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COMMERCIALIZATION OF MAIZE IMPEDES UPTAKE OF SUSTAINABLE INTENSIFICATION PRACTICES AMONG SMALLHOLDER FARMERS OF EASTERN UGANDA

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ABSTRACT

Increased productivity through sustainable intensification of agriculture is a major pathway to strengthening smallholder economies through food crop commercialization. However, due to engendered crop decisions where women tend to own and produce food crops mostly using sustainable practices, and men the cash crops that they produce using intensification practices, it thus remains unclear whether increased smallholder food crop production is attainable in an environmentally friendly manner. Therefore, this study sought to determine the influence of commercialization on the uptake of Sustainable Intensification Practices (SIP) in eastern Uganda. Survey data from a random sample of 584 smallholder maize farmers was subjected to binary logistic analysis in SPSS version 16. Results show commercialization (β = -2.567, p = 0.000), farmer's sex (β = -1.761, p = 0.018), peer influence/ support (β = 1.937, p = 0.015), and autonomy to use productive assets (β = 1.741, p = 0.042) and earned income (β = 1.261, p = 0.034) statistically significantly influence farmer uptake of the SIP. It is demonstrated that commercialization inhibits uptake, and women were less likely to use SIP because of a lack of autonomy in decision-making regarding resource use. In conclusion, the uptake of SIP as embedded in gender relations governing resource use and distribution and, as such, enhanced women's rights over the use of productive resources and earned income should be incorporated in policies and extension programs accompanying the delivery of sustainable intensification practices.

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INTRODUCTION

Commercialization, which is the transformational journey involving moving from subsistence farming systems to either semi-commercial or commercial systems (Morgan, 1977; Nguyen et al., 2024, Mgomezulu et al., 2024), is recognized as a major strategy for poverty alleviation (World Bank, 2007; Mekonnen, 2017). It involves increased uptake of and investment in efficient technologies, leading to increased marketed output (Gebremedhin and Jaleta, 2010; Okezie et al., 2012). Commercialization can stimulate farmers' use of innovations when implemented in smallholder agriculture because it motivates them to seek strategies for increasing output (Wiggins et al., 2011; Sokoni, 2018).

For most developing worlds, including Uganda, smallholder farms constitute 80% of all farms (Graeub, et al., 2016; UBOS, 2020) and mostly produce food crops including maize, millet, and beans (UBOS 2020). Although these crops have long been used as food crops,

the divide between food and cash crops has become thinner today (Shibata R. et al., 2020). A food crop may serve both as food and income source and can be sold in both the domestic and foreign markets (Barbier, 2015), and maize is one of those food crops that have gained prominence as cash crops due to its market demands within the country and across borders. In Uganda, maize is grown across the country and is a direct livelihood source to 2 million households, 1,000 traders/merchants, and 600 millers who count on the crop for income. Agricultural statistics (2019) indicated that maize was produced by 69% of farming households and produced 2.8 million tonnes, with an annual yield of 1.6 MT/Ha (UBOS, 2020). Maize is one of the priority commodities in the Agriculture Sector Strategic Plan – ASSP (GOU, 2016). Maize has high production elasticity, so it is used as a major source of carbohydrates for humans and livestock (Melinda et al., 2011). Green maize, in particular, has conventionally been used in the countryside as a rapid 'hunger reliever' (UBOS, 2020; Mubiru, 2019). Accordingly, maize is Uganda's significant food security commodity and cash crop (RATES, 2003; Otunge, 2010).

While the production of maize showed a steady increase between 1999/2000 and 2018, the increase was due to expanded planting rather than productivity. For example, between 2018 and 2019, production of maize declined by 682 MT (20% of the 2018 production), which was attributable to the corresponding 24 percent less planting, given that productivity for the two periods was the same at 1.7 t/ha (UBOS, 2020). Therefore, the productivity of maize is very low, given that the average global productivity is 5.75 t/ha (Canton, 2021). Eastern Uganda is one of the regions where maize is increasingly commercialized by smallholder farmers (Sokoni, 2018), producing about 47% of the maize in the country (UBOS, 2020).

