Research Journal of Agricultural Economics and Development
ISSN: 2997-5980
Volume 4, Issue 1, 2025 (pp. 1-23)
www.abjournals.org

UNDERSTANDING FARMERS' USE OF IMPROVED MAIZE SEEDS IN UGANDA

Roberto Telleria Juarez[1], Martin Fowler[2], and Christine Martha Kobusingye[3]

[1]Email: roberto.telleriajuarez@fao.org

[2]Email: martinhfowler@gmail.com

[3]Email: cmkobusingye@gmail.com

Cite this article:

Roberto, T. J., Martin, F., Christine, M. K. (2025), Understanding Farmers' Use of Improved Maize Seeds in Uganda. Research Journal of Agricultural Economics and Development 4(1), 1-23. DOI: 10.52589/RJAED-EVFXZTRN

Manuscript History

Received: 19 Oct 2024

Accepted: 18 Dec 2024

Published: 7 Jan 2025

ABSTRACT: *While maize is a key crop for national food security and employment, most maize-growing households have small overall average farm sizes and remain highly vulnerable. The overall cultivated area of maize has been increasing, although such growth has not seen a commensurate gain in yields. The government of Uganda is concerned with this situation and has supported farmers with policies and projects to improve maize yields and, thereby, farm incomes. These projects have generated solid evidence showing that the use of improved seed generates higher productivity and financial returns compared with the use of traditional seeds. In spite of this, the use of improved seeds remains low in Uganda. This paper examines the key factors that influence farmers' decisions to adopt the use of improved maize seeds. To address this objective, a large sample of more than 3,600 maize farmers was analyzed using a binary logistic regression model. We found that maize farmers tend to use improved seeds when they also use fertilizers and pesticides, when improved seeds are obtained from the government and/or purchased from reputable agro-input dealers, and when credit services are readily available. However, a key factor that prevents small maize farmers from using improved seeds is their overall level of vulnerability. For the majority the risk is too high; rather than embarking on investing in seeds with a promise of higher net returns, they prefer to continue using the relatively cheaper traditional seeds that reduce the risk of family members experiencing hunger and poverty. The government needs to provide an enabling environment to make agricultural insurance available to small farmers if the use of improved seeds is to be expanded significantly.*

KEYWORDS: Seeds, Uganda, Maize, Agricultural households.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

INTRODUCTION

Maize is one of the key food crops in Uganda. In 2016, it was produced by 2.5-3.0 million farmers (Daly *et al.*, 2016) accounting for approximately 55% of Ugandan agricultural households (UBOS - Uganda Bureau of Statistic, 2019). Most maize farmers are vulnerable households that operate agricultural plots of 0.5 hectares, on average (Daly *et al.*, 2016). While such plots are small at the individual farmer level, amalgamated maize farmers produce significant surpluses that are even exported to regional markets (MAAIF - Ministry of Agriculture, Animal Industry and Fisheries, 2020). Maize is an important source of employment, and it is the most important food security crop in the country, providing over 40% of the calories consumed in both rural and urban areas (NAADS - National Agricultural Advisory Services, 2021). However, aggregate farm incomes that are obtained mainly from growing maize are generally low (Midamba, 2022), which is linked to small farm sizes (Noack *et al.*, 2019), low productivity (Larson *et al.*, 2016), low education levels (Telleria *et al.*, 2023), and widespread poverty in rural Uganda that concentrates about 80% of the Ugandan poor (World Bank, 2022).

Maize production increased significantly between 2016 and 2020 (the last year for which detailed estimates are available), from approximately 2.48 million tonnes to 4.56 million tonnes (UBOS, 2022a). While this increase was highly significant (83.9%) and was achieved in just a few years, it was mostly attributable to an increase in the area planted – from 1.13 million hectares in 2016 to 1.85 million hectares in 2020 (UBOS, 2022b). Over the same period, yields increased from 2.20 tonnes/ha to 2.46 tonnes/ha.

The government of Uganda, as part of its national agricultural development strategy[1], has expressed its intention to increase maize output (MAAIF, 2020). An effective and profitable way to do this is through the widespread use of improved seeds (FAO, 2006; MAAIF, 2017; Ajambo, 2017; Mugisha & Diiro, 2010). Improved seeds have a pivotal role to play in increasing yields, nationally, and are one of the most economical and efficient ways to raise overall farm productivity (FAO, 2006). In Uganda, research conducted by the Ministry of Agriculture, Animal, Industry and Fisheries (MAAIF, 2017) concluded that maize yields of up to eight tonnes/ha can be obtained using improved seeds, compared to 2.2-2.5 tonnes/ha realized using traditional seeds (or farmers' saved seeds). A report by Mugisha and Diiro (2010) indicates that maize yields from improved seeds in Eastern and Central Uganda were, on average, 71% higher than those from fields planted with traditional seeds (2.9 tonnes/ha *vs* 1.7 tonnes/ha respectively). Research by Bold *et al.* (2015) found that farmers using improved maize seeds produced by the National Agricultural Research Organisation (NARO), obtained 29% higher yields than those growing the crop using traditional seeds.

The government of Uganda, through MAAIF, NARO and other national and international organisations, has implemented many projects and programmes[2] to promote the use of maize improved seeds. Despite the expected benefits and support provided, the use of improved seeds in Uganda has been low and has hardly changed in recent years. A report by the Uganda Bureau

[1] The "*2021-2025 Agro-Industrialization Programme*" and the "*Uganda Vision 2040*".

[2] Such as: the "*Operation Wealth Creation (OWC)*"; the "*Agricultural Value Chain Development Programme*"; the "*Agricultural Cluster Development Project*"; the "*Climate Smart Agriculture Project*"; the "*Uganda Value Added Maize Alliance* Project"; the "*Ugandan Grain Development Project*"; and the "*Promoting Climate Resilient Maize Varieties in Uganda*".

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

of Statistics (UBOS, 2020)[3] indicates that in 2019 85% of maize plots were planted using traditional seeds, with the balance being planted with improved varieties. This begs the question: Why are improved seeds used far less than traditional seeds in spite of the large amount of evidence which shows the latter to be far less productive than the former?

Given that the government of Uganda has decided to support maize farmers with programs and policies to increase maize production and yields (MAAIF, 2020), the objective of this study was to investigate the key factors influencing farmers' decisions to use improved maize seeds. As this study used the most comprehensive micro data currently available in the country - a sample of more than 3,600 maize farmers - we would expect that the findings of this paper to provide solid evidence to inform MAAIF and the maize breeding programme of the policies and interventions required to promote the increased adoption of improved seeds.

LITERATURE REVIEW

Few surveys of Uganda have analyzed the factors behind the use of improved maize seeds and those that did have had relatively small sample sizes. Using a survey of 325 maize farmers from Iganga and Masindi districts (in eastern and central Uganda, respectively), Ajambo *et al*. (2017) analysed the extent to which Ugandan farmers are willing to pay for improved/quality seed. They tried to understand how this willingness is dependent on attributes that are not related to either consumption or yield, alone. Using an empirical hedonic price model, their results showed that maize farmers are willing to pay for early maturing seed varieties that also generate higher yields. Other attributes appreciated by farmers was seed that was pest and disease-resistant.

