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Examining the relationship between farmers' characteristics and access to agricultural extension: Empirical evidence from northern Uganda

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ABSTRACT

Purpose: This study aimed at assessing how farmers' access to agricultural extension is linked to farmers' choice of extension service providers, and the crops and livestock activities engaged in at the farm level.

Methodology/Design/Approach: Cross-sectional data were collected from a sample of 342 farming households. Data analyses were conducted using the descriptive statistics and Probit binary regression model.

Findings: Results show that farmer access to agricultural extension depends on farmer district location, experience, group membership, use of pesticides, crop and livestock production diversity, and information source diversity. Furthermore, results show that gender, marital status, experience credit access, group membership, and livestock production diversity are the main drivers of farmers' choice of service providers for an agricultural extension at the farm level. Lastly, leading determinants of access to agriculture for individual farm enterprises include farmer location (district), gender, marital status, education, experience, land owned, access to credit, group membership, ownership of mobile phones, and market information source diversity.

Practical Implications: Differentiated targeting of agricultural extension across farmer demographic structures and production objectives is not only influenced by varying factors but also important for ensuring that extension services are responsive for food and cash generation needs of local communities.

Theoretical Implications: This study deepens the literature on farmer access to agricultural extension with results demonstrating differences in factors that determine farmers' choice of service providers for agricultural extension and the kind of crop and livestock activities engaged at the farm level.

Originality/value: This research is of high value as it presents empirical results on factors associated with the provision of agricultural extension services where there are many providers and where extension services is targeting different agricultural enterprises.

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Introduction

With many smallholder farmers involved in agricultural production in Sub Saharan Africa (SSA) (Wiggins and Keats 2013), and the need to eradicate rural poverty and food insecurity in most developing countries (UN 2015), the provision of agricultural extension becomes an important component of agricultural development. By enhancing the adoption of relevant farming technologies and providing farmers with relevant production skills, agricultural extension is important in improving household incomes and the food security situation (Rivera 2003; Norton, Alwang, and Masters 2014; Walker and Alwang 2015). For instance, Danso-Abbeam, Ehiakpor, and Aidoo (2018) reported that participation in agricultural extension in Ghana increased household farm incomes by over 11%.

Despite its importance, agricultural extension is not equally accessed across all farmer categories (Norton, Alwang, and Masters 2014). Such variations in extension services access often stem from (1) production orientation i.e. subsistence or commercial, (2) the kind of crop or livestock activities engaged in by the farmer, (3) gender category of the farmer, and (4) interests of extension service providers. For instance, there seems to be more accessibility to agricultural extension among commercially oriented farmers compared to subsistence counterparts. Furthermore, this variability has seen a significant transformation from just focusing on the technical transfer approach of agricultural extension to pluralistic which has enshrined in innovation systems thinking (Suvedi, Ghimire, and Kaplowitz 2017; Davis and Alex 2020). This shift implies that there are currently many players providing extension services to rural farmers (Kalule et al. 2019). In Uganda, the government is moving toward the single spine extension system, which is a pluralistic extension approach (Nkonya et al. 2020). The single spine extension systems envision proper coordination among extension actors (Barungi, Guloba, and Adong 2016), with the aim of ensuring that farmers get the best out of extension services provision. With many players from both the private and public sectors providing extension services, it is expected that different farmers would receive extension services occasionally from more than one provider. In addition, with smallholder farmers being involved in several agricultural enterprises, it is also expected that agricultural extension would target different enterprises for different farmers. Understanding these differences is important in (re)designing agricultural extension messages and interventions. There are several studies on the determinants of access to agricultural extension (see for example; Kalinda, Shute, and Filson 1998; Ajah 2012; Abdallah and Abdul-Rahaman 2016; Mwololo, Nzuma, and Ritho 2019; Olorunfemi, Olorunfemi, and Oladele 2020). Most of these studies, however, focus on specific providers of agricultural extension services without regard to situations where farmers are served by different providers, nor do they focus on the several target agricultural enterprises.

However, with the agricultural extension becoming more demand driven and pluralistic (Swanson 2008; Barungi, Guloba, and Adong 2016; Franzel et al. 2020), understanding the association between farmers' characteristics, and sources of agricultural extension and target enterprises becomes paramount. The pluralistic agricultural extension involves many providers of extension services working in tandem to achieve the same goals of providing farmers with knowledge. The different providers are usually funded from different sources (Swanson 2008; Bitzer et al. 2016). Each of the different providers is limited by how many farmers they can reach and consequently, extension coverage and

frequency remain low. According to the ministry of agriculture, animal industry, and fisheries (MAAIF), the ratio of both local and central government extension workers to farmers is 1:5000 against a target of 1:500 (MAAIF 2016). Synergistic effects are thus expected from the different providers of agricultural extension services. Understanding the factors associated with access to agricultural extension from different providers for different agricultural enterprises is paramount in supporting and enhancing the continued uptake of demand-driven and pluralistic extension services. This study bridges this important knowledge gap by investigating the relationship between smallholder farmers' socioeconomic characteristics, sources of agricultural extension, and target enterprises.

Methodology

Study area

This study was carried out in the Gulu, and Amuru districts of northern Uganda. Gulu district is located at geographical coordinates 02°45'N, 32°00'E, while Amuru district is located at geographical coordinates 02°50'N 33°05'E. These districts were selected purposively based on the presence of agricultural extension services including from local and central government, Non-Governmental organizations (NGO), research institutions and universities, private agricultural extension service providers, and farmers' organizations. Gulu district is more urbanized than the Amuru district. In fact, Amuru district was part of Gulu District until 2006. With the difference in the level of urbanization, it is thus expected that there are differences in extension service provision and subsequent agricultural extension outcomes. In border districts, agriculture is the main economic activity of the majority of households in the two districts, with the households being involved in the cultivation of several crops and rearing livestock including maize, rice, sorghum, soybeans, beans, groundnuts, cassava, sweet potato, banana, millet, cattle, goats, poultry and piggyery. The agricultural extension provided by the different providers usually targets single or multiple agricultural enterprise(s) being undertaken by the smallholder farming households.

