport, time, input purchase, and labour [14, 73]. Therefore, the decision to take up or discard a SAIP by a farmer may be based on one or more perceived attributes of the particular SAIP.

It is therefore hypothesized that:

H₁: Perceptions positively and significantly affect farmers' adoption of SAIPs.

Scholars including; Dinesh et al. [17] and Owombo et al. [53] assert that perceptions may not act alone in shaping farmer's decisions to embrace new agricultural technologies. Rather, perceptions are reinforced by the farmers'

Fig. 1 Conceptual framework: own compilation based on Mwangi and Kariuki [44], Kivlin and Fliegel [29]



socio-economic situations such as gender, age, household size, etc. [34, 52]. Furthermore, Atube et al. [10], Nkomoki et al. [49], Urgessa Waktola and Fekadu [69], Venkatesh et al. [72] revealed that farmers' adoption of agricultural technologies is also shaped by institutional factors including; credit access, insurance access, extension advisory services, and access to markets among others. On the other hand, studies by [44, 52] concluded that farmers' adoption of agricultural technologies is shaped by institutional and socio-economic factors. However, how these factors influence the adoption of SAIPs has scarcely been researched. Therefore, this study hypothesized as follows:

H₂: Socio-economic and institutional aspects positively and significantly affect farmers' adoption of SAIPs.

2 Methodology

2.1 Study context

Crop yields in Eastern Uganda have plummeted to less than one-third of the prospective yields on the national stations for agricultural research mainly due to the degradation of the land [56]. Land degradation is being catalyzed by land fragmentation with limited application of soil amendments and unsustainable farm intensification practices. To improve agricultural productivity in the area, one acre fund (IAF) a nongovernmental organization together with the area smallholder farmers has been promoting the uptake and use of numerous SAIPs including; ISFM, improved maize seeds, legume intercrop, conservation tillage, IPM, agroforestry etc. to enhance maize productivity. IAF and the smallholder farmers pilot-tested SAIPs on maize because of its role as a staple food to most Ugandans as well as a cash crop.

Maize productivity like most crops grown in Uganda is generally low [38], standing at 1.0–1.8 metric tons/hectare contrary to the potential yield of 7.5 million metric tons/hectare [18]. Therefore, yield boosting through embracing appropriate environmentally friendly farming techniques is required. Like many new agricultural practices that have been promoted in developing countries and registered a slow adoption rate [41, 57] the adoption of SAIPs in Uganda is still low. Hence the need for the study.

This research was conducted in Jinja (0.53440 N, 33.30370 E) and Kamuli (0.91870 N, 33.12390 E) districts in Eastern Uganda. The districts were purposively chosen because IAF and local governments have intensively promoted SAIPs in maize production for over a decade.

2.2 Study design and sampling

Raw data was gathered at a single point in time from 320 smallholder maize farmers on their perceptions towards SAIPs. A multi-level sampling method was utilized to get the research respondents. In level one, Kamuli and Jinja districts were intentionally chosen because 1AF was advocating for the adoption of SAIPs in the districts through training maize farmers, on-farm demonstrations, and input supply. In level two, Kitayunjwa and Butansi, and Butayaga and Buwenge sub-counties in Kamuli and Jinja districts respectively were intentionally selected for the research because maize growing was more prominent in these sub-counties than other sub-counties in the two districts and IAF was promoting uptake of SAIPs in the area. In level three, a list of respondents was created by the researchers with the help of IAF sub-county-based focal persons in the research area. From the list created, the number of maize farmers affiliated with 1AF who constituted the study population was 1,600 broken down into sub-county; Butansi (412), Kitayunjwa (417), Buwenge (379), and Butayaga (392). This was followed by Yamane's (1967) simple random sampling formula as used by Uakarn [68] to select the sample as illustrated in Eq. (1).

$$w = \frac{M}{1 + M(u^2)} \quad (1)$$

w denotes the study sample; M is the population of smallholder maize cultivators in the four sub-counties stated above who were enrolled with IAF to champion SAIPs adoption and u is the error margin (5%).

$$w = \frac{1600}{1 + 1600(0.5^2)}$$

$$w = 320$$

The computation of the study sub-sample (w_b) for each of the sub-counties was conducted as a proportion of the total (M_s) of 1AF linked smallholder maize cultivators in each Sub County to the population (M) of maize cultivators from all four sub-counties that linked to IAF to champion SAIPs adoption multiplied by the sample size (w) above.

$$w_b = \frac{M_s}{M} * w \quad (2)$$

Consequently, by skip counting every 5th 1AF affiliated maize farmer, the respondents were selected for the research from each of the sub-counties as follows: Butansi (82), Kitayunjwa (83), Buwenge (77), and Butayaga (78) which totaled 320 respondents.