Using a sample of 160 maize farmers in Kabarole District (western Uganda), Mutyebere *et al.* (2018) analysed the adoption of improved maize varieties vis-à-vis maize production response to inputs among smallholder farmers. Using a Cobb-Douglas production function they estimated and compared input elasticities of fertilizers, seeds, labor, plot size, and herbicides for both improved and local maize. Such comparison permitted identifying those inputs that were more elastic or less elastic to adopters. Their results indicated that maize farmers were more prone to adopt improved seeds, provided that other inputs (such as fertilizers and herbicides) were also applied.

Using a sample of 151 farmers in Nakasongola and Soroti districts (in the central and eastern regions), Mugisha and Diiro (2010) analysed the adoption of improved seed varieties and their impacts on yields and on rural poverty. They used a binary probit model and an Ordinary Least Squares regression model to estimate the determinants of the intensity of adoption. They found that improved seeds were used by many farmers (above 80%), but the intensity of use by each one was very low. Maize yields using improved seeds were higher compared with maize yields using traditional seeds. They also found that the adoption of improved seeds is heavily reliant on awareness - where extension services are available the use of improved seed increased.

[3] Latest figures found at official sources.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

ISSN: 2997-5980
Volume 4, Issue 1, 2025 (pp. 1-23)

METHODOLOGY AND DATA

The neo-classical agricultural household school recognises that farmers' production decisions are typically influenced by several uncertain factors including the availability of farm resources, market imperfections, institutional constraints, natural hazards, and social uncertainties (Ellis, 1993). Farmers typically invest in agricultural technology, seeking to maximize their profits by making the difference between income and costs as high as possible. However, these uncertainties might lead some agricultural households, particularly the most vulnerable, to avoid investing to prevent potential losses (Morduch, 1995). In other words, risk can be too costly in the eyes of poor and vulnerable farmers who, rather than embarking on agricultural investments that have the potential to bring high profits, might prefer low-investment, traditional cultivation that reduces the risk of the family experiencing hunger and destitution. Clearly, such risk-averse behaviour can have implications in terms of efficiency losses and poverty traps (Eswaran & Kotwal, 1986).

Following Ellis (1993), we assumed that households make their production investment decisions hoping to gain, but also consider the risks of losing the value of their investments. This is especially so when the most vulnerable and poorest households make new investment decisions. When farmers invest in improved seeds, several uncertainties are introduced, such as market uncertainties (asymmetrical information on most competitive seed prices, for example), consumption uncertainties (low-quality seeds and poor management of improved seeds), institutional uncertainties (ineffective extension services, non-existent or imperfect credit services and imperfect seed suppliers - government, agro-dealers or relatives) and resource uncertainties (limited suitable land, irrigation and input resources).

These variables were assessed through a binary logistic regression model that aims at explaining, with a high level of accuracy, the main drivers behind farmers' decision to invest in improved seeds or to continue using traditional seeds. This model was chosen because the dependent variable is dichotomous or a dummy variable (coded 1, 0), meaning that two category variables are to be predicted (use of improved seeds or use of traditional seeds). For this kind of dependent variable, the regular linear regression model (whether simple or multiple) is not appropriate. The binary logistic regression determines the impact of multiple independent variables presented simultaneously to predict membership to one or the other of the dependent variable (improved seeds or traditional seeds). In this way, it calculates the probability of using improved seeds over the probability of using traditional seeds, being the results of the analysis in the form of odds ratio. Following Haubrick (2018), the mathematical form of the multiple binary logistic regression model is:

$$\pi(X) = \frac{exp(\beta 0 + \beta 1X1 + \ldots + \ \beta kXk)}{1 + exp(\beta 0 + \beta 1X1 + \ldots + \ \beta kXk)}$$

$$\pi(X) = \frac{exp(X\beta)}{1 + exp(X\beta)}$$

$$\pi(X) = \frac{1}{1 + exp(-X\beta)}$$

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

Where:

- π is the probability that an observation is in a specified category of the binary Y variable, improved seeds or traditional seeds in this case;
- "exp" denotes exponential or power;
- β_0 is the intercept;
- β_1 to β_k are the regression coefficients;
- X_0 to X_k are the independent variables as presented in Table 1 below.

The model describes the probability of an event happening as a function of X variables. For a sample of size n, the likelihood (L) for the binary logistic regression is given by:

$$L(\beta; y, X) = \prod_{i=1}^{n} \pi_i^{yi}(1-\pi_i)^{1-yi}$$

$$L(\beta; y, X) = \prod_{i=1}^{n} \left(\frac{exp\ exp\ (X_i\beta)}{1 + exp\ exp\ (X_i\beta)}\right)^{yi} \left(\frac{1}{1 + exp(X_i\beta)}\right)^{1-yi}$$

This yields the log likelihood:

$$l(\beta) = \sum_{i=1}^{n} [y_i\ log\ log\ (\pi_i)\ + (1 + y_i)\ log\ log\ (1 - \pi_i)\ ]$$

$$l(\beta) = \sum_{i=1}^{n} [y_i X_i \beta - log\ (1 + exp\ (X_i\beta))]$$

To select which variables to include and which to exclude from the model, multicollinearity tests were conducted to detect the presence of multicollinearity between the variables. Those variables that did not display signs of multicollinearity were included in the model and are indicated in Table 1 (Annex 1 shows the results of the multicollinearity test). The dependent variable was the "Main type of seed used for maize cropping", which are either improved seeds or traditional seeds.

Table 1: Variables Entered

X_n	**Independent variables (X_1 to X_{13})**	**Expected sign**
1	Gender – Sex of the household head (dummy: 1=Male, 0=Female)	+
2	Household head education (dummy: 1=Education, 0=No education)	+
3	Fertilizer use - Organic and/or inorganic (dummy: 1= Yes, 0=No)	+
4	Chemical pesticide use (dummy: 1=Yes, 0=No)	+
5	Credit source - financial institutions (dummy: 1=Yes, 0=No)	+
6	Seed supplier - Government (dummy: 1=Yes, 0=No)	+
7	Seed supplier - Relative/neighbor (dummy: 1=Yes, 0=No)	-

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

8	Seed supplier - Local retailer (dummy: 1=Yes, 0=No)	+
9	Seed supplier - Wholesaler (dummy: 1=Yes, 0=No)	+
10	Extension services (dummy: 1=Yes, 0=No)	+
11	Farmers attending trainings (dummy: 1=Yes, 0=No)	+
12	Main economic activity - Off farm job (dummy: 1=Yes, 0=No)	-
13	Age of the household head (natural logarithm of age)	+

Source: *Own elaboration based on 2018 AAS microdata – UBOS.*

All data variables were extracted from the Annual Agricultural Survey (AAS) for the second season of 2018 (UBOS, 2018)[4]. The AAS is the annual national agricultural survey carried out by UBOS which is responsible for collecting, processing, analyzing and disseminating the data. The 2018 survey covered a wide range of agricultural indicators, including maize seed use over a 12-month reference period, with a total coverage of 7,115 households. Out of these, a sub-sample of 3,676 farm households was used in this study; these represented all of the sampled households growing maize. Annex 2 contains descriptive statistics of the variables used in the model.

The independent variables included in the model were either converted into either dummy variables or natural logarithms. This was done to avoid writing separated equation models for each subgroup of the categorical variables. Hence, dummy variables were created for each categorical variable having more than two subcategories, while continue (or scale) variables were transformed into natural logarithms (coefficients on the natural-log scale are directly interpretable as approximate proportional differences).