Sampling design and data collection

The current study adopted a cross-sectional survey research design. The study population consisted of smallholder farmers of smallholder agricultural households. The farmers included both participants and non-participants of the Gulu University's student-field attachment¹ (SFA). In the case of farmers who were participating in the SFA, a list of participants was obtained from the Department of Rural and Agribusiness and was used as a sampling frame. Participating farmers were then randomly selected for inclusion in this study. A total of 114 participating farmers were reached and interviewed. For every participating farmer, two non-participating farmers were included in the study. These were selected from the same parish of the participating farmers. Thus, a total of 228 non-participating households were also included in the study. The total sample size of 342 thus reached seven sub-counties drawn from the two study districts.

Data was collected using structured interviewer-administered questionnaires. The questionnaires were designed to contain information on the socioeconomic factors,

farmers' access to agricultural extension services disaggregated for the different providers and agricultural enterprises, crop and livestock production, and sources of agricultural information. The questionnaire was pretested and the necessary adjustments were made before the full-scale data collection. The collected data were entered into SPSS v25 and STATA v14 for subsequent statistical analysis.

Empirical model

This study investigated the relationship between agricultural extension providers and target enterprises, and farmers' socioeconomic characteristics using regression analysis. First, we investigated the determinants of access to agricultural extension among small-holder farmers. In this analysis, the dependent variable was access to agricultural extension, which was measured as a binary response variable for access or no access to agricultural extension. Secondly, we investigated the relationship between farmers' characteristics and agricultural extension service providers. Since farmers usually receive agricultural extension services from multiple providers, the dependent variable for this analysis reflected whether or not a given farmer received agricultural extension visits from a given service provider conditional on accessing agricultural extension. This implied that the dependent variables for the second analysis were also binary in nature. There were four different binary response variables that formed part of the second analysis. Lastly, we investigated the relationship between farmers' characteristics and agricultural enterprise targeted by extension advice. Again, since it is possible that agricultural extension advice may target multiple agricultural enterprises at the same time, the dependent variable, target agricultural enterprise, was binary in nature, stating whether or not a given enterprise was targeted.

Given the binary outcome of our dependent variables, Ordinary Least Squares (OLS) estimates would provide inconsistent parameter estimates. Subsequently, we adopted a binary regression model for this purpose. In estimating a binary regression model, it is possible to fit a logistic regression model which assumes a logistic distribution of the error term, or a probit regression model which assumes a normal distribution of the error term with the two options usually giving identical results (Cameron and Trivedi 2005; Wooldridge 2016). In this study, we estimate the Binary Probit Regression model, by assuming a normal distribution of the error term.

Let z_i be our binary outcome variable associated with an agricultural extension. z_i would be defined as specified in equation (1).

$$G(z_i) = \begin{cases} 1 & \text{if the } i\text{th farmer response is YES} \\ 0 & \text{if NO} \end{cases} \quad (1)$$

In this case, z_i is a latent variable with probabilities p for $z_i^* = 1$ and $1 - p$ for $z_i^* = 0$. G is the functional form with a standard normal distribution. Each of the binary dependent variables representing access to agricultural extension, provider of agricultural extension, or target agricultural enterprise is independently regressed against x variables as specified in equation (2).

$$z_i^* = X_i' \delta + u_i \quad (2)$$

where X_i represents a vector of explanatory variables which influence access to agricultural extension from a given provider or access to agricultural extension for a given target agricultural enterprise. Table 1 presents a description of the explanatory variables used and their *a priori* expectations. δ is a vector of parameters to be estimated associated with farm specific attributes. The conditional probability is estimated from equation (3).

$$\Pr(z_i = 1|x) = G(z_i^*) = \Phi(x_i'\delta) \quad (3)$$

where $\Phi(\cdot)$ is the standard normal density function that applies to the Binary Probit Model. The marginal effects with respect to changes in the explanatory variables on the dependent variable were estimated from the specification in Equation (4).

$$\frac{\partial \Pr[z_i = 1|x_{ij}]}{\partial x_{ij}} = \frac{\exp(x'\delta)}{1 + \exp(x'\delta)} \quad (4)$$

The parameters of the Binary Probit model were estimated using the method of maximum likelihood estimation (MLE). In the analysis, we applied the Probit regression independently to all the dependent variables specified for this study. The final set of explanatory variables is applied for specific dependent variables given that each regression specification must pass certain assumptions. The results presented are for regressions where the Wald Chi Square was significant, while the Goodness of Fit test was not significant as expected. We estimated robust standard errors for all the regression models due to the presence of heteroskedasticity. A pairwise correlation test was also performed for the explanatory variables and only those with a low (less than 0.45) correlation coefficient were included in the final analysis. Also, to account for the

Table 1. Description of explanatory variables used in the Probit Model estimation and their *a priori* expectations.

Variable	Description	Apriori
District (Gulu)	Dummy: district (1 = Gulu, 0 = Amuru)	+/-
Sex (Male)	Dummy: male headed household (1 = male, 0 = female)	+/-
Married	Dummy: married (1 = married, 0 = otherwise)	+/-
Household size	Number of household members	+
Education	Number of years of formal education	+
Experience	Farming experience in years	-
Age	Age in complete years	-
Land owned	Size of land owned by household in acres	+
Land cultivated	Size of land being cultivated by household in acres	+/-
Group membership	Dummy: the farmer is a member of a farmer's group (1 = yes, 0 = no)	+
Access to credit	Dummy: the farmer has access to agricultural credit (1 = yes, 0 = no)	+
Dependency ratio	The ratio of household members not involved in any economic activity to total household size	-
Record keeping	Dummy: Farmer keeps records (1 = yes, 0 = no)	+
Use purchased seeds	Dummy: farmer uses purchased seeds (1 = yes, 0 = no)	+
Use pesticides	Dummy: farmer uses pesticide (1 = yes, 0 = no)	+
Crop production diversity	Number of crop enterprises being undertaken on farm	-
Livestock production diversity	Number of livestock enterprises being undertaken on farm	-
Mobile Phone	Dummy: Farmer Owns mobile phone (1 = Yes, 0 = No)	+
Information sources	The number of agricultural information sources available to the farmer. Sources considered include: radio, newspaper and print media, farmers' organizations, friends, government and NGO	+

participation in SFA and non-participation, the estimated standard errors were adjusted accordingly.

This study assessed the relationship between farmers' socioeconomic characteristics and four providers of agricultural extension in the region. A separate binary regression analysis was conducted for each of the four providers of extension services identified in this study. This was because it is possible for farmers to obtain extension services from more than one provider. Similarly, separate models were estimated for five crop and three livestock enterprises with the highest percentages of targets.

