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IMPACT OF AGRICULTURAL EXTENSION ON HOUSEHOLDS INCOME DIVERSIFICATION: CASE FROM NORTHERN ETHIOPIA

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ABSTRACT

The study explores the impact of agricultural extension on households' income diversification at a micro level using data from 734 rural households (out of which 390 households are extension participants and 344 households are non-participants) in Tigray region, northern Ethiopia. It also deals with the determinants of extension participation and income diversification. The data is derived from eight tabias from three agro-ecological zones of the Geba catchment collected by MU-IUC project. Descriptive statistics with respective t-values and Heckman Selection Model are employed to the respective objectives of the study. Extension participation faces selection bias because $\rho \neq 0$, in which it was correctly handled using inverse mills ratio. Extension participation reveals positive and significant impact on income diversification with 14.9 percent. Generally, Agricultural extension program had substantial positive impact on households' income level and income diversification.
Keywords: Agricultural extension, income diversification, Heckman Selection Model, Northern Ethiopia

1. INTRODUCTION

The Ethiopian economy is among the most vulnerable in sub-Saharan Africa. Agricultural sector supports the economy heavily in which the sector suffered from recurrent droughts and extreme fluctuations of output. Agricultural production, for instance, has been growing on average by about 2.3 percent during 1980-2000 while population was growing on average at a rate of 2.9 percent per year, leading to a decline in per capita agricultural production by about 0.6 percent per year (Mulat *etal*, 2004). Since 1970s, a large number of studies have investigated the role of non-agricultural economic activities for rural development. Evidence suggests that economic diversity in rural areas has the potential of fostering local economic growth and alleviating the rural-urban income gap and rural poverty. Most studies in the existing literature on rural non-farm activities focus on the diversification of income sources over rural space, or over groups of households within the rural space (Benjamin *etal*, 2002).

The government tried to transform the economy by launching a strategy which takes agriculture as a primary stimulant to generate increased output, employment and income for the people. The strategy is called Agricultural Development Led Industrialization (ADLI) (Belay and Abebaw, 2004). The implementation of ADLI had started through agricultural extension program which is taken as a policy instrument. ***Agricultural extension*** is the application of scientific research to agricultural practices through farmer education. The major elements of the extension package are fertilizer, improved seeds, pesticides and better agricultural practices mainly for cereal crops (teff[1], wheat, maize, barley, sorghum and millet).

Extension services are widely exercised over all the country. Tigray regional state, from northern Ethiopia, has launched an integrated household focused extension package program since 2003/04 to address the problem of poverty (BoARD, 2006). The poor performance of agriculture has resulted in widespread poverty, chronic food insecurity and a growing reliance on international donors for food consumption (Mulat, 1997). This initiates governments and other concerned organizations to transform the old and traditional agriculture in to market oriented. One of the methods to transform agriculture is through the use of extension service as a best practice. Historically the extension service in Ethiopia has been focused on improving productivity and production to improve food security (Berhanu *etal*, 2006). Such programs intervention and other market oriented development strategies can improve the livelihoods of farm households.

[1] *Teff – the most common Ethiopian cereal crop and widely used for food consumption. There are three types of teff: red, white and mixture of two.*

Diversification of income from farm and non-farm activities is common in the rural economy in order to secure and improve their life. Diversification is not only the result of poor performance of agriculture but also the innate behavior of people to improve their wealth status; that is why people diversify their income from different activities. Therefore, diversification is a verification for maintenance and continuous adaptation of highly diverse portfolio of activities for survival as livelihood strategy in contemporary developing countries and used for improvement in wealth status for developed ones.

Farm households diversify their income sources for at least two motives. The first one is the ***pull factor*** where diversification is undertaken for accumulation objectives; and the second is the ***push factor*** where diversification is undertaken to reduce risk, cope up shocks or respond to diminishing returns (Fredu *etal,* 2007). Diversification is widely understood as a form of self-insurance in which people exchange some foregone expected earnings for reduced income variability achieved by selecting a portfolio of assets and activities that have low or negative correlation of incomes (Alderman and Paxson, 1992). In general, diversification is the allocation of productive assets among different income sources for risk minimization and accumulation of wealth.

