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Analyzing Intensity of Adoption of Improved Soybean under Smallholder Farmers in Gumuz Regional State

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ABSTRACT

The importance of agricultural technology in enhancing the welfares of farmers can be realized when yield gain from the technologies results in meaningful income gain. This article aimed at analyzing adoption and intensity of adoption of improved soybean variety among farm households in Bambasi District. In this study a multi-stage stratified sampling technique was employed to select rural peasant Associations and households. Three rural peasant Associations were selected randomly. Structured interview schedule was developed, pre-tested and used for collecting the essential quantitative data for the study from 134 randomly selected households. Descriptive statistics and double hurdle model were employed to analyze data. Results of descriptive analysis showed that there were statistically significant differences between adopter and non-adopter households with distance to market, livestock ownership, and frequency of extension visit, farm income as well as number of oxen owned. Consistent with the findings of previous studies, regression results showed that improved soybean adoption decision of farm households has been determined by sex of household head, distance to the nearest market, being member of cooperatives, number of oxen, participation in training and demonstration and intensity of improved soybean adoption is determined by livestock holding, frequency of extension visit, farm income and asset ownership in improved soybean production. Promoting farmers to form or join cooperatives. Strengthening demonstration centers and Farmers Training Centers (FTC) should be done. Transaction costs should be reduced and scaling up and diffusion of improved soybean varieties in the study area should be broadened.

Key words*:* *Adoption; Bambasi; Double hurdle; Soybean*

1. INTRODUCTION

In Ethiopia, agriculture takes the lion's share (72.7%) in terms of employment. The sector is the livelihood of the 75.26 million (79.77%) of the population. It is the source of food and cash for those who are engaged in the sector and others. Most agricultural holders acquire the food they consume and the cash they need to cover other expenses only from farming activities. Since farming in Ethiopia is often precarious and usually at the mercy of nature, it is invariably an arduous struggle for the holders to make ends meet (UNDP, 2014).

Soybean is among the cash crops which have been given priority in the national effort of meeting increased income and nutritional security of households. To this effect number of improved soybean varieties have been developed by the national research system and disseminated among smallholder farmers. Benishangul Gumuz region is one of the beneficiary regions of the country since 2006. The region has 156,000 ha of land that is suitable for soybean production. However, the contribution of the already disseminated varieties has not been well understood among the beneficiary farmers for informed decision making and to justify further expansion of soybean production zone in the region.

1.1. Statement of the Problem

Though traditional agriculture prevails in developing countries in general and in Ethiopia in particular, some progress has been made in using improved agricultural technologies and inputs. High yielding soybean varieties are among important technologies promoted by the country's agricultural research and extension system.

A good technology has to guarantee sustainable productivity across niche agro ecologies and over a period of time. The possible outcomes of a research undertaking are commonly conceptualized in terms of yield increases or reducing yield losses. However, such yield increases often require additional inputs, which lower the effective value of yield gains. Farmers particularly resource poor ones, will only adopt technologies if net yield gains are significantly greater than zero. (Mills, 1997 cited by Mengistu, 2003).It is then very important to know whether additional yields or returns obtained as a result of using an improved technology are sufficient enough to qualify technology for wide scale dissemination. In this respect, technical changes brought about research have to be evaluated for the benefit that the farmers get from them.

The adoption of improved technologies that enhance agricultural productivity and improve annual income of smallholder farmers in Benishangul Gumuz Region is instrumental for achieving better economic growth of the farmers. Dissemination of improved soybean variety known as *Bellesa-95* was started in 2006 with few early adopters in the region especially in Bambasi *District* in order to increase crop productivity and incomes for small scale farm household. However, its adoption level and impact of improved soybean variety on farm income were not known and no effort had been made to evaluate the program and its activities hence creating an information gap that needed to be filed. In spite of the government‘s efforts to address the issue of low productivity, the adoption of improved soybean varieties still remains difficult to be practiced by the farmers. Therefore, this study was intended to assess the adoption and impact of improved soybean *(Bellesa-95)* on household income.