Results

Population characteristics

Table 2 presents the summary statistics of the population characteristics. It shows that over 65% of the farming households interviewed were from the Gulu district, the majority of whom were male (75%) and married (74%). The average household size was seven household members, with an average duration of formal education of 5.2 years. The household dependency ratio was 45%. This implies that of the total household members, over 45% were not involved in any economic activity. These farmers were on average 41 years old with 22 years of farming experience. The average land owned was 9.2 acres although the farming households were only cultivating an average of 4.4 acres. Over 87% of the farmers were members of a farmer's group, while, about 54% had access to credit from various other sources. Only 23% of the households were keeping a record of their farming activities, while over 49% were using purchased seeds for planting. The use of agricultural pesticides was also low at only 11%. On average, the households were undertaking five crops and two livestock enterprises. Over 44% owned mobile phones, and, were receiving agricultural information from at least two different

Table 2. Summary statistics of population characteristics.

Variable	Mean	Std. Dev.	Min	Max
District (Gulu)	0.65	0.48	0	1
Sex (Male)	0.75	0.43	0	1
Married	0.74	0.44	0	1
Household size	7.22	3.13	1	19
Education	5.17	3.88	0	17
Farming Experience	22.24	13.88	1	60
Age	40.66	13.23	18	80
Land owned (acres)	9.19	19.33	0	200
Land cultivated (acres)	4.36	3.60	0	29
Membership to association	0.87	0.34	0	1
Access to credit	0.54	0.50	0	1
Dependency ratio	0.45	0.21	0	1
Record keeping (1 = yes)	0.23	0.42	0	1
Use purchased seeds	0.49	0.50	0	1
Use pesticides	0.11	0.31	0	1
Crop production diversity	5.20	2.14	0	12
Livestock production diversity	2.05	1.17	0	5
Mobile phone (Yes)	0.44	0.50	0	1
Information sources	2.29	1.10	0	6
Access to agricultural Extension	0.57	0.50	0	1
Annual number of extension visits	6.39	6.45	1	30

Note: In the case of dummies, the mean refers to mean proportions that are converted to percentages in the description.

sources. At least 57% of the households had reportedly received an agricultural extension. For those who had access to extension, the average number of extension visits was six times annually.

Factors associated with overall access to agricultural extension

Probit model estimates for determinants of agricultural extension are presented in Table 3. It shows the district indicator ($p < 0.01$), farming experience ($p < 0.05$), group membership ($p < 0.1$), use of pesticides ($p < 0.1$), livestock production diversity ($p < 0.05$), and a number of agricultural information sources available to the farmer ($p < 0.01$) had a positive significant influence on access to agricultural extension, while, crop production diversity ($p < 0.05$) had a negative significant influence on agricultural extension. Especially, farmers in the Gulu district had a 26% higher likelihood of receiving agricultural extension than their counterparts in the Amuru district. An increase in farming experience would increase the probability of receiving agricultural extension by 10%, while, farmers who are members of a farmers' group were 17% more likely to receive agricultural extension services than those who did not belong to any group. Farmers who were using pesticides in their production were 18% more likely to receive agricultural extension than those who did not. Also, an increase in the number of crop enterprises undertaken on farm would reduce the probability of accessing extension by 4%, while, an increase in the number of livestock enterprises on farm would increase the probability of receiving extension by 7%. Lastly, if a farmer received agricultural and market information from additional sources, it would increase his/her probability of accessing agricultural extension by 24%.

Table 3. Determinants of access to agricultural extension.

Variables	Coef.	SE	Marginal effects	SE
District (1 = Gulu, 0 = Amuru)	0.684***	0.176	0.263	0.067
Male	0.152	0.260	0.059	0.102
Married	-0.274	0.239	-0.103	0.087
Log Household size	-0.125	0.182	-0.048	0.070
Log Education	-0.081	0.124	-0.031	0.048
Log Farming experience	0.256**	0.119	0.098	0.046
Log land owned	-0.042	0.101	-0.016	0.039
Group membership	0.443*	0.255	0.174	0.101
Access to credit	0.111	0.183	0.042	0.070
Dependency ratio	0.130	0.408	0.050	0.156
Record keeping (1 = yes)	-0.029	0.200	-0.011	0.077
Use purchased seeds	-0.150	0.162	-0.057	0.062
Use pesticides	0.518*	0.314	0.182	0.097
Crop production diversity	-0.093**	0.042	-0.036	0.016
Livestock production diversity	0.170**	0.073	0.065	0.028
Ownership of mobile phone	0.193	0.187	0.074	0.071
Number of information sources	0.629***	0.095	0.241	0.035
Constant	-2.235***	0.600		
N	342			
Log Likelihood	-156.202			
Wald $\chi^2(17)$	110.31			
Prob > χ^2	0.000			

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

Farmers' characteristics and source of agricultural extension

Over 57% of the farmers surveyed received extension visits from multiple sources of service providers. The largest provider was Non-Governmental Organization and Community-based organizations that reached over 73% of the farmers surveyed (Figure 1). This was followed by research institutions which in this study included universities and other research-based institutions (41%). Others were: local and central government extension agents (18%) and farmers' organizations² (10%). In this study, farmers' organizations included cooperatives and farmers' associations.

Tables 4 and 5 present binary regression estimates and marginal effects after Probit for the relationship between farmers' characteristics and providers of agricultural extension. The marginal effects estimates presented were consistent with the parameters of the Probit regression model. Results showed that different farmers' characteristics have different effects on access to different sources of agricultural extension services. Especially, male headed households were 25% less likely to receive extension advice from farmers' organizations ($p < 0.05$) and research institutions ($p < 0.1$), than female headed households. Married household heads were 26% more likely to receive extension advice from NGOs ($p < 0.1$) and 8% more likely to receive an extension from farmers' organizations ($p < 0.1$) than their counterparts who were not married.