Many researchers have responded to the impact of extension on farm productivity, food and non-food security, poverty reduction and asset holdings, impact of off-farm activities on farm income and on the linkages of farm/non-farm income (Asres *etal*, 2013; Kidanemariam *etal* (2013); Diao, 2010; Dercon *etal*, 2009; Habtemariam, 2007; Berhanu *etal*, 2006; Tassew, 2002; Mulat, 1997). Moreover, Berhanu *etal*, (2006), stated that impact of the household package extension program on household income and welfare is not known. Therefore, the overall impact of the agricultural extension services on farm households' income diversification is a crucial issue and not well researched yet in Ethiopia specifically in Tigray, northern Ethiopia. Thus, the study is used to examine impact of agricultural extension on income diversification of rural households. It deals in analyzing how extension program influences households' income diversification and to examine the major determinants of extension participation and income diversification.

2. CONCEPTS AND DEFINITIONS OF INCOME DIVERSIFICATION

There are different definitions of income diversification. Among these, Income diversification refers to an increase in the number of sources of income or the balance among the different sources (Ersado, 2003). Secondly, income diversification concerns the switch from subsistence food production to the commercial agriculture. It does not necessarily involve an increase in the number or balance of income sources (Oluwatayo, 2009). Thirdly, income diversification is often used to describe expansion in the importance of non-farm income. Non-farm income includes both off-farm wage labour and non-farm self employment (Reardon, 1997). Finally, income diversification is the process of switching from low value crop production to higher-value crops, livestock, and non-farm activities (Oluwatayo, 2009).

Diversification patterns reflect individuals' voluntary exchange of assets and their allocation of assets across various activities so as to achieve an optimal balance between expected returns and risk exposure conditional on the constraints they face (Barrett *etal*, 2001). Diversification is a means by which individual reduce, or may alleviate, their risk exposure and vulnerability. People diversify by adopting a range of activities in rural areas. Thus income sources may include farm income, off-farm income (waged agricultural income) and non-farm income (non-agricultural income sources, such as non-farm wages and self-employment). Poor households tend to diversify their income to survive, while better-off households usually diversify to accumulate more income (Hamza, 2007). Diversification is experienced by both households, the landless and land owners. Landless households depend on non-farm income to supplement their agricultural wage earnings. Households who possess land and are primarily agricultural also deploy capital and labor between farm and non-farm activities enabling them to diversify incomes across the calendar year and reduce seasonal and inter-annual consumption risks (Fredu *etal*, 2007; Barrett *etal*, 2001).

3. MATERIALS AND METHODS

3.1.1. SAMPLING METHOD

The research site is located in the Geba catchments of Tigray region[2], northern Ethiopia. The study area (the Geba[3] catchment) covers 4600 km^2 area, 10 Woredas[4] and 168 Tabias[5]. Cluster and Stratified sampling methods together

[2] *Region is an autonomous administration territory equivalent to one Administrative State in Federal Government.*
[3] *Geba is name of the river in which the study is going on its catchment, in Tigray region*
[4] *Woreda is the second administrative unit from lower administration units, in Ethiopia equivalent to a district.*

with simple random sampling tool is employed. A three stage sampling technique was used to collect the data. First, ten Woredas in this catchment were identified and grouped into clusters on the basis of their differences in agro-ecological features. Two lowland, six midland and two highland woredas are identified. Accordingly, four woredas; one lowland, one highland and two midland, were selected based on proportion. These are Atsebi - wemberta (highland - Dega), Wukro (midland - Weina Dega), Saharti - Samre (midland - Weina Dega) and Tanqua-Abergle (lowland - Kola). Second, sample of eight tabias (two tabias from each woreda) were randomly selected. The tabias selected are representative of the three agro-ecological zones of the region. Finally, total sample of 734 households were randomly drawn from the selected tabias from a list of eligible households.

3.2 METHOD OF DATA ANALYSIS

3.2.1 HECKMAN SELECTION MODEL

The counterfactual, what would have happened for household's income diversification condition, had they not been participating in agricultural extension programs? Heckman selection model is preferable than the other models. This is because it corrects the selection bias that is occurred in the selection equation. Two stages:

1. Stage I, the model estimates the determinants of extension participation. It uses the binary Probit model over the full sample $i = 1 \dots N$ in order to obtain estimates of the coefficients.
2. Stage II deals with participants only. It shows the impact of extension participation on income diversification. It examines whether participants are more diversified or not (determinants of income diversification).