Commercialization terminologies, such as agro-industrialization, input access, and market access, have recently dominated policy and development conversations. In Uganda, there is increased advocacy for the market development of crops such as maize, cassava, and millet that have traditionally been known to be food crops, and emphasis is put on using Sustainable Intensification Practices (SIP) to ensure that small-sized farms remain sustainably productive (Pretty and Bharucha, 2014; Duric and Njegovan, 2016). Sustainable Intensification Practices are agricultural innovations that increase the present food output without jeopardizing the land's capacity to produce food in the future (Khataza, 2017). Sustainable Intensification (SI) involves the adoption of a variety of practices and contexts, including agroecological farming and the utilization of innovations and new management styles. It uses sustainable or conservational practices such as maize-legume intercropping and organic manure jointly with 'intensification or complementary practices', such as improved varieties and organic fertilizers (Pretty and Bharucha, 2014). Arguably, SI is a compromised decision outcome that foregoes some benefits of sustainability and intensification benefits depending on localized goals that must be attained.

However, in practice, the implementation of SIP remains a challenge. Market-aware farmers, when well-resourced, tended to opt for innovations that increased output (Giovannucci et al., 2012; Hualin Xie et al., 2019). In addition, smallholder farmers are quite often resource-constrained (Graeub et al., 2016), and their contribution to crop production is gendered. Men produce cash crops, and women produce food crops (Mayambala et al. 2024) in contexts where men exert more rights over productive assets. Food crop commercialization can shift ownership of food crop production resources to men, which can lead to increased use of intensification inputs and changes in production and consumption decisions (Okike et al., 2005; Leavy and Poulton, 2007; Godfray et al., 2010); and negative outcomes in regards to the ability of the smallholder farmers to produce food in future (FAO, 2017; Calicioglu et al. 2019; Manida, 2022). Thus, while commercialization can be a strong incentive for the use of SIP, the gendered contexts in cropping decisions are a strong impetus for research to enhance understanding regarding the contribution of commercialization to the uptake of SIP. Therefore, this study sought to examine the influence of commercialization on the uptake of sustainable intensification practices among maize-commercializing smallholder farmers of eastern Uganda.

Conceptual framework

In this study, the uptake of SIP involved farmers' decisions to use manure and or maize-legume intercropping together with improved maize varieties and fertilizers. These innovations were widely delivered within the study area (Mayambala et al. 2024). As such, farmers' uptake of SIP was unlikely to be a chance

outcome, because commercialization was expected to induce the uptake of these innovations. Accordingly, the study adopted the induced innovation theory, which proposes that relative changes in factor and product prices work as powerful stimuli for the innovativeness of agents (Hayami and Ruttan 1971).

In taking up induced innovation theory, it is assumed that any innovation taken up by farmers under their stable farming systems is not accidental, but a result of how the farmers interpret factor and product price signals. Both the factors of production and produced goods are essential in the uptake of SIP because demand for agriculture products raises prices of inputs for which the supply is inelastic relative to the prices of inputs for which the supply is elastic. Expectedly, farmers would be induced to seek cheaper means of production (Chhetri *et al.*, 2012; Smith, 2018). Studies that use induced innovation theory are common (Carter, 2008; Ruttan and Hayami, 2011; Chhetri *et al.*, 2012; Nandonde *et al.*, 2015) and these emphasize the relevance of factors and produce prices in stimulating the uptake of technologies. Hence, it is hypothesized that: *gains in the level of maize commercialization induce the farmers to use expensive inputs by substituting the less productive inputs for innovations that maximize output.*

In addition, Chhetri et al. (2012) indicated that changes in social and cultural values enhance innovation uptake if, by doing so, production is boosted or it is cost-saving. Maize commercialization may involve gender dynamics because maize is traditionally a food crop, and commercialization has tended to transform maize into a men's crop. Cash crops in most African cultures are considered men's crops (Mnimbo, 2018). Theories on gender relations show that social relations between men and women affected the uptake of innovations (Meaton et al., 2015; Akua et al., 2016). "Social relations" refers to the positional structuring of groups of people within a given community based on socially constituted systemic differences (Akua et al., 2016). These differences offer some groups of people powers and privileges over others at some point while simultaneously making others disadvantaged. In the case of gender differences, men and women have differing routines, which give differing constraints for the uptake of innovations for men and women (Akua et al., 2016) and, later, enhance or inhibit one's access to and use of resources and distribution of resultant benefits (Veeman and Politylo, 2003). In this study, men's uptake of SIP is expected to be higher than that of women because men frequently move outside their homes and dominate control over resources. In the case of women, the limited control over resources, inability to make autonomous decisions, unequal rights over assets, and claims over gained earnings (Akua et al., 2016) that they encounter than males are expected to inhibit their uptake of SIP.