In addition, an increase in farming experience would reduce the likelihood of accessing extensions from NGOs ($p < 0.05$) by 13% but would increase the likelihood of accessing extensions from research institutions ($p < 0.01$) by 17%. Similarly, farmers who had access to agricultural credit were 17% more likely to receive agricultural extension services from NGOs ($p < 0.05$) and 8% more likely to receive extension services from farmers' organizations ($p < 0.05$) than those who did not access credit. Farmers who were members of a farmers' group were 39% less likely to receive agricultural extension services from the government ($p < 0.05$) than those who were not. Lastly, livestock production diversity had a positive significant influence on access to agricultural extension services from the government ($p < 0.01$), NGOs ($p < 0.01$), and farmers' organizations (p

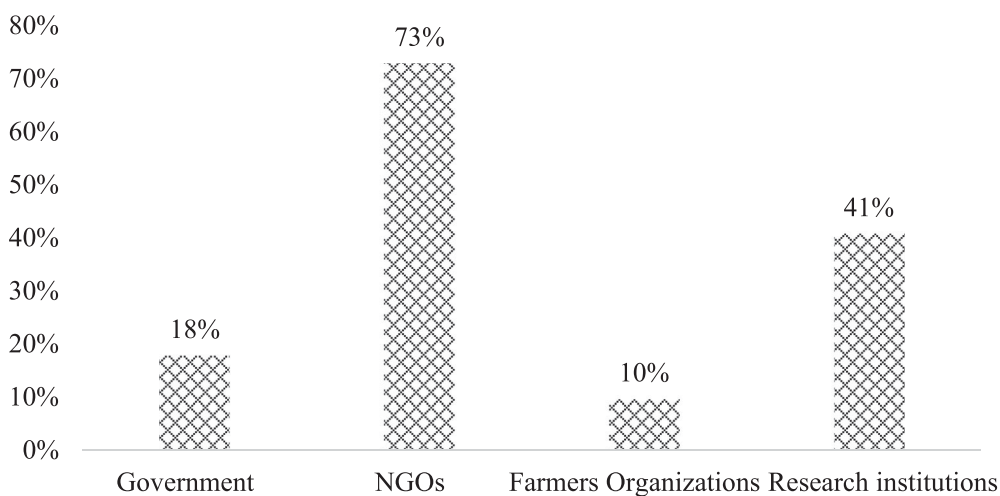


Figure 1. Providers of agricultural extension.

Table 4. The relationship between farmers' socioeconomic characteristics and access to agricultural extension from various sources.

Variable	Government		NGO		Farmers' Organization		Research institutions	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Male Headed	-0.284	0.444	-0.307	0.405	-1.307**	0.565	-0.639*	0.384
Married	0.208	0.431	0.763*	0.398	0.941*	0.551	0.193	0.366
Log education	0.193	0.173	-0.005	0.143	-0.063	0.202	0.005	0.132
Log household size	0.087	0.243	0.075	0.235	0.218	0.400	-0.130	0.228
Log Land size	0.109	0.141	0.078	0.173	0.144	0.150	-0.126	0.144
Log farming experience	0.062	0.160	-0.434**	0.169	-0.024	0.184	0.447***	0.156
Access to credit	0.342	0.262	0.530**	0.221	0.804**	0.381	-0.046	0.206
Group membership	-1.174**	0.469	-0.304	0.556	-0.724	0.626	0.114	0.495
Use purchased seeds	-0.004	0.246	-0.218	0.215	0.166	0.251	0.314	0.203
Use pesticide	-0.105	0.301	-0.366	0.297	-0.438	0.417	0.106	0.275
Crop production diversity	-0.038	0.056	-0.025	0.053	-0.079	0.077	-0.054	0.048
Livestock production diversity	0.380***	0.112	0.303***	0.104	0.293***	0.104	-0.007	0.090
Ownership of mobile phone	0.265	0.233	0.044	0.225	0.078	0.316	0.241	0.213
Dependency ratio	0.738	0.534	-0.354	0.509	0.686	0.609	0.071	0.475
Constant	-2.072***	0.750	1.096	0.921	-2.235**	1.074	-0.893	0.806
N	196		196		196		196	
Log likelihood	-78.673		-98.085		-52.225		-120.871	
Wald $\chi^2(16)$	27.58		28.88		21.94		22.98	
Prob > χ^2	0.016		0.011		0.079		0.061	

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

< 0.01). Especially, an increase in the number of livestock enterprises on the farm would increase the probability of receiving an extension from the government, NGOs, and farmers' organizations by 8%, 9%, and 3% respectively.

Table 5. Marginal effects analysis for the relationship between farmer's socioeconomic characteristics and access to agricultural extension services from various sources.

Variable	Government		NGO		Farmers' Organization		Research institutions	
	Marginal effects	SE	Marginal effects	SE	Marginal effects	SE	Marginal effects	SE
Male Headed	-0.068	0.114	-0.089	0.111	-0.247*	0.140	-0.249*	0.147
Married	0.044	0.087	0.257*	0.141	0.084**	0.039	0.073	0.137
Log education	0.043	0.038	-0.002	0.044	-0.007	0.024	0.002	0.051
Log household size	0.020	0.054	0.023	0.072	0.026	0.047	-0.050	0.088
Log Land size	0.024	0.031	0.024	0.053	0.017	0.018	-0.049	0.055
Log farming experience	0.014	0.036	-0.134**	0.052	-0.003	0.022	0.173***	0.060
Access to credit	0.073	0.054	0.170**	0.073	0.084**	0.034	-0.018	0.080
Group membership	-0.386***	0.179	-0.084	0.135	-0.135	0.157	0.043	0.185
Use purchased seeds	-0.001	0.055	-0.067	0.066	0.020	0.029	0.121	0.078
Use pesticide	-0.023	0.062	-0.122	0.105	-0.041	0.032	0.041	0.108
Crop production diversity	-0.009	0.012	-0.008	0.016	-0.009	0.009	-0.021	0.019
Livestock production diversity	0.085***	0.023	0.093***	0.032	0.034**	0.013	-0.003	0.035
Ownership of mobile phone	0.060	0.053	0.014	0.069	0.009	0.037	0.093	0.082
Dependency ratio	0.165	0.123	-0.109	0.156	0.081	0.073	0.027	0.183

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

Farmers' characteristics and agricultural extension target enterprise

Agricultural extension usually targets different crops and livestock enterprises. Figure 2 presents a frequency distribution of crops and livestock enterprises targeted by agricultural enterprises. Over 21 agricultural enterprises were targeted by agricultural extension. With respect to crop enterprises, maize (56%) and beans (53%) were the most targeted. In the case of livestock, extension's main target enterprises were cattle (15%), goats (13%), and poultry (13%). Other crop enterprises for which extension service reached over 10% were groundnuts (23%), soybeans (20%), vegetables (17%), bananas (12%), and sunflower (10%).