Heckman selection model here is specified according to Greene (2003). Where the first one is the regression model with regard to selection equation (in this case: extension Participation)

$h_i^* = X'1i\gamma + u1 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.1$

Then, estimate the Probit model: $\mathrm{pr}(\mathrm{hi} = 1) = \Phi(X'1i\gamma) \dots\dots\dots\dots\dots\dots\dots\dots 3.2$

And the second model is the outcome equation (in this case: Income diversification Index)

$Y_i^* = X'2i\beta + u2 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.3$

Therefore, $Yi = Y_i^*$ when $hi = 1$ if $h_i^* > 0$

Yi is unobservable, $hi = 0$ if $h_i^* \leq 0 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.4$

The general equation when output equation incorporates selection equation which is conditional to participation (the conditional expectation of the continuous variable given that the binary variable is 1) is:

$= E\{y_i \,|h_i = 1\} = X_{2i}'\beta + E\{u_{1i}|u_{2i} > -X_{1i}'\gamma\} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.5$

$= X_{2i}'\beta + \frac{\sigma_{12}}{\sigma_2^2} E\{u_{2i}|u_{2i} > -X_{1i}'\gamma\} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.6$

$= X_{2i}'\beta + \sigma\rho \frac{\emptyset(X_{1i}'\gamma)}{\Phi(X_{1i}'\gamma)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.7$

It can be condensed as $\mathbf{E\{Y^*|P = 1, X_{1i}, X_{2i}\} = \beta' X_{2i} + \sigma\rho\lambda(\gamma' X_{1i})} \dots\dots 3.8$

Where the following assumptions and terms hold: **Y** is continuous ranges from zero to one and **h** is binary its value is either 1 and 0. $u_1 \sim N(0, \sigma)$; $u_2 \sim N(0, 1)$; corr $(u_1, u_2) = \rho$ and

$\boldsymbol{\lambda = \frac{\emptyset(\gamma' h)}{\Phi(\gamma' h)}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.9$

This is the inverse mills ratio estimated from selection equation (Probit model from 3.1), where $\emptyset$ is the standard normal density function, and $\boldsymbol{\Phi}$ denotes the standard normal cumulative distribution function. When $\rho = 0$, OLS regression provides unbiased estimates while if $\rho \neq 0$, the OLS estimates are biased. Heckman selection model provides consistent and asymptotically efficient. It also used to ascertain determinants of income diversification. Households with income source one are to be zero income diversification index whereas whose income source greater than one are expected to have greater than zero (some positive) income diversification.

Y* is income diversification index obtained through **Simpson's Index of Diversity (SID)**. Therefore, $\boldsymbol{Y^* = 1 - D}$ where $D = \sum(n/N)^2$ and/or $D = \sum n(n-1)/N(N-1) \dots\dots\dots 3.10$

n - The total income from particular source, N - The total income from all income sources available and **Y*** ranges between zero and one.

[5] *Tabia is the smallest unit of local government in rural communities, just lower than Woreda and equivalent to street and each tabia consists of four villages.*

4. DATA ANALYSIS AND DISCUSSION

4.1. THE NATURE AND DESCRIPTION OF THE DATA

The data is collected for multiple purpose and from different dimensions in 2009 by MU-IUC project which includes information on access to extension services. It includes demographic characteristics of the household such as age, gender (sex), educational status, family size, number of adult labor force and number of dependents. Detailed information is gathered on farm characteristics like farm size, farm type and characteristic, land ownership status and access to irrigation. It also contains sources of income. Information on asset ownership, credit facility, inputs and adoption of modern input, crop outputs and sales of previous year harvests, technology adoption status are included.

Sex composition of the respondents and extension participation are presented below. In table 4.1, 194 (26.43 percent) out of 734, are female headed households and 540 (73.57 percent) are male headed. From total, 390 (53.13 percent) and 344 (46.87 percent) of households are participants and non-participants in the program, respectively. From extension participants 79 households (20.26 percent of the participants or 10.76 percent of the total sample) are female headed and 311 households (79.74 percent of the participants or 42.37 percent of the total sample) are male headed. This might indicate that female household heads are marginalized in extension package participation.

Table 4.1: SEX COMPOSITION AND EXTENSION PARTICIPATION STATUS

Household head sex	Frequency	Percent	Ext. participants			Ext. non-participants		
			Obs	Percent		Obs	Percent	
				From participant	From total		From non-participants	From total
Female headed	194	26.43	**79**	20.26	10.76	**115**	33.43	15.67
Male headed	540	73.57	**311**	79.74	42.37	**229**	66.57	31.20
Total	734	100.00	**390**	100.00	53.13	**344**	100.00	46.87

Source: Estimates from MU-IUC, 2009.