Previous research studies (Barungi et al., 2013; Akankwasa et al., 2016; Ndaula et al., 2020; Mulugo et al., 2020; Ndaula et al., 2021) show that farmers can take up innovations based on their socioeconomic situations, including age, peer influence, farm size, education, proportional of maize sold for cash, and access to targeted extension services. To evaluate whether these factors are critical in the uptake of SIP, they are re-incorporated in this study. These factors are presumed to influence SIP uptake differently when they interact with factors drawn from induced innovation theories and gender relations constructs.

MATERIALS AND METHODS

The study was conducted among major maize-producing regions in Bulambuli, Namutumba, and Mayuge. These are rural districts in Eastern Uganda (Figure 1), where the Ministry of Agriculture, Animal Industry, and Fisheries had promoted SIP, including maize-legume intercropping, improved varieties, organic fertilizers, and inorganic fertilizers, through the district production departments among maize commercializing smallholder farmers. Targeting these farmers was purposive because they were likely to exhibit variability in gender roles and their effect on the use of SI practices.

Study Design and Sample Selection

A quantitative cross-sectional survey design was employed on a sample of smallholder maize farmers in July and August of 2019. This period coincided with the beginning of the second growing season which traditionally starts around late July to early September, and harvesting usually occurs in November through to December. With the help of local village council leaders (chairpersons), a list of target households was compiled. The sampling frame had a total of 1350 houses of maize farmers (Table 1). The predetermined sample size was 300 households, estimated using the online sample size estimator (https://www.calculator.net/sample-size-calculator.html), at a 95% confidence level and ±5% margin of error. The selection was conducted using

proportionate sampling at the district level in Microsoft Excel. The final sample had 300 households, and these included 96 from Bulambuli, 102 from Namutumba, and 102 from the Mayuge district.

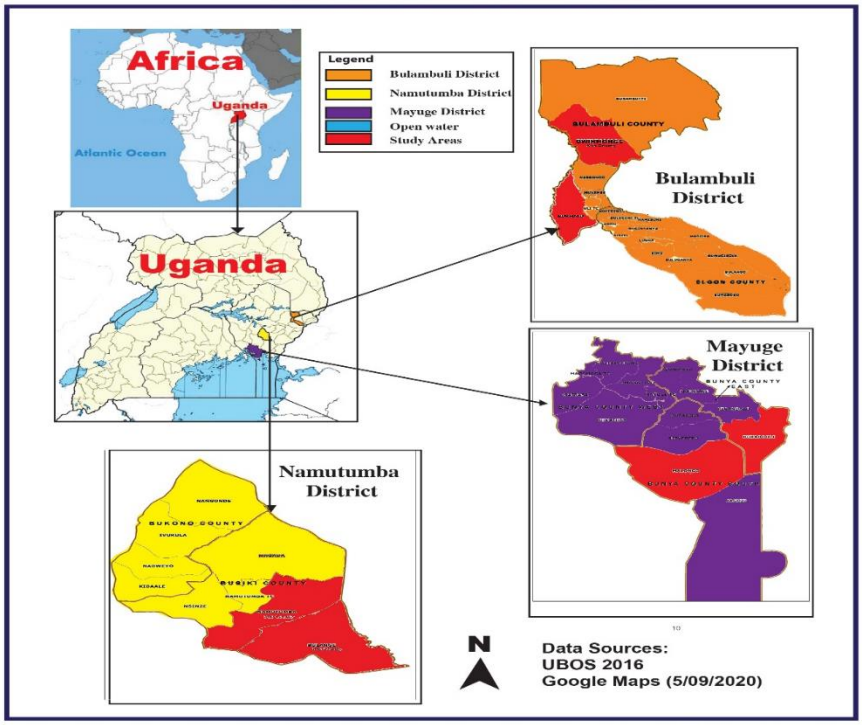

Figure 2. Map of Uganda showing study districts.