Tables 6 and 7 present binary regression estimates and marginal effects after Probit for the relationship between farmers' characteristics and extension target agricultural enterprise. The marginal effects estimates presented were consistent with the parameters of the Probit regression model. Results showed that farmers who were located in the Gulu district were 47% and 25% more likely to receive extension targeting maize ($p < 0.01$) and beans ($p < 0.05$), respectively than those in the Amuru district. Male headed households were 27% and 26% less likely to receive agricultural extension targeting maize ($p < 0.1$) and soybeans ($p < 0.05$) respectively, than female headed households. Also, farmers who were married³ had a 31%, 30%, and 14% higher probability of receiving an extension targeting maize ($p < 0.05$), beans ($p < 0.05$), and soybeans ($p < 0.1$), respectively than their unmarried counterparts. With respect to education, a percentage increase in the number of years spent on formal schooling would reduce the probability of receiving extension services targeting groundnuts ($p < 0.1$) by 7%. Also, a percentage increase in

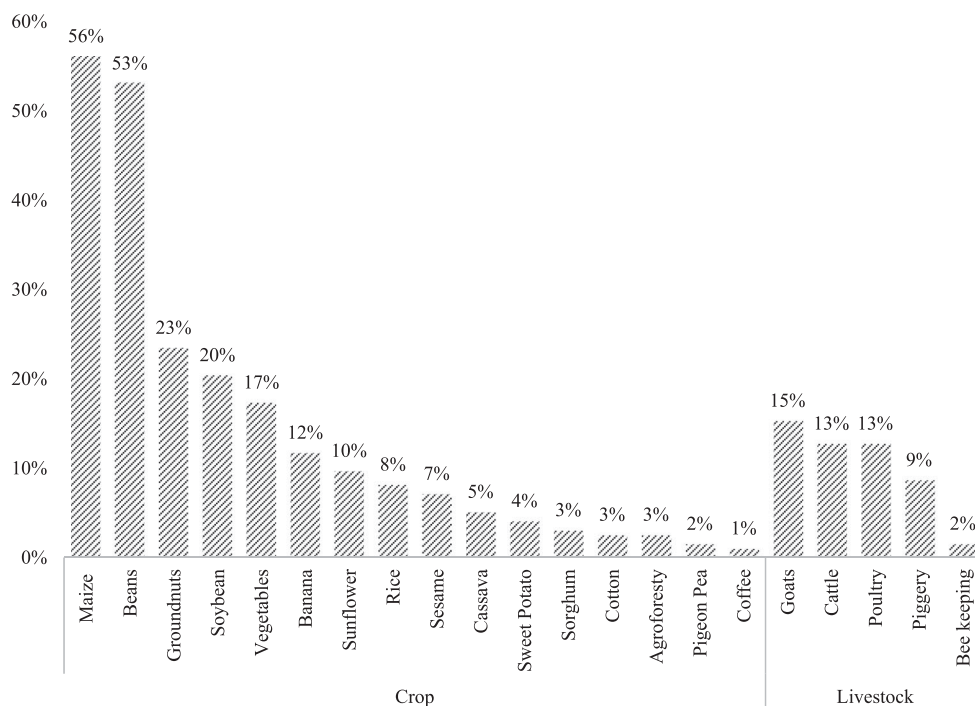


Figure 2. Target agricultural enterprises for agricultural extension.

Table 6. Probit model results for the influence of farmers' characteristics on agricultural extension target enterprises.

Variable	Groundnuts		Maize		Beans		Soybean		Cattle	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
District (1 = Gulu, 0 = Amuru)	0.113	0.323	1.319***	0.331	0.653**	0.285	–	–	–0.269	0.379
Male Headed	–0.074	0.341	–0.721*	0.398	–0.329	0.395	–0.888**	0.402	0.186	0.473
Married	0.275	0.300	0.806**	0.364	0.763**	0.366	0.658*	0.392	–0.608	0.455
Log Education	–0.263*	0.147	–0.024	0.139	–0.016	0.135	–0.039	0.167	–0.230	0.175
Log farming Experience	0.105	0.165	–0.207	0.158	0.055	0.145	–0.380**	0.163	–0.145	0.176
Log Land owned	0.267*	0.155	0.291**	0.139	0.273**	0.131	0.325**	0.135	0.189	0.154
Access to credit	0.035	0.222	0.043	0.215	0.487**	0.202	0.501*	0.264	0.409	0.289
Group membership	0.304	0.658	–0.060	0.496	0.147	0.455	0.546	0.514	–1.144**	0.517
Dependency ratio	–0.059	0.482	0.186	0.479	0.625	0.480	–0.181	0.563	1.044	0.743
Ownership of mobile phone	0.717***	0.251	–0.178	0.220	–0.011	0.219	0.034	0.257	0.693***	0.261
Number of information sources	0.255**	0.110	0.204**	0.097	–0.047	0.094	0.358***	0.120	0.328**	0.146
Constant	–2.782***	0.923	–1.395*	0.765	–1.993***	0.723	–1.967**	0.822	–1.298	0.948
N	196		196		196		196		196	
Log Likelihood	–93.138		–110.751		–120.226		–81.817		–61.781	
Wald chi ² (11)	25.88		43.00		31.76		30.42		25.82	
Prob > chi2	0.007		0.000		0.001		0.001		0.007	

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

Table 7. Marginal effects for the influence of farmers' characteristics on agricultural extension target enterprises.

Variable	Groundnuts		Maize		Beans		Soybean		Cattle	
	Marginal Effect	SE	Marginal Effect	SE	Marginal Effect	SE	Marginal Effect	SE	Marginal Effect	SE
District (1 = Gulu, 0 = Amuru)	0.031	0.086	0.473***	0.090	0.254**	0.104	–	–	–0.047	0.075
Male Head	–0.021	0.099	–0.268**	0.135	–0.129	0.152	–0.256**	0.131	0.027	0.065
Married	0.073	0.076	0.313**	0.133	0.296**	0.133	0.137*	0.070	–0.114	0.100
Log Education	–0.074*	0.041	–0.009	0.055	–0.006	0.054	–0.009	0.040	–0.036	0.029
Log farming Experience	0.030	0.047	–0.082	0.062	0.022	0.058	–0.092**	0.039	–0.023	0.028
Log Land owned	0.075*	0.044	0.115**	0.055	0.109**	0.052	0.078**	0.034	0.030	0.025
Access to credit	0.010	0.062	0.017	0.085	0.192**	0.078	0.113**	0.054	0.060	0.041
Group membership	0.076	0.142	–0.024	0.194	0.058	0.181	0.101	0.071	–0.310*	0.187
Dependency ratio	–0.017	0.136	0.073	0.189	0.249	0.191	–0.044	0.136	0.163	0.108
Ownership of mobile phone	0.204***	0.071	–0.070	0.087	–0.004	0.087	0.008	0.062	0.113**	0.047
Number of information sources	0.072**	0.031	0.080**	0.038	–0.019	0.037	0.086***	0.028	0.051**	0.021

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

farming experience would reduce the probability of receiving extension services targeting soybeans ($p < 0.05$) by 9%.