Similarly, from extension non-participants 115 households (33.43 percent of the non-participants or 15.67 percent of the total sample) are female headed and 229 households (66.57 percent of the non-participants or 31.20 percent of the total sample) are male headed.

Table 4.2: SUMMARY STATISTICS OF SOME IMPORTANT VARIABLES

Variables	Extension non-portico. (N=344)	Extension partic.(N=390)	Mean difference estimate	t-value
	Mean	Mean	mean(0)- mean(1)	
Family size	4.6308	6.0436	-1.413	-8.857***
Age of head	42.74	45.34	-2.605	-2.421**
Adult labor	2.3488	3.082	-0.733	-7.123***
Dependency ratio	1.7324	1.677	0.0538	0.6837
Total farm size	3.8143	4.8987	-1.084	-4.412***
Dummies	*percent*	*percent*	*percent*	*t-value*
Sex of head (male)	0.6657	0.7974	-0.132	-4.079***
Educational status	0.3314	0.40	-0.069	-1.926*
Own land	0.8634	0.9513	-0.0879	-4.199***
Access to irrigation	0.1947	0.2359	-0.041	-1.350
Access to information	0.3546	0.4923	-0.1376	-3.793***
Tanqua Abergele	*0.2064*	*0.2744*	*-0.068*	*-2.148***
Seharti Samre	*0.3169*	*0.3359*	*-0.019*	*-0.548*
Wukro(Kilte-Awlaelo)	*0.2122*	*0.2128*	*-0.001*	*-0.020*
Atsebi Wonberta	*0.2645*	*0.1769*	*0.088*	*2.881****

Source: Estimates from MU-IUC, 2009.
Note: ***, ** and * are Significance at the 1%, 5% and 10% levels

Table 4.2 below presents the summary of family size, sex (gender) of the household head and age of the household head. It also provides useful information of the respondents' like literacy status, adult labor force of the households,

dependency ratio, total farm holding (in tsimad[6]), land ownership status, access to irrigation, access to information and geographical locations (Woreda level). The average family size, age (proxy for agricultural practice experience), adult labor force and total farm holdings (in tsimad) for extension participants are 6, 46, 3, and 4.89, respectively. In a similar manner, the average family size, age, adult labor force and total farm holdings (in tsimad) for extension non-participants are 5, 43, 2.35 and 3.81, respectively. So, participants have larger average values of these variables than their counterparts and they are statistically significant at their respective t-statistic value.

80 percent of extension participant households are male, 40 percent are literate, 95 percent have own land and 49 percent have access to information. Similarly, 67 percent of extension non-participant households are male, 33 percent are literate, 86 percent have own land and 36 percent have access to information. Accordingly, participants have larger percentage values of these variables than their counterparts and the difference between the two groups of households is significant as shown in the t-statistic value.

4.2. AGRICULTURAL EXTENSION PARTICIPATION

Extension participation status is defined in terms of farmers' involvement in different package programs. Households are extension participants if they have involved in at least one of the extension package programs. The most common types of packages include improved seeds, fertilizer, dairy cow, cattle fattening, sheep and goat, modern beehives, improved poultry and so on.

The first stage of Heckman Selection model (Selection equation - agricultural extension participation a binary variable) as shown in table 4.3 is just a Probit model which gives the estimates of explanatory variables on the dependent variable. It looks sound to interpret its signs to show the directions of estimates according to their significance level. It is possible to express the estimation output in terms of marginal effects but still this is confusing because it only holds if the other explanatory variables are at their average value which is not necessary true (Verbeek, 2004).

4.2.1 MAJOR DETERMINANTS OF EXTENSION PARTICIPATION

Age of the household head (taken as proxy for agricultural practices experience) is identified as one possible factor that affect households' agricultural extension participation status as depicted in various literatures. It is highly significant at 1 percent level and affects extension participation positively as shown in table 4.3. It indicates that older household heads tend to participate in agricultural extension package programs as they learn from experience that is *learning by doing*.

Literacy status of the household head (Educational status) is found to be positive and significant at 5 percent level of significance. This reveals that literate households are better in participating agricultural extension than their counterparts. This is largely associated with awareness to the importance of extension participation which improves the productivity and production as depicted in various literatures. Accordingly, literate households tend to adopt improved farm technologies, package related extension services and other livelihood opportunities than the illiterate ones.