Once the variables were selected, several procedures were followed to evaluate the accuracy of the binary logistic regression model. They included testing: 1) the significance of sample sizes; 2) the goodness-of-fit statistics to determine whether or not the model adequately describes the data; 3) the Hosmer and Lemeshow test to assess how the binary logistic model fits the data; 4) the Contingency Table of the Hosmer and Lemeshow test to evaluate the predictive capacity of the overall bivariate model; and 5) the Percentage Accuracy in Classification to assess how well the model is able to predict the correct category of the independent variables. All these tests indicated that, overall, the binary logistic regression model was the most suitable to use in describing the data, as well as to estimate the odds ratios of the independent variables. Annex 3 presents all of the accuracy tests undertaken in this study. To maximise the likelihood (or log likelihood), SPSS (version 26) was used. SPSS uses an iteratively reweighted least-squares technique to find an estimate of the regression coefficients.

[4] The 2018 AAS is the most recent data set so far (May 2024) released for public use by UBOS (https://microdata.ubos.org:7070/index.php/catalog/?page=2&ps=15). The Survey covers the second season, meaning that the data was collected during the second agricultural season (July to December). Technical support for the survey was provided to UBOS under FAO's AGRISurvey Programme.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

RESULTS AND DISCUSSION

A binary logistic regression model was used to examine whether the independent variables had a significant effect on the probability of observing the "improved seed" category compared with the "traditional seeds" category. Table 2 shows which variables have and have no significant impact on the choice of seed used. The constant has an unstandardised value of -6.177, which does not have a significant meaning for seed analysis, but it is necessary for the purpose of building the logistic regression equation of the model. The variable "Gender/Sex of the household head" has an exponential coefficient of 0.65, which is not statistically significant. This result suggests that the gender of the household head (whether female or male) has no correlation with the use of either improved or traditional seeds. This result indicates that there are other factors which have an influence; these are discussed below.

The "Education level of the household head" was found to have the right sign, but not to be statistically significant. This result is unexpected, as empirical studies (Midamba, 2022; Korgitet *et al*., 2019; and Oduro *et al*., 2015, for example) found that farmers attaining higher levels of education tend to use more improved seeds as compared to farmers having low levels or no education at all. The explanation can be associated with a general low level of education of Ugandan farmer household heads; for example, Telleria *et al*. (2023) found that the education of Ugandan female household heads was very low: 90% were unable to complete primary school (probably dropped out at the end of primary school), while only 10% completed secondary school. The situation of male farm household heads was somehow better - 70% were unable to complete primary school, while only 30% completed secondary school (Telleria *op. cit.*). With such low levels of education, it comes as little surprise that the education variable was not significant.

The exponential coefficient (0.20) of the variable "Fertilizer use (organic and/or inorganic)" was found to be statistically significant at the 10% level (CI 0.039 to 1.080). This implies that the odds of a farmer choosing improved seeds is 0.2 times higher when farmers use organic and/or inorganic fertilizers. This finding is important as it reinforces other studies (Mutyebere, 2017; Mutyebere *et al.*, 2018) which found that the yield response from the use of improved seeds is higher when farmers also use fertilizers. Farmers recognise that investing in seeds without investing in fertilizers does not pay off. Fertilizers provide nutrients that the improved maize seeds need to reach their yield potential.

The variable "Chemical pesticide use" was found to have a statistically significant and positive coefficient of 3.53 ($p < 0.05$; CI of 1.252 to 9.975). This implies that farmers using pesticides have a 3.53 higher probability of using improved seeds as compared to farmers not using pesticides[5]. Farmers realize that investing in seeds without investing in pesticides is not convenient. A rational use of pesticides prevents valuable seeds from being damaged or eaten by pests.

The variable "Source credit - Microfinance institutions" has a positive and statistically significant coefficient of 3.44 ($p < 0.1$, with CI of 0.989 to 11.973) meaning that the odds of using improved seeds are 3.44 higher among farmers having access to credit from financial

[5] Farmers use pesticides to control, destroy and/or prevent the presence of pests during cultivation. Pests, comprising insects, rodents, birds, mites and other vertebrates, cause injuries to crop plants and forests eating plants, seedlings and grains, as well as by competing with field crops for nutrients and water (FAO, 2002).

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

Research Journal of Agricultural Economics and Development
ISSN: 2997-5980
Volume 4, Issue 1, 2025 (pp. 1-23)

institutions, compared with farmers not having access to such institutions. This result is confirmed by other studies (USAID, 2003; Chune, 2022) which found that microfinance plays a crucial role in providing credit, particularly prior to the planting season when farmers need to buy improved seeds and tools, which they would not otherwise be able to afford.

Table 2: Variables in the Equation

Variable	B	Sig.	Exp(B)	95% C.I.for EXP(B)	
				Lower	Upper
1. Gender - Sex of the household head	-0.426	0.522	0.65	0.177	2.408
2. Education level of the household head	-0.254	0.773	0.78	0.138	4.356
3. Fertilizer use (organic and/or inorganic)	-1.589	0.061***	0.20	0.039	1.080
4. Chemical pesticide use	1.262	0.017**	3.53	1.252	9.975
5. Source credit - Microfinance institutions	1.236	0.052***	3.44	0.989	11.973
6. Seed supplier - Government	4.483	0.000*	88.51	16.521	474.207
7. Seed supplier - Relative/neighbor	1.316	0.257	3.73	0.382	36.320
8. Seed supplier - Local retailer	2.079	0.000*	7.99	2.844	22.477
9. Seed supplier - Wholesaler	5.648	0.000*	283.66	38.128	2110.319
10. Extension services	0.324	0.601	1.38	0.410	4.666
11. Farmers attending trainings	-0.210	0.730	0.81	0.245	2.680
12. Main economic activity - Off farm job	0.335	0.854	1.40	0.039	49.436
13. Age of the household head	0.615	0.432	1.85	0.398	8.598
Constant	-6.177	0.069	0.002		

*1% level **5% ***10% level

Source: Own elaboration based on microdata from the 2018 Annual Agricultural Survey, UBOS.

The government plays a key role in the probability of farmers using improved seeds. The variable "Seed supplier - Government" has a statistically significant and positive coefficient of 88.51 ($p < 0.1$, with CI of 16.5 to 474.2). This means that the odds of a farmer choosing to use improved seeds is 88.51 times higher when the main source of seeds is the government than when it is obtained from other sources. This finding reflects the support that the government has provided since 2013 through its Operation Wealth Creation (OWC) programme. The programme was a Presidential initiative that provided subsidised and (in some cases) free improved maize seed to farmers who were unable to afford it[6]. In FY 2016/17 more than 355 tonnes of free improved maize seeds were distributed by OWC (MFPED - Ministry of Finance, Planning and Economic Development, 2017). Farmers valued them because they were free and because improved (hybrid) maize seed contributed to increased maize yields (MFPED, 2017). Such a large coefficient indicates that the government was something (seed) that was highly appreciated by the recipient. However, a programme to promote the use of improved seeds that is heavily subsidised by the government, is not sustainable.