Similarly, a percentage increase in land owned by a farmer would increase the probability of receiving extension services targeting groundnuts ($p < 0.1$), maize ($p < 0.05$), beans ($p < 0.05$), and soybeans ($p < 0.05$) by 8%, 12%, 11%, and 8%, respectively. Farmers who had access to credit were 19% more likely to access extension services targeting beans ($p < 0.05$) and 11% more likely to receive extension services targeting soybeans ($p < 0.1$). However, farmers who were members of a farmers' group were 31% less likely to receive extension services targeting cattle ($p < 0.05$), while farmers who owned mobile phones were 20% more likely to receive extensions targeting groundnuts ($p < 0.01$), and, 11% more likely to receive extension targeting cattle ($p < 0.01$). Similarly, if a farmer received agricultural and market information from an additional source, it was likely to increase their probability of receiving extension targeting groundnuts ($p < 0.05$), maize ($p < 0.05$), soybeans ($p < 0.01$), and cattle ($p < 0.05$) by 7%, 8%, 9%, and 5%, respectively.

Discussions

Access to agricultural extension is an important aspect of agricultural development (Norton, Alwang, and Masters 2014). It has been credited for increased technology adoption, improved household income and livelihood (Benin et al. 2011; Emmanuel et al. 2016; Danso-Abbeam, Ehiakpor, and Aidoo 2018; Anang, Bäckman, and Sipiläinen 2020; Maguire-Rajpaul, Khatun, and Hiron 2020). This study showed that over 57% of the farmers had access to agricultural extension from four different providers, targeting several crops and livestock enterprises. The study assessed the determinants of farmers' access to agricultural extension, the relationship between farmers' characteristics and the provider (source) of agricultural extension, and the influence of farmers' characteristics on the target agricultural extension enterprise. Access to agricultural extension was influenced by several factors.

Access to agricultural extension greatly varies across localities. In this study, results show that access to agricultural extension varied across localities and target enterprises. Similar finding was reported by Emmanuel et al. (2016); and Anang, Bäckman, and Sipiläinen (2020) for studies conducted in Ghana. In the provision of agricultural extension, most practitioners usually prioritize different locations based on farmers' needs which are expected to vary across different geographic locations. Similarly, priority agricultural enterprises also tend to vary across geographic locations due to differences in development goals being pursued and differences in production resources. Whereas, farmers' agricultural production needs can generally be categorized into either food or income, the specific crop and livestock enterprises undertaken also vary across different agro-ecologies. For instance, Uganda has 10 main agro-ecological zones, each with specific crops that have a competitive advantage as opposed to other zones (MAAIF 2018). Agricultural extension priorities can thus be set based on the agro-ecological potential of the enterprise, the farmers' farming goal of either improving food production or income or both, and the level of knowledge and skills that the farmers have in the production and marketing of specific agro-enterprises. Access to agricultural extension across different geographic locations is thus influenced by different factors (Foti et al. 2007; Arias,

Leguía, and Sy 2013). This explains why farmers in the Gulu district were more likely to receive an extension, targeting maize and beans crop enterprises.

The gender of the household head influences access to agricultural extension (FAO 2011; Lamontagne-Godwin et al. 2018). In this study, the gender of the household head had a significant influence on receiving an extension from farmers' organizations and research institutions and receiving extensions targeting maize and soybeans. In all these cases, female headed households were more likely to receive extension services. Anang, Bäckman, and Sipiläinen (2020) also reported that female farmers were more likely to access extension services than males. Other studies, however, reported otherwise. For instance, Emmanuel et al. (2016) reported that male headed households had better access to agricultural extension. Umeta, Lemecha, and Mume (2011) also reported that female headed households' participation in extension programs was low. Although women constitute a significant percentage of the agricultural workforce (FAO 2011; Palacios-Lopez, Christiaensen, and Kilic 2017; Doss et al. 2018), several factors are responsible for gendered differences in access to agricultural extension. For instance, Williams and Taron (2020) reported that extension approaches that target specific crops improved women's access to agricultural services. There is, however, no difference in the quality of extension services provided to men and women farmers (Lamontagne-Godwin et al. 2017). With the gender productivity gap costing the country 0.9% of the total Gross Domestic Product (GDP) and 3.6% of the agricultural GDP (UN Women; UNDP; UNEP; World Bank 2015), increased access to agricultural extension for women farmers is seen as one of the options to closing this gap. These findings could be attributed to differences in knowledge levels of male and female farmers as a result of historical bias of focusing agricultural extension on male farmers as household heads. According to Acevedo-Siaca and Goldsmith (2020) female farmers have been observed to lag behind in a number of aspects including access to agricultural extension services. Addressing these lags and information asymmetries within farming households requires empowering women as a pre-condition (Lecoutere, Spielman, and Van Campenhout 2019). This would suggest that such (female) farmers would prefer extension services targeting the crops for which they lack knowledge and skills as opposed to male farmers who may already be knowledgeable in the production of such crops. This has resulted in some extension service providers purposively targeting women farmers in their programs (Davis and Alex 2020). Whereas our finding provides evidence of women accessing agricultural extension from farmer organizations and research institutions, how they use the knowledge and skills obtained from the extension will depend on their access to and control of productive resources. Male farmers have been shown to have better access to and control of productive resources (Akite et al. 2018; Kariuki et al. 2022).

Results also show that, although marital status was not an important factor with respect to access to agricultural extension, it significantly influenced receiving an extension from NGOs and farmer organizations and extension services targeting maize, beans, and soybeans. Wossen et al. (2017) also reported significant differences in access to agricultural extension between married and un-married household heads. Marital status improves on the utilization of agricultural extension messages, especially when the household has to decide on participation in an extension program amidst competing household tasks. In such cases, it is usually the male farmers as household heads who

prefer to attend extension training. The female spouses, on the other hand, would first require the consent of their male partners before attending extension training in cases where the extension training is gender targeting. Consequently, in agricultural extension initiatives that target a specific (women) gender, the marital status of the farmer has been seen as a hindrance or an enhancer of access to agricultural extension and credit, especially when their male spouses are willing (or unwilling) to grant consent for participation in such initiatives (Fletschner and Mesbah 2011; Ankrah, Freeman, and Afful 2020). Generally, the interaction between married couples is an important source of agricultural information that can improve access to agricultural extension services (Lecoutere, Spielman, and Van Campenhout 2019).