2.3 Inclusion and exclusion criteria

Respondents were smallholder farmers growing maize in the study area, affiliated with IAF, and had adopted at least one sustainable agricultural intensification practice for one season (6 months) minimum. In the research, these farmers acted as adopters for SAIPs used on their farms and non-adopters for SAIPs they were not using on their farms. Therefore, they were asked to give their perceptions of practices that they were using and those that they were not on their farms. We zeroed in on using the same respondents to provide information on their perceptions of adopted and unadopted SAIPs because, during the questionnaire pretesting exercise, it was found that farmers not affiliated with IAF were not knowledgeable about SAIPs and hardly gave opinions on their perceptions of the practices. Farmers affiliated with IAF had substantial information acquired through exposure and training that shaped their perceptions of SAIPs. It was also found that adoption of SAIPs was not very high, and therefore it would be possible to have substantial numbers of adopters and non-adopters of different SAIPs within the study sample. The number of adopters and a corresponding number of non-adopters for each practice is in Table 2.

2.4 Data collection

Following a comprehensive review of existing research, the questionnaire was developed. The tool was pretested to ensure that it is valid and generates reliable results on the effect of farmers' perceptions on SAIPs' adoption. The tool was then revised after pretesting. Some questions were added to the tool while others were eliminated to make the tool as clear, valid, and reliable as possible. Before data collection, interviewers obtained informed consent from all research participants. Researchers conducted face-to-face interviews based on semi-structured questionnaires in July 2020 to gather raw data. The interview focused on: household institutional aspects [74]; socio-economic profiles [35]; and perceptions of SAIPs that were binary choices (yes or no) on whether farmers believed the practices were costly, risky, and beneficial [52]. These constituted the perceived costs, perceived risks, and perceived benefits respectively.

Following Joao et al. [25], Omara et al. [52], the perception parameters (perceived costs, risks, and benefits) were unpacked to generate statements that were consistent with attributes of agricultural intensification practices [16, 23, 61] (Table 2). Respondents (adopters and non-adopters) were asked whether they perceived each statement as true or false (coded as 1 or 0). The responses were then computed to give percentages.

2.5 Ethics approval and consent to participate in the research

This research was presented to the Gulu University Research and Ethics Committee (GUREC), which gave us clearance to gather information from small-scale maize farmers in the study area as enshrined in GUREC guidelines of Gulu University. Informed consent was obtained from all research participants before the commencement of each interview.

2.6 Analysis of data

Before extensive data analysis, the data was cleaned by running descriptive statistics in the 24th version of the Statistical Package for Social Sciences (SPSS). Errors found on the dataset were corrected by revisiting hard copies of filled questionnaires and having the data set completed. All 320 questionnaires filled during data collection were utilized in the analysis because they had full information. SPSS was also used to compute the percentage responses on perceptions among adopters and non-adopters of SAIPs. Chi-square was used to assess whether there were significant differences among adopters and non-adopters in their perception of SAIPs. A binomial logistic regression model was used to analyze the effect of predictor variables on the outcome variables, in Stata version 14.

2.7 Binary logistic regression model

Though scholars usually use multivariate probit modeling (MVPM) to assess predictors of farmers' adoption of agricultural technologies [37, 45], involving binary outcomes, we found the multivariate model inappropriate for this study. This is because a test for correlations among outcome variables found that there were neither negative nor positive correlations that the MVPM takes care of. Another option was to use a logit or probit regression model to analyze data. In this study, we utilized the binary logistic regression model (BLRM) to assess the effect of predictor variables on outcome variables because of its ability to compute data faster and provide direct estimates of probabilities than probit models [28, 51]. Farmers' adoption of SAIPs is a dependent variable denoted by 1 if the farmer has adopted the practice and 0 if the farmer has not adopted a practice. The logit model was estimated according Rao [63].