Number of adult labor force affects extension participation positively and shows existence of larger family size in adults in the household tend to have higher probability of participation in the program intervention and is statistically significant at 1 percent level. The rationale behind is that the members of the household can participate in different package programs for diversification. Extension participation by itself needs much time to follow up. This requires large number of adult labor force to handle it smoothly.

Tabia average distance from head quarter (Mekelle) and from near Woreda are statistically significant variables at 1 percent level. The sign of these coefficients are unexpectedly positive. This reveals that households far from the head quarter and near Woreda are more likely to participate in the program than the nearer. This may be due to the massive attention given to the rural economy. Distance has positive effect on extension participation because when households are far from urban areas in general, which can be characterized by having relatively large farm size and large livestock ownership. Of course, total farm size and livestock ownership have positive influence to extension participation in the study area as a verification. This is consistent with the results of Genius *etal*, (2006).

[6] *Tsimad is a local measurement for total farm size (land holdings) of households that can be plowed by a pair of oxen per day and is approximately equal to a quarter of one hectare.*

TABLE 4.3: ESTIMATION OF HECKMAN SELECTION MODEL – ROBUST STANDARD ERRORS:

Number of obs = 734 Censored obs = 344; Uncensored obs = 390 ; Wald chi2(12) = 24.07;
Prob > chi2 = 0.0199 ; **Log pseudolikelihood = -706.5228**

Extension participation (Selection model)		ln(Simpson's income diversification) (Outcome model)	
Variables	Estimate	Estimate	Bias corrected estimate
Age of head	0.0394***	-0.0143***	-0.0141
	(4.46)	(-2.89)	
Sex of head	0.0555	0.0865	
	(0.41)	(1.13)	
Educational status	0.2392**	-0.0475	
	(2.09)	(-0.61)	
Adult labor force	0.1656***	0.0133	
	(3.85)	(0.73)	
ln(total farm size)	0.0403	0.0752	
	(0.46)	(1.32)	
Access to irrigation	0.0965	-0.0618	
	(0.75)	(-0.80)	
Distance from Mekelle	0.0138***	-0.0027***	-0.0025
	(5.09)	(-2.70)	
Distance from Woreda	0.0291***	-0.0050	
	(3.75)	(-1.58)	
Total animals (tlu[7])	0.0043***	0.0002*	0.0002
	(3.77)	(1.86)	
Total animals in1996 (tlu)	5.73e-06	-------	
	(1.07)	-------	
Total own land	0.1651	-0.1820*	-0.1811
	(0.84)	(-1.66)	
Information access	0.2529**	-0.0218	
	(2.43)	(-0.46)	
Member to community orgn.	0.4371***	-------	
	(3.53)	-------	
Extension years of tabia	0.0614***	-------	
	(4.95)	-------	
Distance to ext. center in (hr)	-0.0642	-------	
	(-0.50)	-------	
Extension participation	--------	***0.1490****	
		(2.06)	
constant	-4.606***	-0.0564	
	(-8.34)	(-0.23)	

/athrho	0.1701***	rho	0.1684***	lambda	0.0824**
	(3.06)		(3.11)		(2.72)
/lnsigma	-0.7157***	sigma	0.4889***		
	(-5.27)		(7.36)		

Wald test of indep. eqns. (rho = 0): chi2 (1) = 9.35 Prob > chi2 = 0.0022

Source: Estimates from MU-IUC 2009

Note: ***, **, * significance at 1% level, 5% level and 10% level respectively. Values in parenthesis are z-values.

Total livestock in Tropical Livestock Unit (TLU) is significant at 1 percent with positive sign. Possessing more number of livestock made the household to have more probability of participating in the extension programs because livestock contribute to household as a source of pulling factor, as a means of plough to cultivate the parcel of land, becoming as a source of income and source of supplementary food. Owning more and more number of livestock leads to higher purchasing power of extension packages since livestock can be regarded as the collateral.

[7] *TLU – tropical livestock unit is a conversion factor of animals in same unit see annex 4.*

Access to information is not related with information from development (extension) agents. This is access to information from access to television, radio, magazines and newspapers. From table 4.3, access to information appeared to be significant at 5 percent level and shows a positive sign. Households who have access to this information have higher probability to participate than those do not have because access to information creates greater awareness on extension packages and related programs.

Membership to community organization is defined as being membership to Edir, Equb and other community organizations. Membership to community organization affects extension participation significantly (at 1 percent level) and has positive sign as shown in table 4.3. Being membership to community organization has better probability to participate than those who don`t have due to peer influence. It reveals that information flow about extension programs among members of the community organization.