1.2. Objectives of the study

The general objective of the study is to analyze adoption and Intensity of improved soybean (*bellessa-95*) variety among farm households.

Specific objectives include

1. To analyze factors that affect adoption of improved soybean variety in the study area.
2. To analyze intensity of adoption of improved soybean variety.

2. RESEARCH METHODOLOGY

2.1. Description of the Study Area

Assosa zone is located 664 km southwest of Addis Ababa. Based on CSA (2013), this Zone has a total population of 310,822, of whom 158,932 are men and 151,890 women. When we see number of urban inhabitants it is 39,957 or 12.86% of the population in the *District*. A total of 72,879 households were counted in this Zone.

According to CSA (2015) total population for this *District* is 71,279 out of this 37543 (52.65%) are male and 33,736 (47.34%) are female. The altitude of the area ranges from 1300-1470 m.a.s.l. The temperature of the area ranges from 21-35^{o}C. The rainfall of the area has unimodal pattern extending from May to October with and annual mean of 1350 to 1450 mm.

In the *District* the common crops grown are maize, sorghum *Teff*, chickpea and groundnut. The study area is also suitable for oil crops like soybean and noug. In addition to this, perennial crops such as mango and avocado are common in the *District.*

2.2. Sampling Technique and sample size

A clear and precise identification and definition of the population of the study is an important prerequisite for research sample design. In this study, a three stage sampling procedure was adopted to collect the required primary data. In the first stage, among the seven districts in Assosa Zone, Bambasi *District* was selected purposively since scaling-up of improved soybean variety (*Bellesa-95*) was implemented in the district. In the second stage among 26 *peasant* in the *District* three of them (Dabus, Amba-16 and mender-46) were randomly selected. Finally, stratified random sampling method was employed to identify sample households for inclusion in the study. To this effect, list of adopter households was obtained from district agricultural office and from development agents at each sample *peasant* and then households in the area were categorized into 2 strata, that is483adopterof improved soybean households, and 612 non-adopter households. The total sample was determined using Cochran (1977) stratified sampling procedure considering resource limitation of the study for the District. The sample size thus obtained was assigned to each peasant Associations based on probability proportional to size of the households. 134 sample respondents, 67 sample households from each category were drawn randomly based on probability proportional to sample size (PPS). These both groups were chosen based on their close similarity in their socio-economic characteristics.

$$n = \frac{z^2pq}{e^2} \qquad (1)$$

Where, n_0 is the sample size, Z is the selected critical value of desired confidence level (1.96), pis the estimated proportion of an attribute that is present in the population. q =1-p and e is the desired level of precision which is 0.08.

2.3. Type and Methods of Data Collection

Primary and secondary data were collected through semi-structured schedule and checklists respectively. Trained enumerators were used to collect the data. Primary data was collected from sample households and secondary data sources were *District* administration and some published documents.

The type of primary data collected include households' demographic characteristics, asset endowments, access to market, access to credit, membership in different rural institutions, and income sources. Interviews were conducted with district level agricultural experts on production and productivity of improved soybean to generate supplementary (qualitative) data.

In addition, Focus Group Discussions (FGD) was conducted with groups of selected farmers from each sample peasant Associations to support interpretation of results obtained from field survey on changes in adoption of improved soybean technologies and their impact on household income.

2.4. Method of Data Analysis

2.4.1. Descriptive and inferential statistics

Descriptive statistics such as mean, standard deviation, percentages, frequency, charts, and graphs, used to describe different categories of sample units with respect to the desired socioeconomic characteristics. Moreover, inferential statistics such as chi-square test (for categorical variables) and t-test (for continuous variables) were used to compare and contrast different categories of sample units with respect to the desired characters so as to draw some important conclusions.