$$p_i = \text{pr}(y_i = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_i + \dots + \beta_r x_r)}} = \frac{e^{(\beta_0 + \beta_1 x_i + \dots + \beta_r x_r)}}{1 + e^{-(\beta_0 + \beta_1 x_i + \dots + \beta_r x_r)}} \quad (3)$$

Likewise,

$$p_i = \text{pr}(y_i = 0) = 1 - \text{pr}(y_i = 1) = \frac{1}{1 + e^{(\beta_0 + \beta_1 x_i + \dots + \beta_r x_r)}} \quad (4)$$

Dividing (4) by (5) gives

$$\frac{\text{Pr ob}(Y_i = 1)}{\text{Pr ob}(Y_i = 0)} = \frac{p_i}{1 - p_i} = e^{(\beta_0 + \beta_1 x_1 + \dots + \beta_r x_r)} \quad (5)$$

p_i denotes the chance that a maize farmer has adopted a SAIP; e stands for the exponential constant while $1 - p_i$ denotes the chance that a maize farmer has not adopted a SAIP. Multicollinearity was checked before model estimation and unnecessary variables dropped. The variance inflating factor (VIF) is used to determine the speed with which variances and covariance increase as specified in Eq. 6.

$$\text{VIF} = \frac{1}{1 - R_i^2} \quad (6)$$

where R_i^2 is the coefficient of determination in the regression. The bigger the VIF the larger the collinearity of the explanatory variables [63]. The bigger the VIF the larger the collinearity of the explanatory variables [63]. Chances of heteroscedasticity during computation were managed by estimating a vibrant model that analyses robust variance estimator using a variable list of equations. The mean VIF was 1.67 while the minimum VIF was 2.30 and Minimum VIF was 1.54. This was realized after discarding variables with higher multicollinearity coefficients. The minimum VIF should be 1 and the maximum VIF should be 10 [5, 28] Therefore, the VIF of the study is within the acceptable range, showing the non-presence of multicollinearity amidst predictor variables.

In this study, the outcome variables were the adoption of SAIPs and the predictor variables were the institutional aspects, farmer perceptions, and the socio-economic factors (Table 1). The predictor variables utilized in this study were selected based on previous research [1, 9, 11, 23, 31, 53, 66, 67].

3 Results

3.1 A comparison of the perceptions of SAIPs among adopters and non-adopters

The results in Table 2 indicate significant differences in perceived SAIPs' benefits, costs, and risks among non-adopters and adopters. An analysis of the differences in the percentage responses indicates that perceived benefits seem to positively influence the adoption of SAIPs, while perceived risks and perceived costs negatively affect their adoption. Adopters had significantly better perceptions of benefits associated with SAIPs than non-adopters across all SAIPs. For instance, the percentage differences among adopters and non-adopters on the perception that SAIPs' adoption improves maize yields were positive and significant for improved maize varieties ($p < 0.1$), conservation tillage ($p < 0.01$), IPM ($p < 0.1$), ISFM ($p < 0.01$) and legume intercrop ($p < 0.01$). Likewise, the percentage differences among adopters and non-adopters in the perception that SAIPs' adoption enhances biodiversity conservation were positive and significant for conservation tillage ($p < 0.1$), ISFM ($p < 0.1$), and legume intercrop ($p < 0.01$). Similarly,

Table 1 Independent variables used to assess SAIPs' adoption

Variable	Unit	Description	Sign
Extension services	Dummy	1 for a farmer's access to extension services, and 0 for otherwise	+
Credit	Dummy	1 for farmer's access to credit and 0 for otherwise	+
Group membership	Dummy	1 if a farmer is a member of a group, and 0 for otherwise	+
Market access	Continuous	Distance from the farm to the maize market (km)	-
Experience in farming	Continuous	Number of years a farmer has spent in farming (years)	±
Gender of family head	Dummy	1 for male, 0 for otherwise	±
Size of household	Continuous	Number of people in the farm family	+
Family labour use	Dummy	1 if the farmer uses family labour, and 0 if otherwise	+
Ownership of land	Dummy	1 if a farmer owns the land, and 0 if otherwise	+
Perceived benefit	Dummy	1 if there is a benefit associated with a SAIP and 0 if otherwise	+
Perceived risk	Dummy	1 if there is risk associated with a practice, and 0 if otherwise	-
Perceived cost	Dummy	1 if there is a cost associated with a practice, and 0 if otherwise	-