Table 1. Proportionate sample of farmers used in the study

District/Sub-county	Targeted Households	Selected sample size	Responses
Bulambuli – Bukhalu	49	98	97
Bulambuli – Bwikhonge	47	94	94
Namutumba – Bulange	48	96	95
Namutumba - Namutumba	54	108	101
Mayuge – Malongo	57	114	108
Mayuge – Bukaboli	45	90	89
Total	300	600	584

Data Collection

Data were obtained from 584 smallholder farmers, Table 1, using pre-tested questionnaires. Pre-testing was done in Nabbaale village in Mukono district (not the same study villages) (Beatty and Willis, 2007) and is distant from the study sample. This area had farmers who were growing and commercializing maize and were implementing the government-promoted SIP. 15 households (30 maize farmers) participated in the pre-test. Questionnaire pre-testing ensured the reliability and clarity of the questions. This was checked by using Cronbach alpha estimation, particularly for scaled items. For the main survey, both the husband and wife in participating households were interviewed separately to avoid co-influence of responses, although in 16 households only the wife was interviewed because these households were single-headed or the husband was absent. In addition, trained enumerators were used to administer the questionnaires to reduce inter-rater errors that are common in self-rated questionnaires, especially among participants of low education attainment.

Measures

Data were collected on SIP uptake levels, commercialization levels, gender relations, and farmer characteristics related to the uptake of SIP. SIP uptake level was measured using a 5-point semantic scale derived from previous studies (Lee, 2005; Haile et al., 2017; Kim et al., 2019), as shown in Table 2.

Level 1 = Non adopters, level 2 = adopters of intensification or sustainable practices alone, level 3 = adopters of soil management or agronomic intensification and sustainable practice alone, level 4 = adopters of either all intensification or sustainable practice and one in either type, and level 5 = adopters of all the intensification and sustainable practices. Given that sustainable intensification involves the uptake of both conservational and complimentary practices, the 5-point scale was converted into a binary scale, where scale points 1 and 2 = non-adopters and points 3, 4, and 5 = SIP uptake (Lee, 2005; Haile et al., 2017; Kim et al., 2019).

Table 2. Description of the scale used to measure the level of SIP uptake.

Intensification/complementary practices	Sustainable/conservational practices			
	Non-adopters	Organic fertilizer	Maize-legume intercropping	Organic & Maize-legume intercropping
Non-adopters	1	2	2	2
Inorganic fertilizers	2	3	3	4
Improved maize varieties	2	3	3	4
Inorganic fertilizers & Improved maize varieties	2	4	4	5

Note: Figures 1 to 5 show points and adoption combinations from which they come.

Commercialization levels are measured as farmer's participation in output and input markets. The output side relates to increased marketed surplus while the input side refers to increased use of purchased inputs (Osmani et al., 2015; Nguyen et al., 2024). The output side is measured in two ways: 1) as a ratio of the value of agricultural sales to the value of agricultural production (value terms) and 2) as a ratio of household crop sales to total output (output terms) (Gebreselassie and Ludi, 2008). These measures are calculated as percentages of the total sales value to the total output value and as a percentage of total sales to total output respectively (Pender and Alemu, 2007). A study of commercialization, thus, starts by asking whether a farming household sells any of its output and then considers the degree of commercialization as measured by the value of output sold to the total value produced (Nguyen, et al., 2024; Pender and Alemu, 2007). Such a measure is technically called the Household Commercialization Index (HCI) expressed as:

HCI = (Gross value of all crop sales hh i, year j /x 100.
(Gross value of all crop production hh i, year j)

This index represents a value between zero (0) and one (1), where zero (0) indicates that a household did not sell any output at all, while the value of one (1) indicates that a household sold all output. This measure focuses on the income a farmer obtains after the sale (Okezie et al., 2012). The alternative measure uses inputs expressed as a ratio of input value from the market to the total value of output (Jaleta, M., 2009; Pingali and Rosegrant, 1995; Melesse, 2017). This study adopted the output measure and operationalized smallholder commercialization as a measure of a ratio of output sales value to total output value. By avoiding measuring commercialization using inputs, it was intended to navigate from the likelihood of having a set of variables (SIP as inputs) included in the model as independent and dependent variables.

Social relations were measured using four dimensions, control over resources, control over gained earnings, routine within the household, and autonomy in decision-making. Control over resources was measured with four items (e.g., I use manure from the farm in the garden without having to inquire for permission from anyone), and control over gained earnings was measured using four items (e.g. I use earnings from maize without having to inquire for permission from anyone), adapted from Vedam et al. (2017). Routines within the household were measured using four items (e.g. I am always engaged in tasks around the household throughout the week). In

contrast, autonomy was measured using four items (e.g. My spouse respected my sustainable intensification practice), adapted from Vedam et al. (2017) and Seymour and Peterman (2017). All items were measured using a five-point rating scale from 1 = least and 5 = highest.