2.4.2. Econometric analysis

2.4.2.1. The double-hurdle model

This model assumes farmers faced with two hurdles in any agricultural decision making processes (Cragg, 1997; Sanchez, 2005 and Humphreys, 2010). Accordingly, the decision to participate in an activity is made first and then the decision regarding the level of participation in the activity follows. In this study, thus, double-hurdle model was chosen because it allows for the distinction between the determinants of adoption and the level of adoption in soybean production through two separate stages. This model estimation procedure involves running a probit regression to identify factors affecting the decision to participate in the activity using all sample population in the first stage, and a truncated regression model on the participating households to analyze the factors that affect the extent of adoption, in the second stage. In the study it was applied the first stage of double hurdle model to examine the factors determining the decision to adopt improved soybean and it is analyzed by a means of the probit.

According to Burke (2009), double hurdle model is useful because it allows a subset of the data to pile-up at some value without causing bias in estimating the determinants of the continuous dependent variable in the second stage, hence it can obtained all the data in the remaining sample for the participants (Burke, 2009). Thus, in double hurdle model, there are no restrictions regarding the elements of explanatory variables in each decision stages. That means it is possible to separately analyze the determinants of adoption of improved soybean decision and the determinants of the level of adoption decisions. Due to this separablity, the estimates of adoption decisions can be obtained by a means of probit regression and that of the level of adoption decision can be analyzed by use of a truncated regression. According to Burke (2009), the separablity in estimation may not be mistaken for separability in estimation is possible.

The double hurdle (D-H) model is a parametric generalization of the Tobit model, in which two separate stochastic processes determine the adoption decision and the amount of produced technology. The first equation in the D-H model relates to the decision to adopt improved soybean varieties. (y) Can be expressed as follows:

$Y_i = 1\ if\ Y_i^* > 0$ and $0\ if Y_i^* \leq 0$ (2)

$Y_i^* = X_i^{'} \alpha + \varepsilon_i$ (Adoption Equation)

Where: Y_i^* is latent adoption of improved soybean that takes the value of 1 if a household adopt improved soybean variety and 0 otherwise, x is a vector of household characteristics and α is a vector of parameters. Equation (2) is a probit model that examines the probability that the i^{th}

farmer would make adoption decision to adopt improved soybean varieties.

The second hurdle, which closely resembles the Tobit model, is expressed as:

$t_i = t_i^* > 0 \; and \; if \; Y_i^* > 0$

t_i= 0 Otherwise

$t_i^* = Z_i\beta + U_i$ (Produced amount of improved soybean equation)

Where: t_i is the observed response on how much quantal of soybean produced, Z is a vector of the household characteristics and β is a vector of parameters (Mignouna, *et al*. (2011) $\varepsilon_i \; and \; U_i$ are error terms.

$\varepsilon_i \sim N(0,1) \; and \; U_i \sim N(0,\sigma^2)$

Following (Cragg 1971) model, the study assumes independence between the two error terms. The log likelihood function for the D-H model is as:

$$LnL_{dh} = \sum_{+} \phi \, ln\left[(Z_i^{'}\beta)\frac{1}{\sigma}\phi\left(\frac{y_{i-}x_i^{'}\beta}{\sigma}\right)\right] + \sum_0 ln[1 - \phi[X_i^{'}]\phi(x_i^*\alpha)]\,\phi\left[\frac{Z_i^{'}\beta}{\sigma}\right] \qquad (3)$$

Where $\phi \; and \; \phi$ are the standard normal cumulative distribution function and density function, respectivelyWhen either the assumption of normality or homoscedasticity is violated, maximum likelihood estimation produces inconsistent parameter estimates (Carroll*et al* 2005).

The double hurdle model of equation (2) (i.e, the first hurdle) is a probit model that examines the probability that the ith farmer would make a decision to adopt improved soybean varieties. Equation (3) (i.e, the second hurdle) is a truncated regression model that examines the amount of produced improved soybean varieties (Bhunbaneswar, *et.al* 2008).

Therefore, the log-likelihood of the D-H model is the sum of the log-likelihood from a probit model and the truncated regression model (Adam, *et al.* 2012).