Number of participation years (Extension years) that the tabia stay in agricultural extension packages found to be significant at 1 percent level with positive sign. This means development agents provide advisory services on well organized manner on extension packages and on adoption of agricultural technologies and rural development related issues. Learning by doing from previous experience made households to have higher probability of participation.

4.3. RURAL INCOME DIVERSIFICATION INDEX

This is a comparative analysis of income diversification index between households of extension participants and non-participants. This index is found using Simpson's Index of Diversification (SID). As indicated in table 4.4, the overall Simpson's Mean Income Diversification index is 0.4795. While the SID for extension participants and non-participants are 0.4977 and 0.4587, respectively. It shows that extension participant have a little bit higher income diversification than non-participants. The marginal effect is probably due to policy intervention of extension packages. These may help households to have higher diversification level and leads to have more income source.

TABLE 4.4: MEAN OF SIMPSON INCOME DIVERSIFICATION INDEX (SINCDIVI)

Variable Name	Ext. participant	Ext. non-participant	Total pop_n	Mean difference	t-value
Mean of sincdivi	0.4977	0.4587	0.4795	-0.039	-3.477***
Mean of sincdivi of Male headed	0.5025	0.4904	0.4974	-0.012	-1.048
Mean of sincdivi Female headed	0.4790	0.3956	0.4296	-0.083	-3.051***

Source: Estimates from MU-IUC, 2009.
Note: *** Significance at the 1% level

Male headed households have higher income diversification index than female headed ones, in both extension participants and non-participants. Income diversification index is higher in participants than non-participants. There is a significant difference in the Mean of Simpson's income diversification index between extension participants and non-participants. Participants exceeds on average by 0.039 units to their counterparts.

4.3.1 MAJOR DETERMINANTS OF INCOME DIVERSIFICATION

The model is correctly specified. No signs for problems of multicollinearity and heteroskedasticity. The problem of multicollinearity can be expressed as the violation of the assumption of covariance between explanatory variables should be zero. Thus, the avoidance of such problems enables the explanatory variable to contribute to the variation in the dependent variable separately. The average **VIF is 1.74** for the outcome and **1.46** for selection equations. It is used the robust standard errors and then the model automatically corrects the problem of heteroskedasticity.

The second stage of the Heckman Model (the outcome equation - log of income diversification index which is continuous variable) is a standard regression model analogous to OLS and tested for its validity and assumptions (see table 4.3). The test for selection bias, rho (ρ), the correlation between the errors of the two equations is significantly different from zero at 1 percent level. This shows that participating in the extension packages has selection problems but corrected using Inverse Mills ratio. The existence of selection bias also implies that there is heteroskedasticity problem. The problem of heteroskedasticity is corrected by robust standard errors.

Some instrument variables are identified and incorporated in the selection equation in addressing the question of endogeneity with the outcome equation in the Model. For its validity, it is tested using Hausman test and any one variable in the residual regression is not significant as shown in annex 3. The null hypothesis, the instruments are uncorrelated with the residuals, is accepted because the critical Chi(2) value with three degrees of freedom at 0.05

significance level is ***7.8147*** and which is greater than nR^2 = ***5.138.*** Therefore, no sign of endogeneity exists with extension participation and income diversification.

The statistical significant estimates in the outcome equation should be interpreted to identify the determinants of income diversification. If a variable appears only in the outcome equation, its coefficient can be interpreted as the marginal effect of a one unit change in that variable on the dependent variable like OLS estimates. If, on the other hand, a variable appears in both the selection and outcome equations, the coefficient in the outcome equation is affected by its presence in the selection equation as well. In this case, the estimates of the outcome equation can be corrected from selection bias and can be obtained using estimates of the outcome equation minus the product of the coefficients of the selection equation, rho, sigma and delta (Where delta = inverse mills*(inverse mills + select_xb)) (Sweeney, 2006). Then, the adjusted coefficients for each observation shows the marginal effect.

Age of the household head (a proxy for experience) is one of the major socio-demographic factors that determine rural households' income diversification. It is significant at 1 percent level and affects income diversification negatively as depicted in table 4.3. It indicates that older household heads tend to decrease their income diversification behavior. When a household is getting older by a year, income diversification decreases by 1.4 percent than the previous year. This may be due to aged households decrease efforts on diversification because of the natural balance, i.e. loss of force to work (physically weak) in different working conditions in any time, day and night.