Table 2 Comparing perceptions of SAIPs among adopters and non-adopters

Perception	Improved maize variety (A, n = 187), (NA, n = 133)			Conservation tillage (A, n = 114), (NA, n = 206)			IPM (A, n = 180), (NA, n = 140)			ISFM (A, n = 166), (NA, n = 154)			Legume intercrop (A, n = 142), (NA, n = 178)		
	A	NA	χ^2	A	NA	χ^2	A	NA	χ^2	A	NA	χ^2	A	NA	χ^2
Perceived benefits															
SAIP improves yield	98	84	3.44*	93	45	7.43***	98	79	11.34*	96	53	9.70***	77	38	11.49***
SAIP improves biodiversity conservation	56	53	0.83	81	63	2.61*	67	64	1.67	81	62	7.69*	92	64	8.33**
SAIP improves soil, and water conservation	49	46	0.64	98	59	8.95***	42	39	2.23	77	44	7.58***	96	43	9.67***
Perceived risks															
Pollutes environment	-	-	-	59	72	-3.70*	53	68	-2.97*	33	54	-6.42**	-	-	-
SAIP causes biodiversity loss	35	38	-0.45	36	59	-5.61*	43	54	-3.40*	34	37	-3.15	11	13	-1.90
Perceived costs															
SAIP is time-consuming	32	41	-9.56*	35	50	-2.65*	37	56	-6.52**	81	79	1.89	19	33	-2.71*
SAIP is expensive	63	79	-4.90**	36	51	-1.54**	34	53	-1.64**	58	82	-13.53**	27	24	1.71
SAIP is labour intensive	45	42	0.71	30	33	-0.75	52	73	-4.97**	66	83	-2.87*	60	57	3.62

A adopters, NA non-adopters, SAIP sustainable agricultural intensification practice, χ^2 chi-square

***, **, and * stand for significance level at 1%, 10% and 5% respectively

Table 3 Overall pooled means for perceptions of SAIPs

Perceptions	Improved maize variety		Conservation tillage		IPM		ISFM		Legume intercrop	
	Mean	S. D	Mean	S. D	Mean	S. D	Mean	S. D	Mean	S. D
Perceived benefits	64.0	23.8	71.5	20.4	64.7	09.7	68.9	19.2	68.3	23.6
Perceived risks	18.3	05.4	56.5	11.1	54.5	13.2	48.7	23.5	12.1	02.2
Perceived costs	50.3	17.6	39.2	12.8	46.3	14.4	78.1	04.6	40.4	13.2

S. D standard deviation, *IPM* integrated pest management, *ISFM* integrated soil fertility management

Table 4 Perceptions affecting farmers' adoption of SAIPs

Variable	IMV	CT	IPM	ISFM	LIC
	Coef. (S.E)	Coef. (S.E)	Coef. (S.E)	Coef. (S.E)	Coef. (S.E)
Perceived benefits	0.163** (0.047)	0.165** (0.021)	0.150* (0.053)	0.154** (0.079)	0.173** (0.094)
Perceived risks	-0.035 (0.027)	-0.078* (0.046)	-0.083* (0.051)	-0.175* (0.056)	-0.001 (0.033)
Perceived costs	-0.154* (0.072)	-0.043 (0.079)	-0.217 (0.092)	-0.359*** (0.092)	-0.051 (0.086)
Constant	-1.253	-1.097	-1.326	-1.591	-0.142
Number of observations	320	320	320	320	320
Pseudo-R ²	0.3942	0.2513	0.1706	0.3855	0.2371
Log-likelihood	-175.820	-48.427	-121.074	-187.641	-189.523
LR chi2(11)	123.46	154.63	208.10	103.62	43.33
Prob > chi2	0.000	0.0000	0.000	0.0000	0.000

CT conservation tillage, *IMV* improved maize varieties, *LIC* legume intercrop, *IPM* integrated pest management, *ISFM* integrated soil fertility management, *Coef.* coefficients, *S. E* standard error

** $p < 0.05$, *** $p < 0.01$, and * $p < 0.1$

the percentage differences in the perception among adopters and non-adopters that SAIPs improve soil and water conservation were positive and significant ($p < 0.01$) for conservation tillage, ISFM, and legume intercrop ($p < 0.01$).