In addition, the questionnaire included the farmers' socioeconomic situations, including age measured in years, the highest level of formal education in years, farm size in acres, and the proportion of maize sold for cash in percentage. It also included peer influence measured using four items on a five-point rating scaling and access to targeted extension services measured on a binary scale.

Analytical framework

The analysis was conducted using binary logistic regression in SPSS version 16, which was ideal given that the dependent variable was dichotomous (non-adoption of SIP = 1 and adoption of SIP = 2) and the independent variables involved both variables that were measured on continuous and categorical scales (Kavia et al., 2007).

Preceding the regression analysis, principal component analysis (PCA) was carried out on scaled variables (control over resources, control over gained earnings, routine within the household, autonomy in decision-making, and peer influence) for data reduction and extraction of variables. Extraction of variables was based on the rule of taking components with Eigenvalues greater than 1 (Kaiser, 1961). Gujarati's (1995) procedures were used to complete the logit analysis. Farmer uptake of SIP was analyzed in the following equation:

$$Y = \beta 0 + \beta i[Commerce\_Level]i + \beta j[Social\_Relations]j + \beta k[Socio\_Econ]k + \varepsilon \quad (1)$$

Where Y represents the farmer's decision-making for the uptake of SIP (uptake = 1; no uptake = 0). [Commerce_Level] is a vector of levels of maize commercialization, which was measured using HCI for maize. [Social_Relations] comprises three components: (1) control over productive assets, (2) control over gained earnings, and (3) autonomy in decision-making. [Socio_Econ] comprised age, education, farm size, proportion of maize sold, peer influence, and access to targeted extension services. β0 is the constant while βi, βj, and βk represent the various coefficients of factors under commercialization level, social relations, and socioeconomic, respectively, and ε is the error term. The hypothesized signs of the coefficients (Table 3).

Table 3. Priori signs of explanatory variables used in the study.

Variable	Priori sign	Reference
Maize commercialization level	+/-	Pender and Alemu, 2007 and Nguyen, et al., (2024)
Control over resources	+/-	Vedam et al. (2017) and Seymour and Peterman (2017)
Control over gained earnings	+/-	Vedam et al. (2017) and Seymour and Peterman (2017)
Routine within household	-	Vedam et al. (2017) and Seymour and Peterman (2017)
Autonomy in decision making	+	Vedam et al. (2017) and Seymour and Peterman (2017)
Age	+/-	Barungi et al. 2013; Akankwasa et al, 2016
Education	+	Barungi et al. 2013; Akankwasa et al, 2016
Farm size	+	Barungi et al. 2013; Akankwasa et al, 2016
Proportional of maize sold	+	Akankwasa et al, 2016; Ndaula et al., 2020
Peer influence	+	Ndaula et al., 2020; Mulugo et al. 2020
Extension services	+	Ndaula et al., 2020; Mulugo et al. 2020

In determining the explanatory variables for uptake of SIP among maize commercializing smallholder farmers, the Maximum Likelihood Estimation Method was used. This involved entering all the model variables, removing the most insignificant variables, and re-running the model until stable predictors were determined. The Beta values and the associated signs were used to determine the effect and magnitude of the predictor. A negative sign represented an inhibitor, whereas a positive sign reflected an enhancer (Moussa et al., 2009). The odds ratio coefficients for individual variables greater than 1 indicated a very high responsiveness/likelihood of farmers to uptake SIP as the status of the predictors was adjusted. However, those less than one were interpreted to mean low responsiveness. The procedures have been applied in similar studies (Abetew, 2009; Wegary, 2013;

Gonfa, 2015), where dichotomous dependent variables are explained using independent variables on varying scales.

RESULTS AND DISCUSSION

Most respondents were female, and the mean age was 41 years (Table 4). This suggests that the sample was middle-aged adults (Horng et al., 2001). Most farmers had not completed primary education (mean <7 years) and had 14 years of experience cultivating maize for income.