[6] The OWC (https://www.modva.go.ug/operation-wealth-creation-owc/) was implemented by MAAIF, by the army through the Uganda People's Defense Forces and by the National Agricultural Advisory Services (NAADS). The OWC sought to enhance rural livelihoods by increasing agricultural productivity and profitability.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

The variable “Seed supplier - Relative/neighbor” was not statistically significant, indicating that farmers do not obtain improved seed from relatives or neighbors. Seeds that are considered “improved” need to have some sort of assurance or certification attached to them. Such assurance can be obtained following formal seed certification procedures, and/or through certified farmers specialising in the production and multiplication of seeds. Seeds produced by relatives or friends do not have any kind of assurance, which is reflected by the non-statistically significant coefficient estimated by the model.

The coefficients of “Seed supplier - Local retailer” and “Seed supplier - Wholesaler” were both statistically significant at the 1% level. This indicates that the odds of a farmer using improved maize seed are higher when the seed comes from these two types of seed dealers. Generally, local retailers and wholesale seed suppliers are legally- and long-established dealers that sell improved seed with quality control certification to assure the farmer of their high quality. Therefore, it is consistent to find statistically significant coefficients for seeds traded by legally established sellers.

While having the expected sign, the variable representing access to “Extension services” was found to be not statistically significant. This is an unexpected result as generally farmers having access to agricultural extension services are understood to have higher probability of using improved seeds compared with farmers not having access to extension services (Fishman *et al.*, 2017; Danso-Abbeam *et al*., 2018). The explanation for this result could be the overall level of access to extension services: the 2018 AAS (UBOS, 2020) points out that in 2018 just 11.7% of all agricultural households in the country received extension services in that year. This finding suggests that, while agricultural extension is a critical service to promote the use of, among other things, improved seed, the odds of using it is not statistically significant because agricultural extension services are hardly reaching the farming population.

The variable “Farmers attending training” was found to be not statistically significant. This finding is also unexpected as training typically helps farmers acquire knowledge to skillfully manage the use of improved seeds. The underlying reason explaining this result can be found in the level of access to training courses. The AAS revealed that in 2018 most agricultural households in the country (88.1%) did not receive any training on the management of improved seeds. In fact, only 11.9% of them received some kind of agricultural training, and that this was not necessarily on the management of improved seeds. Hence, this finding shows that the odds of using improved seed are not statistically significant given that farmers’ training initiatives were unable to reach a sizable number of Ugandan farmers.

The variable “Main economic activity – Off farm job” was not statistically significant. This finding suggests that farmers devoting most of their time to off-farm activities are less likely to use improved seeds compared with farmers mainly engaged in cropping. Indeed, this appears logical since farmers not involved full-time in agriculture are not likely to invest in improved seed. It is also supported by the fact that the average area of farmland available for cropping is only 0.5 ha. This limited area means that most farmers practice subsistence agriculture - producing mainly for home consumption (AGRA, 2019; Jjagwe et al., 2020, and, as such, farming and livelihoods are highly vulnerable.

Finally, the variable “Age of the household head” was found to be not statistically significant. This implies that the use of improved seeds is not determined by the age of the farm household head. This finding is sustained by Morara’s (2022) research, which found that older farmers

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

ages[7] and those having limited education[8] tend to be afraid or opposed to adopting more costly agricultural inputs/new technology.

The binary logistic regression model results suggest that the presence of a set of specific variables (fertilizer use, pesticide use, availability of improved seeds from the government and/or from legally established traders, and accessibility to credit) increases the probability of a farmer adopting improved maize seed. Furthermore, the majority of farmers are poor and face such difficulties as a lack of education, small cropping areas, and limited access to training and extension services. In fact, UBOS (2020) estimated that in 2019, 54% of Ugandan agricultural household heads had an average annual farm income of USD 244 (or UGX 893,047), which is equivalent to USD 0.66 per day. This figure is below Uganda's national poverty line which is estimated as being between USD 0.88 and USD 1.04 per day (DevInit, 2020).

The poor are more vulnerable to natural catastrophes, health hazards, and economic downturns, than any other group. The AAS collected vulnerability data that allows indicators to be generated measuring farmers' vulnerability. These data refer to shocks in the form of sudden losses in crop production, livestock herds, farm assets, household well being due to extreme weather conditions (such as drought, hailstorms, floods and tidal waves), pest and disease attacks, household illnesses or diseases, and/or household insecurity. Using the microdata from the 2018 AAS, we estimated that most farmers (72.7%, or 4,289 household heads) reported at least one shock in 2018, while the balance reported no shocks (Table 3). Among farmers that experienced at least one shock, the main one experienced was drought that reduced agricultural output (reported by 51.8% of the sample). Pest/disease outbreak (22.6%) was the next most important risk factor. The drought shock was a spillover of the extensive droughts that Uganda experienced in 2016 and 2017 (UBOS, 2019), while the pest and disease shock was mainly attributed to Fall Armyworm depredations during the first growing season of 2018 (UBOS, 2019).

Table 3: Household Shocks

Shock (yes/no)	**No**	**Yes**
Any shock in the last 12 months	27.3% (1,612)	72.7% (4,289)
Main shock		
Drought		51.8
Pests or disease outbreak		22.6
Erratic or heavy rains		6.3
Floods and tidal waves		6.1
Hailstorms		4.7
Illness or disease in the household		4.4
Insecurity		2.6
Other		1.6
Total (%)		**100.0**

Note: For the vulnerability analysis, the AAS microdata does not allow maize producers to be disaggregated from the rest of the agricultural producers. Therefore, for this analysis all

[7] The mean age of agricultural household heads in Uganda was estimated at 47 years of age (Rietveld *et al.,* 2012).

[8] Most agricultural household heads in Uganda have no education nor did they finish primary school (Telleria *et al.,* 2023).

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

surveyed farmers who answered the question about the main shock experienced (n= 5,901) were included.

Source: Own calculations based on the AAS 2018 data.

The AAS also asked farmers to assess the extent to which shocks reduced agricultural production. The results indicate that regardless of the type of the shock, if a shock occurred, the level of damage was generally severe (Table 4). For example, for most farmers (62.3%) the drought shock caused severe damage. Moderate damage was reported by 29.6% of the farmers that suffered from drought, while 7.8% and 0.3% of the farmers reported slight and minimal damage, respectively. The flood shock caused severe damage among 55.1% of the farmers that experienced this shock, while hailstorms caused severe damage according to 51.5% of the farmers that reported that shock.

Table 4: Shock Damage Level

Shock	How shock affected/damaged crop or livestock production (%)				
	Minimal	Slight	Moderate	Severe	Total
Drought	0.3	7.8	29.6	62.3	100.0
Pests or disease outbreak	0.2	16.4	41.5	42.0	100.0
Hailstorms	0.2	7.6	40.7	51.5	100.0
Floods and tidal waves	1.0	8.1	35.8	55.1	100.0
Illness or disease in the household	1.2	24.1	38.0	36.7	100.0
Erratic or heavy rains	1.3	18.6	39.2	40.9	100.0
Insecurity	1.1	22.6	24.3	52.0	100.0
Other shock	-	10.1	27.5	62.4	100.0

n = 4,289 household heads.

Source: *Own elaboration based on microdata from the 2018 Annual Agricultural Survey, UBOS.*

When shocks struck, farmers mitigated them in a number of different ways (Table 5). However, in most instances (61.2%), the farmers were unable to respond to shocks. This finding reveals the high level of vulnerability of agricultural households to shocks. This may have a number of explanations, such as: not having or were unable to sell surplus crops, livestock, land, and/or other assets on the farm (such as machinery and equipment); inability to find alternative jobs (such as off-farm employment); the lack of relatives, government agencies, and/or NGOs from whom to obtain support; and/or they were unable to borrow money.