Conversely, non-adopters had a higher perception of risks and costs associated with SAIPs than adopters. The percentage differences among adopters and non-adopters on the perception that SAIPs may cause environmental pollution were negative and significant for conservation tillage ($p < 0.1$), integrated pest management ($p < 0.1$), and ISFM ($p < 0.01$). Similarly, the percentage differences between adopters and non-adopters on the perception that SAIPs may cause biodiversity loss were negative and significant ($p < 0.1$) for conservation tillage and IPM.

As expected, non-adopters perceived SAIPs as more costly than adopters for most SAIPs. The percentage differences between non-adopters and adopters were negative and significant for the perception that SAIPs are time-consuming, for conservation tillage ($p < 0.1$), IPM ($p < 0.05$), and legume intercrop ($p < 0.05$). Also, the percentage differences among non-adopters were negative and significant ($p < 0.05$) for the perception that SAIPs are expensive, for improved maize varieties, conservation tillage, IPM, and legume intercrop. Last but not least, the percentage differences between non-adopters and adopters were also negative and significant for the belief that SAIPs are labour intensive, for IPM ($p < 0.05$), and ISFM ($p < 0.1$).

3.2 Overall mean perception of SAIPs

The overall perception means of SAIPs were obtained by merging perceptions of non-adopters and adopters. Results indicate that conservation tillage was highly perceived as a benefit (72%), followed by integrated soil fertility management (69%). Legume intercrop was perceived to possess the least risks (12.1%). As for costs, integrated soil fertility management was the most expensive (78%), followed by integrated pest management (46.3%) (Table 3).

3.3 Perceptions affecting farmers' adoption of SAIPs

Research findings presented in Table 4 on the goodness of fit of the BLRM show that the pseudo-R-squared values were 39.4%, 25.1%, 17.6%, 38.6%, and 23.7% with their matching log-likelihood ratios of -129.514 , -149.842 , -185.766 , -122.167 , and -170.849 for the effect of perceptions on the adoption of all the five SAIPs including, improved maize varieties, conservation tillage, IPM, ISFM, and legume intercrop correspondingly. The confidence level of the BLRM was 1% throughout all 5 SAIPs, and none of the coefficients were equal to zero. According to Midamba and Kizito (2022), the pseudo-R-squared values and the log-likelihood ratios of all SAIPs fit within acceptable limits. Consequently, the BLRM was suitable to represent the results on the effect of perceptions on the adoption of SAIPs.

Results in Table 4 indicate that perceived benefits positively and significantly affected the adoption of all SAIPs i.e., improved maize varieties ($p < 0.05$), conservation tillage ($p < 0.05$), IPM ($p < 0.1$), IPM ($p < 0.05$) and legume intercrop ($p < 0.05$). This implies that farmers who believe that SAIPs are more beneficial than conventional agricultural practices are more likely to adopt them.

As expected, perceived risks negatively and significantly ($p < 0.1$) affected the adoption of conservation tillage, IPM, and ISFM. Similarly, perceived costs had a negative and significant effect on farmers' adoption of improved maize varieties ($p < 0.1$) and ISFM ($p < 0.01$). This implies that the chances of farmers taking up SAIPs that were perceived to be risky and expensive were low.

3.4 Effect of socio-economic and institutional factors on the adoption of SAIPs

Research findings in Table 5 concerning BLRM goodness of fit indicate that the pseudo-R-squared values were 42.6%, 39.1%, 40.1%, 39.5%, and 23.5% corresponding to log-likelihood ratios of -163.919 , -147.316 , -113.063 , -163.352 , and -196.824 for improved maize varieties, conservation tillage, IPM, ISFM, and legume intercrop, successively. The BLRM confidence level stands at 1% for all SAIPs, with not one of the coefficients being equal to zero. All the log-likelihood ratios and pseudo-R-squared values lie within the allowable limits [39], therefore the BLRM was suitable for presenting research outcomes on determinants of SAIPs' adoption.