Farmers' level of education is important in a number of aspects. In this study, results show that farmers with low levels of education were more likely to receive extensions targeting groundnuts. Farmers' level of education also had a positive effect on access to extension in studies conducted in rural Nigeria (Wossen et al. 2017), Ghana (Emmanuel et al. 2016), and Haiti (Arias, Leguía, and Sy 2013). However, Anang, Bäckman, and Sipiläinen (2020) reported that farmers' level of education had a negative influence on access to the extension. This finding reveals differences in crop choices by farmers of different levels of education. Studies by Amare, Mavrotas, and Edeh (2018) and Luh, Chang, and Ho (2022) observed that farmers' level of education influences crop choices. Specifically, Amare, Mavrotas, and Edeh (2018) showed that more educated farmers were more likely to choose cash crops as opposed to purely food crops. These farmers would therefore prefer receiving extension services targeting these cash crops. Consequently, less educated farmers would prefer non-cash crops where only the surplus is marketed. With less than 50% of the groundnut usually marketed (Mango et al. 2018; Tabe-Ojong et al. 2022), groundnut would thus be a preferred crop for the less educated farmers who are mostly focusing on producing food crops. For such farmers, commodity specific extension services become critical to improving their products to meet the household food requirements as well as provide some surplus to sell.

This study also shows the importance of farming experience with respect to access to agricultural extension. Generally, more experienced farmers were more likely to have access to agricultural extension. They were also more likely to receive an extension from research institutions, but less likely to receive an extension from NGOs. Additionally, farmers with more years of farming experience were less likely to receive extensions targeting soybeans. Similar results were reported by Olorunfemi, Olorunfemi, and Oladele (2020), and Danso-Abbeam, Ehiakpor, and Aidoo (2018). Farming experience has also been shown to have a significant influence on soybean production. According to Ali and Awade (2019), more experienced credit constrained farmers had significantly higher levels of productivity in Ghana. Farmers who have spent relatively longer-time farming certain crops understand the challenges associated with the production of such crops and would more likely be willing to seek extension services wherever it is provided. Certain agricultural extension programs also target more experienced farmers such as in the case of model farmers used for most governments programs (Franzel et al. 2011; Hailemichael and Haug 2020). Research institutions are also involved in agricultural extension, through demonstrations and the introduction of new technologies. In the case of technology trials, research institutions usually select more experienced farmers to participate, while, the less experienced farmers are expected to see from the

more experienced ones. The influence of experience on target agricultural enterprise is largely due to changes in technology with respect to a given enterprise. Usually, for the same enterprise and same technology, the extension message would remain the same such that if a farmer receives it, he/she will only require another extension advice targeting the same enterprise in the presence of new technology. This finding on the significance of farming experience on access to extension from research institutions points to the relevance of the lead-farmer or model farmer approach to technology dissemination. According to Rust et al. (2022), farmers have been shown to place more trust on fellow farmers than on agricultural experts when learning about certain practices. Research institutions aware of this would thus target farmers who can make it easier for their newly generated technologies to be disseminated through the farmer-to-farmer approach, which has been shown to have benefits both social and economic benefits (Kiptot et al. 2016).

Land is an important factor in agricultural production. In this study, farmers with more land were more likely to receive extensions targeting all the crop enterprises analyzed. This finding is similar to those reported in earlier studies (Foti et al. 2007; Arias, Leguía, and Sy 2013; Abdallah and Abdul-Rahaman 2016; Emmanuel et al. 2016; Danso-Abbeam, Ehiakpor, and Aidoo 2018; Anang, Bäckman, and Sipiläinen 2020). More land allows farmers to try new varieties of different crops and new technologies associated with the current and potential varieties (Anang, Bäckman, and Sipiläinen 2020). Such farmers are thus more likely to have access to agricultural extension for such crop enterprises.

Farmers who had access to credit were more likely to receive an extension from NGOs and Farmers' Organizations. Similarly, these farmers were more likely to receive extensions targeting beans and soybeans enterprises. This finding is consistent with those of previous studies (Emmanuel et al. 2016; Wossen et al. 2017; Danso-Abbeam, Ehiakpor, and Aidoo 2018). According to Chandio et al. (2020) access to agricultural extension increases the demand for agricultural credit. Similarly, Moahid and Maharjan (2020) observed that farmers' access to agricultural extension was positively associated with participation in formal credit markets. A number of extension service providers may incorporate credit provision as part of the extension message or they may provide linkages between farmers and credit institutions as a way of encouraging the uptake of agricultural technologies. Similarly, uptake of new technology received through agricultural extension may require farmers to invest some capital resources. In cases where farmers do not have the resources to be invested, access to credit becomes important. This could partly explain why access to agricultural credit has a significant influence on receiving extensions targeting beans and soybeans. This finding implies could be attributed to the market orientation and level of commercialization of a farmer for a given agricultural enterprise. A farmer who has access to credit is usually more commercialized (Mariyono 2019a; Sekyi, Abu, and Nkegbe 2020) and has a generally better market orientation (Mariyono 2019b). Thus, farmers growing a given crop with commercial intent, are more likely to access credit for such crops. In the study areas, soybean is usually promoted as a cash crop. Consequently, the majority of farmers usually grow soybeans as income crops, while, groundnuts and maize are cultivated with the goal of providing both food and income. Such farmers would find it easier to borrow for soybean

production, than, for maize or groundnut production. In such cases, access to credit would most likely improve their access to the extension.