Tabia Average Distance from Head quarter (Mekelle) is a variable which affects income diversification of rural households in the rural economy. The sign of the coefficient of the variable is negative and is significantly different from zero at 1 percent significance level. Farther a tabia located from the head quarter, households in that tabia are far from information about diversification, exposure (awareness) about businesses and marketing conditions and thus affect income diversification inversely. In addition, it may be because of the fact that rural households are busy in crop cultivation and land management which consumes much of the household's time and is consistent with results of Lanjouw and Lanjouw, (2001).

Total livestock in TLU (Tropical Livestock Unit) is significant at 10 percent significance level with positive sign as indicated in table 4.3. Possessing more number of livestock made the household to have more source of income. If total livestock of a household increases by one unit, income diversification increases by 0.02 percent. Livestock serves as a source of pulling factor. It is also source of income and source of supplementary food. Livestock can also be considered as one way of diversification as an individual having one more option in his portfolio.

Land ownership status affects income diversification significantly at 10 percent level in opposite direction. This means that being owner of land, diversification of households' income source is lessened by 18.11 percent than their counter parts. This may be due to owners of land fully spent their time in their crop production and treatment of land like preventing the land from degradation and preparation of composts for soil fertility. Therefore, households who have own land devote on intensification rather than diversification while the reverse holds for non-land owners.

4.3.2 IMPACT OF AGRICULTURAL EXTENSION ON INCOME DIVERSIFICATION

The main notion is to identify and examine the impact of agricultural extension participation on income diversification. The selectivity variable is ***extension participation***. Heckman selection model corrects the selection bias and the impact indicator also shows corrected impact. The impact indicator, ***extension participation***, is statistically different from zero. It is significant at 5 percent and affects income diversification positively. Participants of extension packages have higher level of income diversification index. In magnitude wise, being participants in extension packages, income diversification of these households, on average, increased by 14.9 percent. Since extension package types themselves are parts of the sources of income, participants have higher income diversification level.

The package types provided are sources of income diversification. It is to mean investing in different income sources. This result is consistent with Evenson and Mwabu, (2001) and Kidanemariam *etal* (2013), that the contribution of agricultural extension to farm yield and income is positive in which this is one way of income diversification.

5. CONCLUSIONS

Ethiopia faced a problem of severe food insecurity and mal-nutrition that manifests itself on the reliance of hands of foreign donors for long time. The government tries to solve this incident using different mechanisms among them commercializing the agricultural sector to market oriented using different approaches such as agricultural extension services. Income diversification is to have more sources of income and is one of the strategies to alleviate the problems of food insecurity. The Simpson's income diversification index is computed for extension participants and

non-participants. Accordingly, the average income diversification index for participants is higher than non-participants. It is significantly different from zero with diversity indices 0.4977 and 0.4587 for participants and non-participants, respectively. This result is consistent with the Heckman Selection output which incorporates socio-economic and other explanatory factors. The treatment variable in the outcome equation, extension participation, has a positive impact on income diversification and is statistically significant. Being extension participant, income diversification level increases by 14.90 percent.

The Selection equation of Heckman Selection Model, which is a Probit Model, tries to show the determinants of extension participation. Member to community organization, access to information, literacy (educational) status of the household head and number of adult labor force are the dominant variables that positively and significantly affect extension participation condition, respectively. Whereas the Outcome equation, which is analogous to OLS model, reveals the determinants of income diversification. Accordingly, the most dominant variables are own land and extension participation status. Having own land affects income diversification negatively and extension participation affects positively.

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ANNEXES

ANNEX 1:

ESTIMATION USING PROBIT MODEL

Probit regression — Number of obs = 734
LR chi2 (15) = 142.88
Prob > chi2 = 0.0000
Log likelihood = -435.88541 — Pseudo R2 = 0.1408