The average marketed output was 65% of produced maize, which aligns with the sample purposively made of commercial maize farmers. On average, maize was being produced on 2 acres. Most farmers had not received extension services and depended on peers for information, indicating the likelihood of conformance to social influence.

Table 4. Socio-economic attributes of maize farmers using SI measures

Variable (n =584)	Mean	Std. Deviation	Minimum	Maximum
Sex (male =1; female = 0)	0.98	0.51	0	1
Age (years)	41.065	13.546	17.00	97.00
Education (years)	6.110	3.531	.00	16.00
Experience in growing maize (years)	14.126	9.596	1.00	49.00
Proportion of maize sold (%)	65	9.6	0	100
Farm size (acres)	2.081	1.693	0.25	25.0
Extension services (yes = 1; No =0)	0.42	0.39	0	1
Peer influence (scaled)	3.83	0.83	1	5

Kaiser–Meyer–Olkin (KMO) measure of 0.715 was above the *threshold (≥ 0.50),* and Bartlett's test of sphericity was significant ($p < 0.001$) (Table 5), which indicated the suitability of the extracted variables to be used further in regression analysis (Leech et al., 2005). The items included in the principal component analysis were 16, four from control over productive assets, control over earned income, autonomy in decision making, and peer influence.

Three principal components were extracted. Given that the item autonomy in decision-making loaded highly along with control over productive assets (Component 1) and control over earned income (Component 2), the components were renamed resource use autonomy and earning use autonomy. Component 3 is loaded with items of peer influence. Altogether, the three extracted variables explained 72.0% of the total variance in the original variables, the explained variance for resource use autonomy was 45.2%; autonomy to use earned income was 18.8% and 9.0% for peer influence. The items for each component had high coefficients in the range of 0.822 to 0.502, which confirmed convergent validity (Murtagh, 2012). In addition, Cronbach's alpha values, between 0.72 and 0.90, meant that the internal consistency of items included under each component was acceptable (Taber, 2018).

Factors associated with the uptake of sustainable intensification practices

The likelihood ratio chi-square value of 154.67 (p = 0.0000) obtained from binary logistic regression analysis, Table 6, shows the model fitted well with the dataset. This suggested that the retained variables significantly explained the uptake of sustainable intensification practices among maize farmers. The high pseudo R^2 (75%) shows that the model provides a good explanatory mechanism for the uptake of SIP. Beta coefficients estimate the strength of the effect of each independent variable (age, education, farm size, proportion of maize sold, peer influence, extension services, resource use autonomy, earning use autonomy) on the dichotomous dependent variable (uptake of sustainable intensification practices. The higher the absolute value of the coefficient, the stronger the effect and a negative sign would indicate an inhibitor of the uptake of SIP. The coefficients for age, education, farm size, and proportion of maize sold were insignificant, suggesting that these factors' association had no practical relevance for the uptake of sustainable intensification practices. Broadly, the uptake of sustainable intensification practices was found to be influenced by maize commercialization (β = -2.567, p = 0.000), farmer's sex (β = -1.761, p = 0.018), peer

influence/ support (β = 1.937, p = 0.015), access to extensions services (β = 0.476, p = 0.022), and autonomy to use productive assets (β = 1.741, p = 0.042) and earned income from maize (β = 1.261, p = 0.034).

Table 4. Factor loadings for scaled items (social relations and peer influence) n = 584).

Item description	Mean score (1-5)	Cronbach alpha (%)	Factor loadings		
			Factor 1 Resources use autonomy	Factor 2 Earning use autonomy	Factor 3 Peer influence
Husband respects wife's decision on chosen SI practices	1.9		.822		
Wife uses manure without deterrence from husband	2.3		.709		
Husband explains advantages and disadvantages of chosen preferred SIP to wife	1.9		.697		
Wife Intercrops maize with legumes without being deterred by husband	2.2		.691		
Wife uses land without being deterred by the husband	3.2		.684		
Wife freely goes out of home to buy improved seed without deterrence by husband	3.4		.656		
Mean score	2.5	89.2			
Wife uses maize income without consulting husband	1.9			.736	
Wife receives maize income without fear of husband	3.5			.728	
Wife keeps earned income without fear of husband	2.6			.712	
Wife can use earned income from maize to buy manure without deterrence from the husband	1.4			.675	
Wife can use earned money from maize to buy food without deterrence from the husband	3.8			.504	
Wife can use earned money from maize to buy inorganic fertilizers without deterrence from the husband	3.2			.502	
Mean score	2.7	74.6			
I cannot fail to use SIP because my friend would be upset	4.1				0.883
My fellow farmers believe that I should use SIP	3.6				0.881
My fellow farmers use SIP innovations	3.8				0.790
My family and neighbors use SIP	3.8				0.710
Mean score	3.83	72.9			
Eigenvalues			8.098	5.039	3.642
% of variance explained			45.2%	18.8%	9.0%

Kaiser–Meyer–Olkin = 0.715; approx. chi-squared = 2801.4. Bartlett's sphericity test, p < 0.001.