In this study, farmers who were members of a farmers' group were more likely to have access to agricultural extension. This finding is supported by those previous studies that reported a positive relationship between access to agricultural extension and group membership (Abdallah and Abdul-Rahaman 2016; Danso-Abbeam, Ehiakpor, and Aidoo 2018; Anang, Bäckman, and Sipiläinen 2020). In order to reach many farmers within a short time-frame, extension workers usually reach farmers in groups. Group membership is an important attribute to farmers with respect to agricultural extension. Results also showed that farmers who were members of a farmers group were less likely to receive an extension from government extension service agents. According to Kiptot et al. (2016), government extension services are usually ill-equipped to provide robust extension coverage. The current ratio of extension staff to farmers for Uganda is at 1:1800, against an ideal target of 1:500 (Nkonya et al. 2020). With these inadequacies in mind, farmers who have come together as a group find it prudent to look for alternatives that would help bridge the gap in government extension services. Similarly, different providers of agricultural extension have different approaches to extension service provision. With the model farmer approach (Franzel et al. 2011), group membership ceases to be an important factor for a farmer to have access to agricultural extension. Similarly, agricultural extension provided to a group of farmers may not be possible for certain agricultural enterprises. In this study, farmers who were members of a farmers' group were less likely to receive agricultural extensions targeting cattle. This is due to the practicality associated with providing extension advice for certain agricultural enterprises. It is for instance possible to have a demonstration plot for maize to train farmers on maize production, however, it may not be possible to have the same in the case of cattle. Extension workers faced with such challenges would therefore target individual farmers undertaking such enterprises.

Results also show that farmers who were using agro-pesticides were more likely to have access to agricultural extension. Application of agro-pesticides requires farmers' to be knowledgeable on a number of issues including the dosage of pesticides with respect to different pests, the application procedure, and safe use and disposal of the pesticide. Farmers would therefore be willing to access extension services with respect to such services.

The number of crop and livestock enterprises on the farm is also important for agricultural extension. In this study, farmers with few crop enterprises were more likely to have access to agricultural extension. When farmers have few crop enterprises on the farm, they become more specialized. Specialization is a characteristic of commercializing farmers, which is associated with increased demand for agricultural extension. According to Foti et al. (2007), an increase in the level of commercialization on the farm is associated with increased demand for agricultural extension services.

Ownership of mobile phones is important in improving communication between the farmers and other relevant stakeholders. In this study, farmers who owned mobile phones were more likely to receive extensions targeting groundnuts and cattle. According to Coggins et al. (2022), the success of digital technologies in the provision of agricultural extension largely depends on how the developers are able to design systems that can overcome the constraints that have limited the use of such tools. These

constraints include poor connectivity and accessibility issues common in most rural areas where farmers are located, the cost of the services, and high levels of illiteracy. Such constraints can best be addressed by adopting using centered designs (Ortiz-Crespo et al. 2021). This study has also shown the importance of agricultural and market information for improving access to the extension. Farmers who receive agricultural and market information are more likely to have better access to agricultural extension for several agricultural enterprises on the farm. According to Wossen et al. (2017), farmers who had mobile phone coverage were more likely to have access to agricultural extension. A mobile phone allows farmers to communicate directly to extension agents in case of need such as a disease outbreak in cattle. It thus improves access to agricultural extension for agricultural enterprises where farmers require direct communication with the extension agent for the challenge to be addressed. Additionally, farmers are usually informed of upcoming extension contacts using digital extension tools including mobile phones and radio (Coggin et al. 2022). Receiving agricultural and market information from several sources thereby increases farmers' chances of being aware of and participating in upcoming extension visits communicated through these media.

Conclusions and recommendations

This study assessed factors associated with the provision of agricultural extension services with a focus on accessing extension services, providers of agricultural extension services, and target crop and livestock enterprises for agricultural extension service provision. Results provide insights into factors associated with the provision of agricultural extension services. Several factors have differential effects on the different aspects of agricultural extension service provision. In order to improve the pluralistic nature of agricultural extension, the focus should be on harnessing the benefits of the factors that improve extension provision. This may include improving access to credit, provision of agricultural and market information to multiple-sources, and encouraging smallholder commercialization which comes with enhanced demand for agricultural extension.

This study has two main relevance. First, is the theoretical relevance of this study. The current study extends the literature on smallholder farmers' access to agricultural extension services in developing country context. It demonstrates that there are practical differences in factors associated with farmers' choice of agricultural extension service provider and agricultural extension target agricultural enterprise at the smallholder farm level. Second, is the practical relevance of the current study. Key practical policy relevance of this study is the need to have extension systems that harness farmers' innovation aimed at addressing the challenges faced by farmers in increasing their productivity. This study provides advocates for differentiated targeting of agricultural extension services. Consequently, for better effectiveness of agricultural extension, it would be practical for some providers of extension to target a certain type of farmers which they can best serve. In addition, the extension should also focus on the specific crops of interest to a given group of farmers with similar characteristics. Thus, differentiated targeting has to take into consideration the different factors associated with the choice of extension service providers and/or extension target commodity. For instance, the current study provides evidence that less educated farmers would prefer extension

services targeting dual-purpose crops such as groundnuts as opposed to cash crops such as soybeans.

The findings of this study are also relevant in the context of the current discourse on demand-driven agricultural extension services. By providing insights into context specific farmer characteristics with respect to access extension services, designers of demand driven approaches can use this information to propose ways of creating demand for specific agricultural extension approaches. The findings of this study are also relevant in understanding the synergies created by the different extension services providers working together following a pluralistic approach such as Uganda's single spine extension systems. It is possible that extension services can use the findings of this study to target the specific farmers who would best benefit from their interventions as opposed to targeting any farmer they come across in their areas of jurisdiction.

Study limitations

It is important to note that the extent of application of this study's findings is only limited to situations where the providers are considered individually. In some cases, however, extension services providers collaborate and partner with each other, providing extension services jointly to farmers on a range of aspects. Whereas our study provides evidence on female farmers' access to agricultural extension, it did not look at whether the female farmers put into practice the extension messages they receive. This aspect can best be addressed by another study, designed specifically for the same.

Notes

1. As part of the training curricula for students of bachelor of agriculture, the faculty of agriculture and Environment has been implementing the student field attachment where second year students of the then Bachelor of Agriculture (now renamed to Bachelor of Science in Agriculture after a revision) are attached to smallholder farmers so that they work with such farmers with technical backstopping from academic staff (Kalule et al. 2019). This program has been in place since inception of the faculty in 2005. The attachment period from 2005 to 2015 has been up a year. Every year, a new cohort of students are attached to the different smallholder farmers for the required period.
2. We consider farmer organization without disaggregating the gender composition of the organizations. The assessment of the gender composition of the farmer groups was outside the scope of the study as it would have required a different approach altogether.
3. The married farmers were mostly males (91% of all males, as opposed to 21% of all females). Most of the females in the study were widowed (58% of all females).

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