A minority of farmers were able to respond positively to shocks. Such response included being able to that succeeded in finding off-farm job (15.8% of the sample), while 9.1% of them received help from relatives, government, and/or NGOs, 7.8% managed to sell crops, livestock and/or other farm assets, while 2.2% of the farmers managed to borrow money from financial institutions and/or local moneylenders. Interestingly, only 1.2% of the sample opted to reduce household expenditures.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

Table 5: Response to Shock

Response	Percent
Did nothing (unable to respond)	61.2
Found other work, not on the holding	15.8
Received help from relatives, government, and NGOs	9.1
Sold crop, livestock, land, machinery, and/or buildings	7.8
Borrowed money/got a loan	2.2
Reduced household expenses (e.g. health and education)	1.2
Other	2.7
Total	**100.0**

n = 4,289 household heads.

Source: *Own estimates derived from AAS data.*

The AAS specifically asked farm households how such shocks impacted food security at the household level. Using the AAS data, we estimated that most agricultural households (92.8%) experienced food shortages due to losses in crop production (Table 6). UBOS (2020) computed the same variable and obtained a similar close figure (90.5%), which confirms our estimate. This finding is highly significant as it shows how important obtaining good harvests is for ensuring the food security of agricultural households. For this reason, interventions aimed at improving the resilience, productivity, and sustainability of crop production are of paramount importance in ensuring household food security, livelihoods, and resilience.

Table 6: First Reason for the Food Shortage

Reason	Percent
Loss of crops/insufficient production	92.8
Lack of capital	5.2
Inability to work because of illness, disability, injury or old age	1.5
Lack of job opportunity outside the holding	0.4
Total	**100.0**

n = 2,569 household heads.

Source: *Authors' calculations based on data collected under the AAS.*

In conclusion, it is clear that smallholder farmers are highly vulnerable to shocks. Given that many of them are already below the poverty line, a shock can have a fundamentally negative impact on their precarious socio-economic status. In this context, it is important to be aware that investing in improved seeds can represent a high risk to vulnerable farmers; they may well reject the idea due to the possibility of losing the very limited savings they might have.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

POLICY IMPLICATIONS

This paper has shown that farmers' decisions to adopt improved maize seeds depend not only on the ability of the seeds to improve production, but also on a number of other factors. Findings from using the binary logistic regression model suggest that the use of improved maize seeds tends to increase when the government ensures that good quality seeds are traded through legal and reputable input traders/stockists; farmers use agricultural inputs (fertilizers and pesticides) in conjunction with improved seeds; and when credit institutions are able to lend money to the maize farmers in question. In addition, making extension services and agricultural training available to these farmers can further facilitate the adoption of improved seed. These findings suggest that promoting the use of improved maize seeds should not be done in isolation but, rather, as part of a comprehensive programme of rural development.

In fact, Uganda has a long history of developmental strategies and programmes[9] going back to the 1960s (Balirwa, 1992). Many of them have incorporated the fundamental idea of promoting the use of improved seeds as only one component in a range of activities such as promoting the use of fertilisers and pesticides, supplemented with, among other things, extension, credit, marketing and research services. These programmes have contributed to the growth of the maize sub-sector, with the country managing to more than double maize yields from 1.1 tonnes/ha in the 1960s to 2.7 tonnes/ha by 2023 (FAOSTAT - Food and Agriculture Organization Statistics, 2024). Nevertheless, in spite of these efforts, still only a small proportion (15%) of maize farmers in the country were using improved seeds in 2018.

Regarding the initial question posed in this paper "*Why improved seeds are little used while a substantial amount of evidence indicates that they are beneficial to farmers?*", our analysis suggests that perceived vulnerability is what prevents them from investing in improved seeds. That is, since most of these producers cultivate under subsistence conditions and are below the poverty line, any shock or occurrence of sub-optimal weather conditions can result in the investment failing to generate a positive return, which would abruptly and negatively impact their already-precarious livelihoods. Such farmers need to exercise extreme caution before deciding to invest in improved maize seeds. The investment needed represents a very high risk to them and, in such instances, they most likely consider it to be too risky due to the possibility of losing the limited savings they have. As such, most farmers would still prefer to cultivate using traditional seeds which are tried and tested and offer low risks.

The question of how to manage risks goes beyond the scope of this paper. Nevertheless, it is important to realise that in promoting the use of improved maize seeds, the government needs to provide an enabling legal and regulatory environment for agricultural insurance to be made available to underserved groups. Uganda has been advancing on this matter. Currently, there are several key players in the agricultural insurance space in Uganda that are actively involved in promoting different types of agricultural insurance.

For example, The Uganda Agricultural Insurance Scheme (UAIS) is a partnership between the government and the insurance industry that seeks to encourage smallholder farmers to adopt

[9] Such as the Ugandan Grain Development Project, the Promoting Climate Resilient Maize Varieties in Uganda, the Uganda Value Added Maize Alliance Project, Operation Wealth Creation, the Agricultural Value Chain Development Programme, the Agricultural Cluster Development Project and the Climate Smart Agriculture Project.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

insurance by reducing the cost of premiums. Under this scheme, the government provides a premium subsidy (up to 50%) to smallholder farmers. The Uganda Insurers Association (UIA) is actively involved in promoting agricultural insurance by collaborating with the government and private sector players. Jubilee Insurance offers agricultural insurance to farmers to cover risks such as weather-related crop failure, livestock diseases, and other agricultural losses. UAP Old Mutual Uganda offers weather-indexed crop insurance and livestock insurance. Lion Assurance Company Limited (LAC) provides crop and livestock insurance to farmers as part of the UAIS. Agricultural insurance in Uganda is still in the developmental stages, but with sustained support from the government, private sector, and international partners, it holds great potential for transforming the agricultural sector by reducing risks and increasing resilience among small farmers.

REFERENCES

AGRA, 2019. Feeding Africa's soils: Fertilisers to support Africa's agricultural transformation. Nairobi, Kenya. Alliance for a Green Revolution in Africa (AGRA). https://agra.org/wp-content/uploads/2019/11/FeedingAfrica%E2%80%99sSoils.pdf;

Ajambo R., Elepu G., Bashaasha B. and Okori P., 2017. Farmers' preferences for maize attributes in eastern and western Uganda. African Crop Science Journal, Vol. 25, No. 2, pp. 177 – 187. https://www.ajol.info/index.php/acsj/article/view/156973/146582;

Balirwa E., 1992. Maize Research and Production in Uganda. USAID. https://pdf.usaid.gov/pdf_docs/PNABT623.pdf;

Barriga A., and Fiala N., 2018. The supply chain for seed in Uganda: Where does it all go wrong? University of Connecticut. http://nathanfiala.com/wp-content/uploads/2018/06/The-supply-chain-for-seed-in-Uganda.pdf;

Bold T., Kayuki C., Kaizzi, Svensson J., and Yanagizawa-Drott D., 2015. Low quality, low returns, low adoption. Policy brief. International Growth Centre. https://www.theigc.org/wp-content/uploads/2015/09/Policy-Note-Low-Quality-Low-Returns-Low-Adoption.pdf;

Chune, M. D., 2022. Determinants of Maize Production Income in Western Uganda. East African Journal of Agriculture and Biotechnology; Volume 5, Issue 1, 2022. pp 1 to 13. https://www.researchgate.net/publication/358150337_Determinants_of_Maize_Production_Income_in_Western_Uganda.