Extension participation	Coefficient	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Age of head	0.0392***	0.0088	4.47	0.000	0.0220	0.0563
Sex of head	0.0521	0.1337	0.39	0.697	-0.2099	0.3141
Educational status	0.2393**	0.1143	2.09	0.036	0.0153	0.4633
Adult labor force	0.1675***	0.0410	4.09	0.000	0.0872	0.2478
ln(total farm size)	0.0421	0.0896	0.47	0.638	-0.1335	0.2177
Access to irrigation	0.0906	0.1275	0.71	0.477	-0.1591	0.3404
Distance Mekelle	0.0137***	0.0027	5.04	0.000	0.0084	0.0190
Distance Woreda	0.0289***	0.0080	3.61	0.000	0.0132	0.0446
Total animals (tlu)	0.0044	0.0048	0.92	0.359	-0.0050	0.0137
Total animals in1996 (tlu)	5.34e-06	5.27e-06	1.01	0.311	-4.99e-06	0.00002
Total own land	0.1604	0.1995	0.80	0.421	-0.2306	0.5514
Information access	0.2591**	0.1045	2.48	0.013	0.0542	0.4639
Member to community org.	0.4279***	0.1222	3.50	0.000	0.1884	0.6674
Extension years	0.0594***	0.0127	4.67	0.000	0.0345	0.0844
Distance to ext. center in (hr)	-0.0494	0.1208	-0.41	0.682	-0.2861	0.1873
Constant	-4.5661***	0.5450	-8.38	0.000	-5.6344	-3.4978

Note: 0 failures and 1 success completely determined.

ANNEX 2:

PROBIT MODEL SPECIFICATION FOR EXTENSION PARTICIPATION STATUS

	-------- True --------		
Classified |	D	~D |	Total
+ |	286	138 |	424
- |	104	206 |	310
Total |	390	344 |	734

Classified + if predicted Pr(D) >= 0.5
True D defined as extenpart!= 0

Sensitivity	Pr(+| D)	73.33%
Specificity	Pr(-|~D)	59.88%
Positive predictive value	Pr(D| +)	67.45%
Negative predictive value	Pr(~D| -)	66.45%
False + rate for true ~D	Pr(+|~D)	40.12%
False - rate for true D	Pr(-| D)	26.67%
False + rate for classified +	Pr(~D| +)	32.55%
False - rate for classified -	Pr(D| -)	33.55%
Correctly classified		67.03%

ANNEX 3:

HAUSMAN TEST – CHECKING FOR ENDOGENEITY PROBLEMS

reg residlnsincdivi agehead headsexdum headedum adultlaborforce lntfarsize accirrigation tabiadismak tabiadiswmak tTLUanima ttluanima96 townland infodum mcomorgdum extensionyears disextenhr

Source	SS	df	MS		
				Number of obs =	734
				F(15, 718) =	0.34
Model	1.380	15	0.092	Prob > F =	0.9910
Residual	194.477	718	0.2709	R-squared =	0.0070
				Adj R-squared =	-0.0137
Total	195.857	733	0.267	Root MSE =	0.5204

Reg residual ln(Simpson's income diversification)	Coefficient	Standard Error	t	P>|t|
Age of head	-0.0003	0.0034	-0.10	0.919
Sex of head(male)	0.0053	0.0525	0.10	0.920
Educational status of the Head	-0.0004	0.0441	-0.01	0.993
Adult labor force	0.0003	0.0155	0.02	0.984
ln(total farm size)	0.0131	0.0352	0.37	0.710
Access to irrigation	-0.0071	0.0499	-0.14	0.887
Distance from Mekelle	0.0004	0.0010	0.34	0.732
Distance from near Woreda	-0.0003	0.0031	-0.11	0.911
Total animals (livestock) (tlu)	7.03e-06	0.0003	0.03	0.978
Total animals (livestock) in 1996 EC(tlu)	-3.12e-06	2.02e-06	-1.54	0.123
Total own land	0.0001	0.0745	0.00	0.999
Information access	-0.0015	0.0409	-0.04	0.971
Member to community organization	0.0510	0.0483	1.06	0.291
Extension years of tabia	-0.0011	0.0049	-0.23	0.818
Distance to extension center in (hr)	0.0731	0.0472	1.55	0.122
Constant	-0.0637	0.1991	-0.32	0.749

Note: No one variable is significant in the residual regression above

- $nR^2 = 734*0.0070 =$ ***5.138***
- Chi(2) critical with three degrees of freedom at 0.05 significance level is ***7.8147***

ANNEX 4:

CONVERSION FACTOR FOR TROPICAL LIVESTOCK UNIT (TLU)

Animal type	Tropical Livestock Unit (TLU)
Calf	0.25
Heifer	0.75
Cow and Ox	1.00
Horse and Mule	1.10
Donkey	0.70
Camel	1.25
Sheep and Goat	0.13
Chicken (Poultry)	0.013

Source: Storck, *etal*. (1991)