Table 5 Institutional and socio-economic factors affecting farmer perception of SAIPs

Variables	IMV	CT	IPM	ISFM	LIC
	Coef. (S.E)	Coef. (S.E)	Coef. (S.E)	Coef. (S.E)	Coef. (S.E)
Extension services	0.165** (0.076)	0.168* (0.084)	0.162* (0.089)	0.043 (0.084)	0.045 (0.077)
Credit	0.281*** (0.074)	0.240*** (0.085)	0.011 (0.095)	0.205*** (0.077)	-0.004 (0.079)
Group membership	-0.122 (0.075)	0.141* (0.077)	0.110 (0.196)	-0.076 (0.068)	-0.011 (0.067)
Market access	0.143*** (0.049)	0.166*** (0.051)	0.160*** (0.057)	0.034 (0.043)	0.036 (0.044)
Experience in farming	0.009 (0.034)	0.023 (0.036)	-0.071* (0.039)	-0.004 (0.033)	-0.002 (0.031)
Family head's gender	0.054 (0.089)	-0.032 (0.099)	0.295*** (0.101)	-0.038 (0.083)	-0.021 (0.083)
Size of household	-0.024** (0.009)	-0.009 (0.010)	0.014 (0.011)	0.007 (0.009)	0.006 (0.009)
Family labour	-0.094 (0.070)	-0.123 (0.077)	0.059 (0.086)	-0.008 (0.069)	-0.089 (0.066)
Ownership of land	-0.027 (0.049)	0.075 (0.051)	0.036 (0.059)	0.125*** (0.047)	-0.013 (0.043)
Intensity	0.017 (0.037)	-0.103*** (0.038)	-0.195*** (0.051)	-0.045 (0.037)	-0.069 (0.032)
Constant	-1.341	-1.045	-1.649	-1.452	-0.191
Number of observations	320	320	320	320	320
Pseudo-R ²	0.4262	0.3913	0.4010	0.3952	0.2351
Log likelihood	-163.919	-147.316	-113.063	-163.352	-196.824
LR chi2(11)	112.57	145.36	209.00	102.31	41.11
Prob > chi2	0.000	0.0000	0.000	0.0000	0.000

CT conservation tillage, IMV improved maize varieties, IPM integrated pest management, ISFM integrated soil fertility management, LIC legume intercrop

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

A binary logistic regression computed to ascertain socio-economic and institutional aspects affecting farmers' adoption of SAIPs (Table 4) shows that extension information access positively and significantly improved farmer adoption of conservation tillage ($p < 0.1$), improved maize varieties ($p < 0.05$), and IPM ($p < 0.1$). This implies that farmers who received agricultural extension information had substantial knowledge of the potential benefits of SAIPs which improved their adoption.

Similarly, access to financial loans significantly enhanced farmers' chances of taking up conservation tillage ($p < 0.01$), improved maize varieties ($p < 0.01$), and ISFM ($p < 0.01$). This implies that access to credit improves farmers' available cash for investing in SAIPs.

In addition, market access uplifted farmers' uptake of conservation tillage ($p < 0.01$), IPM ($p < 0.01$), and improved varieties of maize ($p < 0.01$). This implies that the shorter the distance to the market, the higher the chances of taking up SAIPs in maize production.

Furthermore, membership in farmers' groups significantly improved farmers' adoption of conservation tillage ($p < 0.01$). This is because group membership enhances farmers' connections with exposed farmers from whom they can learn new ideas such as the application of SAIPs on their farms.

Relatedly, the gender of a household head positively and significantly affected farmers' adoption of IPM ($p < 0.01$). This implies that males were keen on using IPM to control pests in maize gardens compared to females.

Conversely, farmer experience in farming and household size of households negatively and significantly affected farmer perception of utilizing IPM ($p < 0.1$) and improved varieties of maize ($p < 0.01$) respectively.

4 Discussions

4.1 Farmer perceptions and adoption of SAIPs

Farmer perceptions play a pivotal function in catalyzing the uptake of modern farming practices [50, 52, 65, 75]. Comprehending farmers' perceptions of agricultural practices is key to recommending strategies for their adoption [35, 44]. Assessment of perceptions on SAIPs' benefits, risks, and costs was conducted in Jinja and Kamuli Districts, eastern Uganda. The study found that adopters had higher perception of SAIPs' benefits while non-adopters had higher perceptions of their risks and costs. This suggests that perceived benefits increased adoption while perceived risks and perceived benefits led to the rejection of SAIPs.