Daly J., Hamrick D., Gereffi G., and Guinn A., 2016. Maize Value Chains in East Africa. International Growth Centre. International Growth Centre. Policy brief, 38202. https://www.theigc.org/wp-content/uploads/2017/03/Maize-value-chains.pdf;

Danso-Abbeam G., Ehiakpor D. S., and Aidoo R., 2018. Agricultural extension and its effects on farm productivity and income: insight from Northern Ghana. Agriculture & Food Security, 7(1), 1-10. https://agricultureandfoodsecurity.biomedcentral.com/articles/10.1186/s40066-018-0225-x;

Deepthi Elizabeth Koladya and Md. Abdul Awalb. Seed industry and seed policy reforms in Bangladesh: Impacts and implications. International Food and Agribusiness Management Review. Volume 21 Issue 7, 2018; DOI: 10.22434/IFAMR2017.0061 https://www.wageningenacademic.com/doi/pdf/10.22434/IFAMR2017.0061;

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

Devinit, 2020. Poverty in Uganda: National and regional data and trends – Factsheet. https://devinit-prod-static.ams3.cdn.digitaloceanspaces.com/media/documents/Poverty_in_Uganda_-_National_and_regional_data_and_trends.pdf;

Ellis F., 1993. Peasant Economics - Farm Households in Agrarian Development. University of East Anglia, 2nd Edition. http://www2.fct.unesp.br/docentes/geo/bernardo/BIBLIOGRAFIA%20DISCIPLINAS%20POS-GRADUACAO/FRANK%20ELLIS/Peasant%20Economics.pdf;

Eswaran M., and Kotwal A., 1986. Access to Capital and Agrarian Production Organisation. Economic Journal 96:482–98. https://www.jstor.org/stable/2233128;

FAO (2002). International Code of Conduct on the Distribution and Use of Pesticides. Rome: Food and Agriculture Organization of the United Nations. http://www.fao.org/3/y4544e/y4544e00.htm;

FAO, 2006. Quality Declared Seed Systems. FAO Plant Production and Protection Paper 185. https://www.fao.org/3/a0503e/a0503e.pdf;

Fishman R., Smith S. C., Bobic V., and Sulaiman M., 2017. How Sustainable Are Benefits from Extension for Smallholder Farmers? Evidence from a Randomized Phase-Out of the BRAC Program in Uganda. https://thedocs.worldbank.org/en/doc/654151495654744367-0010022017/original/E2RandomizedPhaseoutFeb24.pdf;

Gebre G. G., Isoda H., Rahut D. B., Amekawa Y., and Nomura H., 2021. Gender differences in agricultural productivity: Evidence from maize farm households in southern Ethiopia. GeoJournal, 86(2), 843- 864. https://pubmed.ncbi.nlm.nih.gov/34720354;

GIZ, 2020. Climate Risk Profile: Uganda. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). https://agrica.de/wp-content/uploads/2021/01/GIZ_Climate-risk-profile-Uganda_EN_final.pdf;

Haubrick J., 2018. 12.1 - binary logistic regression model. https://online.stat.psu.edu/stat462/node/207/#:~:text=%CF%80%20is%20the%20probability%20that,a%20function%20of%20X%20variables;

IFAD, 2020. Climate Change and Future Crop Suitability in Uganda. Hunter R., Crespo O., Coldrey K., Cronin K., and New, M. International Fund for Agricultural Development (IFAD), Rome. https://www.ifad.org/documents/38714170/42164624/climate_analysis_uganda.pdf/f7b00f39-83a6-361f-08c7-3803630610e9?t=1605782476000#:~:text=Uganda%20is%20characterised%20by%20a,subsistence%20crops%20to%20be%20produced;

Jjagwe J., Chelimo K., Karungi J., Komakech J., and Lederer J., 2020. Comparative Performance of Organic Fertilisers in Maize (Zea mays L.) Growth, Yield, and Economic Results. Agronomy 10(1):69; doi:10.3390/agronomy10010069. https://www.mdpi.com/2073-4395/10/1/69/pdf;

Korgitet H. S., and Biru M. W., 2019. The Effect of Farmers Education on Farm Productivity: Evidence from Small - Scale Maize Producing Farmers in North Bench District, Bench Maji Zone. Research on Humanities and Social Sciences, 9 (17), 26- 34. https://www.iiste.org/Journals/index.php/RHSS/article/view/49641;

Larson D.F., Savastano S., Murray S., Palacios-López A., 2016. On the Determinants of Low Productivity in Maize Farming in Uganda: The Role of Markets, Fertilizer Use and

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

Gender. Natural Resource Management and Policy, vol 48. Springer. https://link.springer.com/chapter/10.1007/978-4-431-55693-0_8#citeas;

Lybbert T., 2020. Assessing seed system resilience with structured genotyping in Uganda. https://basis.ucdavis.edu/sites/g/files/dgvnsk466/files/2020-04/MRR%20project%20in-brief%20-%20Lybbert%20Uganda.pdf;

MAAIF, 2017. Maize Training Manual for Extension workers in Uganda. Ministry of Agriculture Animal Industry and Fisheries. https://www.agriculture.go.ug/wp-content/uploads/2019/09/Maize-training-manual-for-extension-workers-in-Uganda.pdf;

MAAIF, 2020. Agro-Industrialization Programme Implementation Action Plan - NDPIII. Ministry of Agriculture, Animal, Industry and Fisheries. https://mlhud.go.ug/wp-content/uploads/2021/03/AGROINDUSTRIALIZATION-PIAP-_Final-17.11.pdf;

Menard S., 2010. Logistic Regression: From Introductory to Advanced Concepts and Applications. SAGE Publications, Inc. https://methods.sagepub.com/book/logistic-regression-from-introductory-to-advanced-concepts-and-applications;

MFPED, 2017. Distribution of Inputs by NAADS/Operation Wealth Creation: What are some of the benefits to farmers? Ministry of Finance, Planning and Economic Development (MFPED). https://www.finance.go.ug/sites/default/files/archive-files/Publications/BMAU%20Briefing%20Paper%2027-17%20-%20Distribution%20of%20Inputs%20by%20NAADS-Operation%20Wealth%20Creation%20-%20What%20are%20some%20of%20the%20benefits%20to%20farmers.pdf;

Midamba D. C., 2022. Determinants of Maize Production Income in Western Uganda. East African Journal of Agriculture and Biotechnology, Volume 5, Issue 1, 2022. https://www.researchgate.net/publication/358150337_Determinants_of_Maize_Production_Income_in_Western_Uganda;

Morara Nyairo N., Pfeiffer L., Spaulding A., and Russell M., 2022. Farmers' attitudes and perceptions of adoption of agricultural innovations in Kenya: a mixed methods analysis. Journal of Agriculture and Rural Development in the Tropics and Subtropics, Vol. 123 No. 1 (2022) 147–160. https://www.jarts.info/index.php/jarts/article/view/202203085855;

Morduch J., 1995. Income Smoothing and Consumption Smoothing. Journal of Economic Perspectives 9(3):103–14. https://www.aeaweb.org/articles?id=10.1257/jep.9.3.103;