Table 6. Factors influencing farmers' uptake of sustainable intensification practices.

Category	Coeff.	Z- Value	P>z
Maize commercialization	-2.567	-2.530	0.000
Sex	-1.761	-2.024	0.018
Age	-0.461	-1.350	0.088
Education	0.935	1.090	0.276
Farm size	-0.361	-0.560	0.579
Proportion of maize sold	0.503	1.460	0.146
Peer influence	1.937	1.960	0.022
Extension service	0.476	2.430	0.015
Resource use autonomy	1.741	2.170	0.042
Earning use autonomy	1.721	2.140	0.034
Cons	-18.650	-3.470	0.001

Model Summary: No of observations = 584, Log-likelihood = 65.644223, LR chi (10) = 154.67, Prob> chi^2 = 0.0000, Pseudo R^2 = 0.745 (75%).

The size of the coefficients reveals that uptake is more influenced by maize commercialization, and its influence was revealed to be negative. This could have been so because, in this study, commercialization was measured in terms of output, and increased output was mainly attained through intensification practices, increased use of fertilizers, and improved maize varieties. In addition, maize was previously a food crop managed by women who had little access to bought inputs and, as such, depended on sustainable resources such as manure and inter-cropping systems, and locally available seed. Commercializing the crop can swiftly represent men's dominance in maize production. Men have access to and control over resources, including purchasing intensification inputs.

Other variables with strong influence were peer influence, sex, and autonomy in the use of productive resources and earned incomes. The negative coefficient for sex indicates that men are more likely to take up SIP than their female counterparts, which concurs with Mayambala et al. (2024), who suggested that the uptake of SIP is embedded in gender patterns of resource use and distribution. On the contrary, peer influence, resource use autonomy, earning use autonomy, and extension services were enhancers for the uptake of SIP. However, women's autonomy to use productive and earned income was low. Table 5 points to the likelihood of increasing the uptake of SIP through increased women's rights to use these resources. This concurs with Mayambala et al. (2024). Without use rights, women cannot access manure, land, or income (which can be used to buy inputs such as fertilizers and improved seed). Although access to extension was significantly associated with the uptake of SIP, the coefficient value of less than 1 indicated that access to extension leads to less drastic increases in the uptake of SIP, which is common for mediated variables. It is, therefore, possible that the effects of access to extension services were being mediated by peer learning, where the more experimental farmers later supported peers to also appreciate and take up the intervention. Also, most of the participants of this study had not accessed extension services, which points to the need to strengthen extension messages supporting sustainable intensification practices.

CONCLUSION

Our study demonstrates that the uptake of sustainable intensification practices among maize commercializing households is an engendered process that is inhibited by the level of commercialization and enhanced through increasing the rights of women overtaking autonomous decisions related to the use of productive resources and earned incomes. From a theoretical perspective, this invites future studies on the use of sustainable intensification practices to incorporate constructs from gender relations theories. Pragmatically, efforts that target to reverse male-dominated decision-making, such as increased women's rights over earned incomes through nurturing women-oriented savings and credit cooperatives, will enhance the uptake of sustainable intensification practices. Such intervention reduces the temptation of men to exercise proxy control over women's earnings and gives women access to their

financial resources when they need them to purchase inputs, including those meant for sustainable intensification practices. Further, the study emphasizes the need to support the delivery of SIP first through the most promising adopter, who constitutes the farmers' peer community, and later supports the less experimental group with the use of SIP. This can involve incorporating peer-to-peer learning as part of the extension model for delivering SIP. Thus, this study recommends that gender relations, particularly rights over the use of productive resources and earned incomes, and peer-to-peer extension services be considered in programs aimed at increasing farmer uptake for sustainable intensification practices.

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