Whether a Tobit or a double hurdle model is more appropriate can be determined by separately running the Tobit and the double hurdle models and then conducting a likelihood ratio test that compares the Tobit with the sum of the log likelihood functions of the probit and truncated regression models (Greene, 1993 cited in (Berhanu and Swinton 2003)

$$LR = -2\left[LogL_T - \left(LogL_p + LogL_{TR}\right)\right] \sim X_K^2 \qquad (4)$$

Where $LogL_T$ = log-likelihood for the Tobit model, $LogL_p$ = log-likelihood for the Probit model, $LogL_{TR}$= log-likelihood for the truncated model and k is the number of independent variables in the equations.

3. RESULTS AND DISCUSSION

This chapter mainly presents the findings of the study with an appropriate level of discussion. It is divided in to two sub-headings that could give a brief account of the subjects that were being investigated by the study. The first sub-heading presents descriptive analysis of sample households. The second sub-heading is econometric model for adoption and intensity of adoption of improved soybean variety by sample households.

Descriptive Analysis

In this section of analyses descriptive statistics such as mean, standard deviation, percentage, t-test and chi-square test were employed using STATA 13 software programs. In this study, adopters of a technology refer to farmers who used improved soybean varieties by allocating proportion of their land and those farmers who experienced growing of local variety considered as non-adopters.

4.1.1. Adoption status and major constraints in soybean production

In the area, the average improved soybean farm size of sample grower households was 2.91ha, and the maximum farm size was 12 ha and the minimum was 0.8 ha. The average quintal obtained was 6.47quintal and the maximum was 85 quintal while the minimum was 0.75 quintal. The average gross income from improved soybean production of the sample adopter households from one season harvest during 2014/2015 production year was 3897.46*birr*.

From the sample of the population 50% are non-adopters and 50% of them are adopters. Improvement in production and productivity of a given crop depends, among other things, on presence and use of better and improved varieties.

The landholding of the sample households ranges from 0.8 ha to 12.5 ha with an average figure of 1.51hectares. The average livestock (including cattle, sheep, goats, pack animals, and poultry) was 3.45 TLU with the minimum and the maximum holdings of 0 TLU and 38.22 TLU respectively. The average labor force available was 6 man equivalents. Households generated cash income by selling crops (such as soybean, sorghum, maize, chickpea and noug) about 54% could do also from off-farm activities. About 72% had access to institutional credit to purchase farm inputs. The average distance from the nearest market place was 3.46km with the minimum and maximum figures equal to 0.2 km and 8 km, respectively.

4.1.2. Descriptive statistics for socioeconomic variables in the study

A combination of different descriptive, the means and standard deviation and inferential, the t-test and X^2-test, statistics for explanatory variables of sample households were performed on the household level data to inform the subsequent empirical data analysis.

The descriptive and inferential results presented on Table 3 show that there was statistically significant difference between adopters and non-adopters in terms of distance to market, TLU, frequency of extension visit, farm income and oxen ownership in favor of the adopters.

Table 1.Descriptive statistics of continuous independent variables

Variables	Mean across adoption categories		t-test	P Value
	Adopter	Non-adopter		
Distance to market	2.91	4.00	3.66***	0.0001
Age of household head	46.71	47.597	0.37	0.7087
Livestock holding(TLU)	4.22	2.52	2.50 **	0.0134
Family size	6.447	5.83	-.26	0.2096
Frequency of Visit	21.94	15.32	1.74 *	0.0825
Distance to main road	1.05	1.12	0.36	0.7131
Farm income	8.99	8.28	3.97***	0.0001
Farm experience	27.84	28.74	0.43	0.6689
Oxen ownership	1.16	0.5970	2.46 **	0.0148

Source: own survey, ***, **, and * indicates that at 1%, 5% & 10 significance level respectively

The descriptive and inferential statistics results presented in Table 4 show that 94.05% of adopters were male headed households. Regarding to participation in training 97.61% of adopters were participants of training and 84.52% of them were members of cooperatives. On the other hand, 94.03% of adopters and 76.22% of non-adopters participated in demonstration in 2014/2015 cropping season.