Mugisha J. and Diiro G., 2010. Explaining the Adoption of Improved Maize Varieties and its Effects on Yields among Smallholder Maize Farmers in Eastern and Central Uganda. Middle-East Journal of Scientific Research 5 (1): 06-13, 2010. https://www.sid.ir/paper/632140/en;

Mutyebere R., Nanyanzi S., Bonabana J., Basamba T., Nanyanzi A., Sheila J., Bonabana-Wabbi T., Ateenyi B., 2018. Adoption of Improved Varieties and Input Elasticities Among Smallholder Maize Farmers in Kabarole District-Western Uganda. International Journal of Agricultural Sciences and Natural Resources 2017; 4(6): 50-5. https://www.researchgate.net/publication/322952923_Adoption_of_Improved_Varieties_and_Input_Elasticities_Among_Smallholder_Maize_Farmers_in_Kabarole_District-Western_Uganda_Citation;

NAADS, 2021. Profit margins on maize production. National Agriculture Advisory Services (NAADS). https://naads.or.ug/profit-margins-on-maize-production/#;

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

Noack F., and Larsen A., 2019. The contrasting effects of farm size on farm incomes and food production. Environmental Research Letters, 14 (8), 084024. https://iopscience.iop.org/article/10.1088/1748-9326/ab2dbf/meta;

Oduro-Ofori E., Aboagye A. P., and Acquaye N. A. E., 2015. Effects of education on the agricultural productivity of farmers in the Offinso Municipality. International Journal of Development Research, 4(9), 1951–1960. https://www.researchgate.net/publication/281032030_EFFECTS_OF_EDUCATION_ON_THE_AGRICULTURAL_PRODUCTIVITY_OF_FARMERS_IN_THE_OFFINSO_MUNICIPALITY;

Okoboi G., 2010. Improved inputs use and productivity in Uganda's maize sub-sector. Research Series No. 69, Economic Policy Research Center (EPRC), Kampala, Uganda. https://www.researchgate.net/publication/254386597_Improved_inputs_use_and_productivity_in_Uganda's_maize_sub-sector;

Rietveld A., Mpiira S., and Staver C., 2012. Targeting young adults/young households in Central Uganda: Where is the next generation of farmers? https://www.future-agricultures.org/wp-content/uploads/pdf-archive/Rietveld%20et%20al%20Targeting%20young%20adults.pdf;

Sexsmith, K., Smaller, C. & Speller, W. (2017). How to Improve Gender Equality in Agriculture. Policy Brief 5. 1–8. https://www.iisd.org/system/files/publications/how-to-improve-gender-equality-agriculture.pdf;

Telleria R. and Tusiime M., 2023. Characterising agricultural holdings in Uganda: Inputs to improving policy formulation. Journal of Development and Agricultural Economics. Vol. 15(1), pp. 11-25, January-March 2023;

UBOS, 2019. Annual Agricultural Survey - 2018, Second Season. Uganda Bureau of Statistics https://microdata.ubos.org:7070/index.php/catalog/62/data-dictionary/F20?file_name=PH_5.16_Shocks_&_FoodSecurity;

UBOS, 2020. 2019 Annual Agricultural Survey Report (AAS 2019). Table 4- 9: Percentage of plots where crops were planted with improved seeds, by crop. Uganda Bureau of Statistics. https://www.ubos.org/wp-content/uploads/publications/04_2022AAS2019_Report.pdf;

UBOS, 2022a. Crop production for selected Food Crops, 2016-2020 (MT). Uganda Bureau of Statistics. https://www.ubos.org/explore-statistics/2/;

UBOS, 2022b. Area planted for selected Food Crops, 2016-2020 (Ha). Uganda Bureau of Statistics. https://www.ubos.org/explore-statistics/2/;

USAID, 2021. Uganda Seed Sector Profile. Feed the Future Global Supporting Seed Systems for Development. https://pdf.usaid.gov/pdf_docs/PA00Z8M6.pdf;

USAID, 2003. Micro-credit helps promote food security in Guinea. https://reliefweb.int/report/guinea/micro-credit-helps-promote-food-security-guinea;

World Bank, 2022. Uganda Poverty Assessment: Strengthening Resilience to Accelerate Poverty Reduction. International Bank for Reconstruction and Development / The World Bank. https://elibrary.worldbank.org/doi/epdf/10.1596/39855.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

ANNEX 1: MULTICOLLINEARITY TEST

The assumption of absence of multicollinearity was examined. Variance Inflation Factors (VIFs) were calculated to detect the presence of multicollinearity between the predictors. High VIFs indicated increased effects of multicollinearity in the model between predictors. Following Menard (2010), VIFs greater than five were cause for concern, whereas VIFs equal or greater than 10 were considered the maximum upper limit. All predictors used in the binary logistic regression model had VIF values less than 10.

All microdata used in this study came from the 2018 Annual Agricultural Survey. Multicollinearity was found in the following variables, which were removed from the model: 1) “Total area under crop - ha”; 2) “Yield”; 3) “Prices of maize”; 4) “Quantity of maize produced”; 5) “Irrigation”; 6) “Quantity of seeds applied to crop that has been purchased - tonnes”; 7) “Total quantity harvested of crop – tonnes; 8) “Distance to markets”; 9) “Seed Source - Other”; 10) “Main Economic - Non-agricultural paid job”; and 11) “Main economic role - Salaried Worker”. Irrigation is an input typically included in modelling exercises.

For our binary logistic regression model, irrigation was not included given that multicollinearity tests showed collinearity issues between irrigation (as independent variable) and mainly the type of seed used for maize cropping (the dependent variable). Additionally, Uganda is characterized for benefiting from a bimodal rainfall system (i.e. two rainy seasons per year), and for having abundant surface water resources including lakes, rivers and wetlands (GIZ, 2020) that allow a diverse range of crops to be produced in most districts of the country (IFAD, 2022). This context suggests that Ugandan farmers are not hugely concerned about counting with irrigation facilities. And in fact, UBOS (2020) reports that only 2.6% of all agricultural households in the country irrigated their lands in 2019.

Data associated with climatic conditions, such as rainfall, temperature, and humidity, were not used in this study. This kind of data conditions what econometric methods can be applied to extract meaningful insights. As data on climatic conditions is frequently collected overtime (generally hourly, daily, and weekly), the data builds time-series structures, which is different from cross-sectional data (that corresponds to the microdata from the 2018 Annual Agricultural Survey).