Perceived benefits positively and significantly influenced the adoption of all SAIPs. Farmers who believed that SAIPs improve maize yields, enhance the conservation of soil and water, and sustain biodiversity had a high possibility of embracing SAIPs. The fact that perceived benefits improved the possibility of taking up SAIPs implies that as farmers gain more awareness of the extended environmental advantages of technology, their chances of taking it up increase [52]. This was corroborated by Precious et al. [59], Dessart et al. [15], Feder et al. [19], Ghimire et al. [21], Mugonola et al. [42] who revealed that a farmer takes up an agricultural practice if its perceived utility, in this context the benefit of using a SAIP, is higher than the benefit got from using the existing practice. This study also agrees with other studies carried out in SSA that found farmers had adopted various agricultural technologies because they were perceived to increase crop yields, maintain biodiversity, and enhance soil and water conservation [27, 37, 40, 47]. This implies that adoption efforts should focus on creating awareness and showcasing SAIPs' advantages through practical demonstrations in farmers' gardens [59]. Another reason for showcasing the benefits of SAIPs on the farm would be to ensure that their uptake by farmers is consistent with the biophysical and socioeconomic aspects of the area [59, 70]. Additionally, Showcasing the benefits of SAIPs to farmers unlocks the minds of those who have harbored resentment toward SAIPs. This study's findings provide strong evidence to support the null hypothesis that perceptions positively affect the adoption of SAIPs. The findings highlight the need to enhance farmers' appreciation of the benefits of SAIPs to foster the adoption of SAIPs.

Perceived risks of SAIPs negatively and significantly affected the adoption of SAIPs such as conservation tillage, IPM, and ISFM. The negative effect of perceived risks on the possibility of taking up SAIPs suggests that the more the farmers become suspicious of possible risks associated with certain agricultural practices, the higher the chances of rejecting them [8, 29]. The non-adopters rated SAIPs to be riskier than adopters. This was probably because non-adopters associated SAIPs like conservation tillage, IPM, and ISFM with biodiversity loss and environmental pollution if not applied with strict compliance to their recommended application procedure. Another plausible explanation for this scenario could be that non-adopters had limited knowledge of the application procedure and actual risks associated with using SAIPs due to limited knowledge and experience. These study findings are consistent with other scholars who argue that

farmers will not embrace innovations when they perceive them as risky [3, 6, 31]. This study finding does not provide evidence to support the null hypothesis that perceptions positively affect the adoption of SAIPs. Since perceived risks constrained adoption, there is a need for awareness raising, knowledge, and skills provision to smallholder farmers in the safe handling of SAIPs to minimize risk averseness among target farmers.

Perceived costs negatively and significantly influenced the adoption of SAIPs including; improved maize varieties and ISFM. Regarding costs, non-adopters perceived SAIPs as more costly than adopters i.e. in terms of time, labour requirements, and expenses incurred to procure inputs. This was probably because non-adopter farmers lacked knowledge of costs associated with the SAIPs and perhaps were also less knowledgeable about the benefits of adoption. The negation of SAIPs by non-adopters based on costs is in agreement with Mwangi and Kariuki [44], Yigezu et al. [75] who revealed that when technologies are perceived to be costly, they are less adopted compared to the cheaper ones, even when the former produces better results than the latter. This research finding conforms with Oyetunde-Usman et al. [55] narrative, that farmers are less likely to take up innovations that are perceived to be expensive, as long as they have not been able to secure low-cost loans to procure them. Since SAIPs require buying agricultural inputs and attending agricultural training that may require transport, this may present substantial costs to farmers in cash and time thereby affecting adoption. Research results showed that most SAIPs were perceived to be expensive, implying that availing of affordable SAIPs is required to facilitate their adoption. This finding nullifies the hypothesis that perceptions positively affect the adoption of SAIPs. It implies that efforts to promote SAIPs' adoption should focus on using locally available cheap resources.

4.2 Influence of institutional socio-economic factors

The main factors influencing the adoption of SAIPs included access to extension services, credit, and market. Accessibility to agricultural information and advisory services positively affected farmers' adoption of conservation tillage, IPM, and improved maize varieties. This implies that access to agricultural extension information improved farmers' appreciation of the risks, costs, and benefits linked to each of the SAIPs under discussion and enhance farmers' ability to take up SAIPs from an informed perspective. Additionally, farmers who subscribed to groups embraced SAIPs more than non-group members because farmers easily accessed extension information through groups. This aligns with Bontsa et al. [13], Kule et al. [30] and Mwaura et al. [45] who disclosed that farmers' access to agricultural extension information leads to improved attitudes and knowledge on benefits, risks, and costs of technologies enabling farmers to embrace them from an informed point of view. Another study carried out in Ethiopian on agricultural technologies uptake found that farmers who had access to agricultural information and training perceived the benefits of soil and water conservation practices better than those who never accessed training, and had high chances of taking up soil and water conservation techniques [33]. Therefore, awareness creation and sensitization of farmers through method and result demonstrations can assist in improving and sustaining positive perceptions of the benefits of SAIPs which consequently uplifts adoption.