Table 2.Descriptive statistics of Dummy/ discrete Independent Variables

	Percentage of adoption category			
Variables	Adopter	Non-adopter	χ2 value	p-value
Sex of household head			4.97**	0.026
-Male	94.05	79.10		
-Female	4.95	20.90		
Participation in training			35.47***	0.000
-Yes	97.61	53.73		
-No	2.39	46.27		
Cooperative membership			10.45***	0.001
-Yes	84.52	58.21		
-No	15.48	41.79		
Residence status			2.51	0.472
-Indigenous	31.34	35.8		

-settler	68.66	64.2		
Participation in demonstration			33.81***	0.000
Yes	94.03	76.22		
No	5.97	23.78		

Source: own survey (2016), ** and *** indicates 5% and 1% of significance probability level

4.2. Econometric Analysis

4.2.1. Determinants of adoption of improved soybean variety

Before running the double hurdle model all the hypothesized explanatory variables were checked for the existence of correlation problem. The existence of outliers was also checked by box plot. The model was statistically significant at 1% level indicating the goodness of fit of the model to estimate at least one of the explanatory variables. Based on the above test, both the hypothesized continuous and dummy/categorical variables were included into the model.

Estimates of the parameters of the variables expected to determine the adoption and intensity of adoption of improved soybean production package are displayed in Table 5. A total of eleven explanatory variables were included into the econometric model out of which six variables were found to significantly influence adoption of improved soybean production package. These are sex of household head, distance to the market, being member of cooperatives, participation in demonstration, participation in training, and ownership of oxen.

Table 3. Maximum likelihood estimates of 1st Hurdle (Probit) model

Variable	Estimated Coefficient.	Standard Error	Z	P>|z|
Sex of household head	0.3530	0.14199	2.49	0.013 **
Age of household head	-0.0132	0.01375	-0.96	0.339
Total family size	0.0152	0.02425	0.63	0.532
Farm experience	0.0185	0.01188	1.30	0.196
Distance to market	-0.0339	0.01010	-2.85	0.004***
Cooperative membership	0.3223	0.13513	2.39	0.017**
Oxen ownership	0.1499	0.07471	2.01	0.045**
Frequency of visit	0.0031	0.00320	0.97	0.333
Participation in training	0.5906	0.14982	3.94	0.000 ***
Participation in demonstration	0.4464	0.25547	1.75	0.081*
Farm income	0.1008	0.07660	1.32	0.188
_cons	-9.677368	2.91236	-3.32	0.001

Log likelihood	-47.7693
LR chi2 (21)	90.22
Prob> chi2	0.0000
Pseudo R^2	0.4857

Source: Model output, ***, ** and *represents 1%, 5% & 10% level of Significance respectively

4.2.2. Factors determining the extent of soybean adoption

This section focuses on factors determining the extent of farmers' soybean adoption, conditional on decision to adopt improved soybean. Truncated regression is used in this case, which is the second stage of the double-hurdle model, to analyze the problem. Analyzing the estimated parameters, it is possible to highlight that the coefficients of four variables are statistically significant at different significance levels.

Table 4. Maximum likelihood estimates of 2nd Hurdle (Truncated regression) model

Variables	**dy/dx**	**Std. Err.**	**z**	**P>|z|**
Sex of household head	1.2108	0.8885	1.36	0.173
Livestock holding (TLU)	0.1390	.07081	1.96	0.050**
Age of household head	-0.0096	0.0557	-0.17	0.864
Total family size	0.0352	0.1158	-0.11	0.761
Farm experience	-0.0260	0.2308	1.01	0.910
Distance to market	-0.2087	0.2280	-0.92	0.360
Cooperative membership	0.2845	0.7811	0.36	0.716
Oxen own	-0.1760	0.2629	-0.67	0.503
Frequency of visit	0.0346	0.0182	1.90	0.058*
Participation in training	0.3964	1.4013	0.28	0.777
Participation in demonstration	0.5570	1.6289	0.34	0.732
Farm income	0.8135	0.4043	2.01	0.044**
Asset ownership	1.7338	0.7221	2.40	0.016**
Constant	-19.246	7.6550	-2.51	0.012**
Number of observations		67		
Log likelihood		-133.772		
Wald chi2(20)		30.41		
Prob> chi2		0.0041		