No multicollinearity among the predictors was found in the following variables, which were included in the model: 1) “Gender”; 2) “Education”; 3) “Fertilizer use”; 4) “Chemical pesticide use”; 5) “Credit source – Financial institutions”; 6) “Seed supplier – Government”; 7) “Seed supplier – Relative/neighbor”; 8) “Seed supplier – Local retailer”; 9) “Seed supplier – Wholesaler”; 10) “Extension services”; 11) “Farmers attending trainings”; 12) “Main economic activity – Off farm job”; and 13)”; “Age of the household head”.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

Research Journal of Agricultural Economics and Development
ISSN: 2997-5980
Volume 4, Issue 1, 2025 (pp. 1-23)
www.abjournals.org

ANNEX 2: DESCRIPTIVE STATISTICS OF VARIABLES USED IN THE MODEL

Statistics

	Main type of seed used for maize (pp_s4_6c16)	Gender (sex)	Education level dummy	Ln Total area under maize crop in the plot - ha	Ln Yield - tonnes/ha	Extension services	Seed supplier - Government	Seed supplier - Relative/neighbour	Seed supplier - Local retailer	Seed supplier - Wholesaler	Main economic activity - Crop production	Main economic activity - Off farm job	Use of fertilizers (organic and/or inorganic), dummy
Valid	3510	3109	3102	3509	3082	3327	3510	3510	3510	3510	3106	3106	2941
Missing	0	401	408	1	428	183	0	0	0	0	404	404	569

Gender (sex)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	2568	69.9	78.6	78.6
	Female	700	19.0	21.4	100.0
	Total	3268	88.9	100.0	
Missing	System	408	11.1		
Total		3676	100.0		

Education level dummy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No education	472	12.8	14.5	14.5
	Education	2789	75.9	85.5	100.0
	Total	3261	88.7	100.0	
Missing	System	415	11.3		
Total		3676	100.0		

Extension services

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	444	12.1	12.7	12.7
	No	3044	82.8	87.3	100.0
	Total	3488	94.9	100.0	
Missing	System	188	5.1		
Total		3676	100.0		

Seed supplier - Government

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3375	91.8	96.0	96.0
	Yes	140	3.8	4.0	100.0
	Total	3515	95.6	100.0	
Missing	System	161	4.4		
Total		3676	100.0		

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

Seed supplier - Relative/neighbour

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3400	92.5	96.7	96.7
	Yes	115	3.1	3.3	100.0
	Total	3515	95.6	100.0	
Missing	System	161	4.4		
Total		3676	100.0		

Seed supplier - Local retailer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3111	84.6	88.5	88.5
	Yes	404	11.0	11.5	100.0
	Total	3515	95.6	100.0	
Missing	System	161	4.4		
Total		3676	100.0		

Seed supplier - Wholesaler

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3347	95.4	95.4	95.4
	Yes	163	4.6	4.6	100.0
	Total	3510	100.0	100.0	

Main economic activity - Crop production

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	683	18.6	20.9	20.9
	Yes	2582	70.2	79.1	100.0
	Total	3265	88.8	100.0	
Missing	System	411	11.2		
Total		3676	100.0		

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

Main economic activity - Off farm job

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3195	86.9	97.9	97.9
	Yes	70	1.9	2.1	100.0
	Total	3265	88.8	100.0	
Missing	System	411	11.2		
Total		3676	100.0		

Use of fertilizers (organic and/or inorganic), dummy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	2802	76.2	90.8	90.8
	Yes	284	7.7	9.2	100.0
	Total	3086	83.9	100.0	
Missing	System	590	16.1		
Total		3676	100.0		

Ln total area and Ln yields

	Ln Total area under maize crop in the plot - ha	Ln Yield - tonnes/ha
N	3566	3132
Minimum	-8.51	-4.00
Maximum	2.74	2.30
Median	-2.3357	.3298
Std. Deviation	1.39348	.98336
Mean	-2.3811	.3201

Note: Negative numbers of mean and median are because many values of total area are between 0 and 1. Therefore, the natural logarithm of any number less than 1 and higher than 0 is a negative number.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Yield - tonnes/ha	2881	.02	5.50	1.62	1.19386
Total area under maize crop in the plot - ha	3355	.01	15.46	.25	.59240

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

ANNEX 3: TESTING THE BINARY LOGISTIC REGRESSION MODEL

This Annex presents all procedures followed to test the accuracy of the binary logistic regression model. Table 1 tested if the sample sizes for both traditional seeds and improved seeds were statistically different from each other. The null hypothesis was that the frequency of maize plots using traditional seeds and the frequency of maize plots using improved seeds were not statistically significantly different from each other. The Wald statistic was very high (1035.026) and the p-value (0.000) less than 1% level rejecting the null hypothesis. Therefore, the frequency of maize plots using traditional seeds and the frequency of maize plots using improved seeds were statistically different from each other. Thus, the probability of finding a farmer using traditional seeds is different (higher) as compared to the probability of finding a farmer using improved seeds.

Table 1: Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-2.268	.071	1035.026	1	.000	.103

Source: Own elaboration based on microdata from the 2018 Annual Agricultural Survey, UBOS.

Goodness-of-fit statistic was used to determine whether the model adequately describes the data or not. The Omnibus Test of model coefficients indicates that the model is significant at 1% level, indicating that the model is satisfactorily describing the data (Table 2). The Chi-square values and the *p*-values are statistically significant, and therefore the model has some predictive capacity.

Table 2: Omnibus test of model coefficients

		Chi-square	df	Sig.
Step 1	Step	261.034	11	.000
	Block	261.034	11	.000
	Model	261.034	11	.000

Source: Own elaboration based on microdata from the 2018 Annual Agricultural Survey, UBOS.

The Hosmer and Lemeshow test was not significant at 1% level indicating that the binary logistic model fitted the data relatively well. In other words, the difference between the observed and predicted value cases is small indicating that the data fitted relatively well the model, and that the model's predictive capacity is acceptable (Table 3).

Table 3: Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	17.574	8	.025

Source: Own elaboration based on microdata from the 2018 Annual Agricultural Survey, UBOS.

Further analysis of the predictive capacity of the overall bivariate model was done using the contingency table of the "Hosmer and Lemeshow test" (Table 4). This test separates the predicted probabilities into ten categories, accounts the number of plots in those categories, and compares them against the expected vs the observed types of seeds. For example, in category 10 the expected number of plots with improved seeds was 88.824 while the observed

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN

number of plots with improved seeds was 88. The deviation of both values was not very big, and therefore the predictive capacity of the model is acceptable.

Table 4: Contingency table for the Hosmer and Lemeshow Test

	Main type of seed used for maize (pp_s4_6c16) = Traditional seeds		Main type of seed used for maize (pp_s4_6c16) = Improved seeds		
	Observed	Expected	Observed	Expected	Total
1	230	232.114	7	4.886	237
2	232	229.808	5	7.192	237
3	229	228.091	8	8.909	237
4	232	226.421	5	10.579	237
5	229	224.509	8	12.491	237
6	213	222.337	24	14.663	237
7	211	219.066	26	17.934	237
8	218	214.234	19	22.766	237
9	205	203.245	32	33.755	237
10	146	145.176	88	88.824	234

Source: Own elaboration based on microdata from the 2018 Annual Agricultural Survey, UBOS.

The Percentage Accuracy in Classification (PAC) indicates how well the model can predict the correct category of the independent variables. Overall, the model exhibits good sensitivity as it was able to correctly predict 91.8% of the households that will use improved and traditional seeds (Table 5).

Table 5: Percentage Accuracy in Classification (PAC)

		Predicted		
		Main type of seed used for maize (pp_s4_6c16)		
Observed		Traditional seeds	Improved seeds	Percentage Correct
Main type of seed used for maize (pp_s4_6c16)	Traditional seeds	2128	17	99.2
	Improved seeds	178	44	19.8
Overall Percentage				91.8

Source: Own elaboration based on microdata from the 2018 Annual Agricultural Survey, UBOS.

In conclusion, all these tests indicate that the binary logistic regression model is overall suitable to describe the data, as well as to estimate the odds ratios of the dependent variables.

Article DOI: 10.52589/RJAED-EVFXZTRN
DOI URL: https://doi.org/10.52589/RJAED-EVFXZTRN