Similarly, accessing financial loans improved farmer perceptions on the adoption of conservation tillage, improved maize varieties, and IPM. This could be due to enhanced farmers' ability to buy certain SAIPs' ingredients that require money. This finding corroborates with Bontsa et al. [13] and Ndiritu et al. [46] who revealed that farmers' accessibility to credit was positively linked to improved perception of taking up agricultural technologies. Financial loans make it easy for cultivators to buy the agricultural inputs required to constitute SAIPs and apply them on the farm.

Furthermore, market access positively influenced farmer perceptions on taking up IPM, conservation tillage, and improved maize varieties. Market access influenced farmers' decision to adopt SAIPs since they were sure of easily delivering their maize produce to buyers and getting paid instantly. In addition, market access tends to trigger more investment in SAIPs by farmers because they are sure of the market for maize produced. This is in agreement with Bontsa et al. [13], Jha et al. [24], Marie et al. [33] who assert that market access triggers market-oriented production which generates substantial income that enables farmers to invest in the adoption of agricultural technologies that improve farm production and productivity.

The findings of the study support the null hypothesis that institutional and socio-economic factors affect the adoption of SAIPs positively. The findings highlight the need to consider institutional and economic aspects in promoting the adoption of SAIPs.

4.3 Conclusions

Agriculture is the mainstay of smallholder farmers and provides most of their livelihood needs in Uganda. Although agriculture is vital, the sector is struggling with low agricultural productivity due to the continued use of inferior farming

practices. Consequently, SAIPs offer a solution to low agricultural productivity. Remarkably, farmers are slow to adopt SAIPs, which could improve agricultural productivity in Uganda. Comprehending the implications of farmer perceptions on the adoption of SAIPs by smallholder farmers is key for tackling productivity constraints. This research assessed farmers' Perceptions and their effect on the SAIPs' adoption among smallholder maize farmers in Jinja and Kamuli districts, in eastern Uganda. Specifically, a comparison of the perceptions of SAIPs among adopters and non-adopters was done. The effect of perceptions, and institutional and socio-economic factors on SAIPs' adoption were also investigated. Chi-square was utilized to compute the perception differences among adopters and non-adopters of SAIPs. The binomial logistic regression model was used to assess the effect of perceptions, and institutional and socio-economic factors on SAIP's adoption. The Chi-square results revealed that adopters had higher perceptions of benefits associated with SAIPs than non-adopters, while non-adopters perceived SAIPs to be more risky and costly than adopters. The binomial logistic regression model results revealed that perceived benefits, access to extension services, credit, and market were the positive determinants of SAIPs' adoption. On the contrary, perceived risks and costs were the main inhibitors of SAIPs' adoption. Hence, this study deduces that these factors are crucial in affecting the adoption of SAIPs among smallholder farmers in Eastern Uganda.

4.4 Policy recommendations

The research results suggest the following recommendations for practitioners and policymakers. Extension services and farmers' training programs should be designed and strengthened to address concerns and misconceptions about SAIPs. Farmers' education and sensitization programs such as radio talk shows, exhibitions, and method and result demonstrations should be implemented to raise farmers' awareness about the benefits of SAIPs. Policies and development programs promoting SAIPs should consider farmers' perceptions of these practices.

4.5 Limitations of the study

The research has a few limitations that deserve mention. This research used only three aspects (perceived benefits, costs, and risks) to assess the effect of perceptions on SAIPs' adoption. Future research should consider more aspects in assessing the effect of perceptions on SAIPs' adoption.

Author contributions E.K.K, A.O, D.A, and W. O participated in research design; E.K.K trained data collection research assistants and also participated in data collection; and E.K.K and D.M.O analyzed data. E.K.K wrote the manuscript draft. All authors were involved in reading the manuscript drafts, proposing areas of improvement and approval of the final manuscript.

Data availability The dataset for this research can be availed by the corresponding author on request.

Declarations

Competing interests No conflict of interest is declared by all the authors.

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