Source: Model output. ** represents 5% and *** represents 10% level of significance

4. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1. Summary and Conclusions

Soybean is among the cash crops which have been given priority in the national effort of meeting increased income and nutritional security of households. To this effect number of improved soybean varieties have been developed by the national research system and disseminated among smallholder farmers. Benishangul Gumuz region is one of the beneficiary regions of the country since 2006. The region has 156,000 ha of land that is suitable for soybean production. However, the contribution of the already disseminated varieties has not been well understood among the beneficiary farmers for informed decision making and to justify further expansion of soybean production zone in the region.

This study was conducted in Bambasi District of Benishangul Gumuz Regional State, which is located about 620 km away from Addis Ababa. In this area, soybean is an important crop, which serves as source of cash. New technologies that include improved varieties have been introduced by agricultural research centers and other non–governmental organizations. However, adoption of improved soybean production technology package, intensity of adoption and impact of the variety was not well studied in the study area.

The objective of this study was to provide empirical evidence on adoption and intensity of adoption of improved soybean and to assess impact of improved soybean (*Bellessa-95*) variety on income of farm households. For this study, a total of 134 respondents from three peasant associations were interviewed using semi-structured interview schedule. In this study, a three-stage stratified random sampling method was adopted to collect the required primary data. Focus group discussion and key informant interview was also conducted. Secondary data on basic agricultural activities and population was also collected from different stakeholders

Descriptive statistics such as mean, standard deviation, percentages, frequency, charts, and graphs, used to describe different categories of sample units with respect to the desired socioeconomic characteristics. Moreover, inferential statistics such as chi-square test (for categorical variables) and t-test (for continuous variables) were used to compare and contrast different categories of sample units with respect to the desired characters so as to draw some important conclusions. Double hurdle and propensity score matching models were used to analyze adoption and impact of improved soybean respectively.

The descriptive and inferential results show that there was statistically significant difference between adopters and non-adopters in terms of distance to market, TLU, frequency of extension visit, farm income and oxen ownership in favor of the adopters.94.05% of adopters were male headed households. About 98% of adopters were participants of training in crop production and 84.52% of them were members of cooperatives. On the other hand, 94.03% of adopters and 76.22% of non-adopters participated in demonstration in 2014/2015 cropping season.

The double-hurdle model results showed that sex of household head, membership in cooperatives, number of oxen owned, participation in demonstration and participation in training affect adoption of improved soybean variety positively and significantly while distance to the nearest market affected adoption of improved soybean negatively and significantly. On the other hand, extent of adoption was affected by frequency of extension visit, livestock holding, and farm income and asset ownership.

The estimation of the impact of improved soybean variety on farm income showed that sex of household head, religion of household head, distance to the nearest market and cooperative membership of household head have been the major factors of group difference.

After matching for household characteristics, it was found that, on average, adoption of improved soybean variety has increased annual income of households by 1118.1 *birr*.

4.2. Recommendations

Based on the results of this research, the following core points are presented as recommendations in order to improve the application level and income gained from improved soybean.

Continuous training in improved soybean production**:** In order to increase farmer's income policy makers should devise more effective farmers' training mechanisms and provide more applicable improved soybean production mechanisms.

Promoting farmers to form or join cooperatives: Farmers should be encouraged to form cooperatives or join existing ones by government and non-governmental organizations to enhance their access to improved seeds and inputs.

Strengthening demonstration centers and Farmers Training centers (FTC): Forcing farmers to adopt any kind of agricultural technology will not bring the expected outcome rather it may aggravated their rigidity not to accept any new farming technologies. Therefore in order to improve farmers level of adoption of improved soybean as well as income extension workers and researchers should provide farmers with more practical trainings under farmers' direct participation in the demonstration centers.

Reduced transaction costs: Distance to the nearest market found to negatively influence on increased adoption of the varieties causing high transaction cost due to lack of access to seeds of the varieties. Therefore, improvement of access to improved varieties through improved communication networks and availability of the seeds within easy reach of the farmers is vital.

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