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Dynamics of Farmers' Participation in Conservation Agriculture: Binary Logistic Regression Analysis

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Abstract
This study attempts to examine the determinants of farmer's participation in conservation agriculture in Guto Gidda and Sasigga districts of Oromia Regional National State in Ethiopia. Primary data for the study were collected from 142 farm households heads drawn from five kebeles of Sasiga district and four kebeles of Guto Gida district through structured questionnaire. Majority of respondent households perceive conservation agriculture as adaptation strategy to climate change. Out of the total respondents 91.55 percent were those households who perceive conservation agriculture as an adaptation strategy to climate change. Binary logit model was employed to examine farmer's participation in conservation agriculture. Estimation result shows that education level of the household head, number of active family labour and main employment of the household head were significant variables in determining participation in conservation agriculture.
Keywords: Conservation Agriculture, Logit, Western Ethiopia

1. Introduction

Throughout the world today, depletion of natural resources is among the major problems facing human beings (Abera, 2003). Agriculture places heavy burden on the environment in the process of providing humanity with food and fiber, while climate is the primary determinant of agricultural productivity (Bruce *et al*., 2001; Apata *et al*., 2009).

Ethiopia, one of the developing countries, is facing serious natural resource degradation problems (Anemut, 2006). One of the main features of the country is the diversity in altitude and accompanying climatic and ecological variations (Shibru & Kifle, 1998). According to Anemut (2006) environmental damage hamper development through reducing the level of welfare of the society by depleting environmental resources, reducing the quality of environment and decreasing long term productivity.

According to Desta (2012) and Deressa *et al*., (2011) agriculture is the backbone of the Ethiopian economy and is given special attention by the government to spearhead the economic transformation of the country. Climate is a primary determinant of agricultural productivity. Agronomic and economic impacts from climate change depend primarily on the rate and magnitude of change in climate attributes and the agricultural effects of these changes, and the ability of agricultural production to adapt to changing environmental conditions (Bruce *et al*., 2001). Though climate change is a threat to agriculture and non-agricultural socio-economic development, agricultural production activities are generally more vulnerable to climate change than other sectors (Ayanwuyi *et al*., 2010).

Land degradation, loss of soil fertility and lack of sufficient natural resources such as forests that protect ecological balance are major environmental problems prevailing in Guto Gida and Sasiga districts. Moreover, adaptation strategies for environmental conservation require cooperation and local participation in environmental rehabilitation which in turn requires examining the determinants of participation in conservation agriculture as adaptation methods to climate change.

Literatures on farmers' participation in conservation agriculture in Ethiopia in general and in the Oromia Region in particular are very few. There are no empirical studies conducted on farmers' participation decision on agricultural conservation strategies in Guto Gida and Sasiga districts. The purpose of this study is therefore, to examine the determinants of farmers' participation in conservation agriculture and farmers perception of conservation agriculture as adaptation strategy to climate change in Guto Gida and Sasiga districts, East Wollega Zone.

2. Materials and methods

This paper used both primary and secondary data. Primary data was collected by structured questionnaire. Detailed information on household and farm characteristics, household socio-economic and demographic characteristics, location characteristics and farm management practices and other related information were collected through interview of sample household heads.

The study was conducted in Guto Gida and Sasiga districts, East Wollega Zone of Oromia Regional

State. These districts were purposefully selected due to the fact that in these areas the environment has been degraded largely and the occurrence of climate change that affect agricultural production during the year 2010 and 2011 in three kebeles of Guto Gida district. Systematic random sampling technique was employed to draw sample of household heads. From a total of 50 peasant associations in these districts nine peasant associations were selected randomly. From these sampled peasant associations based on formula by Kothari (2004) 142 households were selected proportionally.

A logistic regression analysis was employed to identify the factors that influence farmer's participation in conservation agriculture as an adaptation to climate change. The farmers' participation in conservation agriculture is dependent variable which takes a value of 1 if the farmer was participated and 0 if farmer did not participated. The basic model of the logit estimation (Gujarati, 2004) is as follows:

$$p_i = prob\ (y_i = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_{1i} + ... + \beta_k x_{ki})}}$$

$$= \frac{e^{(\beta_0 + \beta_1 x_{1i} + ... + \beta_k x_{ki})}}{1 + e^{-(\beta_0 + \beta_1 x_{1i} + ... + \beta_k x_{ki})}} \quad \text{..... (4)}$$

Similarly,

$$p_i = prob\ (Y_i = 0) = 1 - prob\ (Y_i = 1)$$

$$= \frac{1}{1 + e^{(\beta_0 + \beta_1 x_{1i} + ... + \beta_k x_{ki})}} \quad \text{..... (5)}$$

By dividing (4) by (5) we get

$$\frac{\Pr ob\ (Y_i = 1)}{\Pr ob\ (Y_i = 0)} = \frac{p_i}{1 - p_i} = e^{(\beta_0 + \beta_1 x_{1i} + ... + \beta_k x_{ki})} \quad \text{..... (6)}$$

Where P_i is the probability that household participate in conservation agriculture and then (1-P_i) is the probability that household is non participant in conservation agriculture and e is the exponential constant.

The two computing models commonly used in the adoption studies are the probit and logit models. But the results obtained from the two models are very similar since the normal and logistic distributions from which the models are derived are very similar (Gujarati, 2004). As a result, only the logit model will be reported in the paper even if both models will be estimated for the purpose of comparison.

In this analysis before estimating the model, it was necessary to check the existence of multicolinearity among the hypothesized explanatory variables. Multicolinearity problem arises when at least one of the independent variables is a linear combination of the others; with the rest that we have too few independent normal equations and, hence, cannot derive estimators for our entire coefficient. VIF shows how the variance of an estimator is inflated by the presence of multicolinearity (Gujarati, 2004). The speed with which variances and covariances increase can be seen with the variance-inflating factor (VIF) , which is defined as $VIF_j = \frac{1}{1 - R_j^2}$ where R_j^2 is the coefficient of determination in the regression. The larger the value of VIF_j, the more troublesome or collinear the explanatory variables is (Gujarati, 2004).

In solving the problem of heteroskedasticity literatures used robust standard errors (Charles and Rashid, 2007). To address the possibilities of heteroskedasticity in the model, the researchers estimated a robust model that computes a robust variance estimator based on a variable list of equation.

The dependent variable, farmers' participation in conservation agriculture has a dichotomous nature measuring the willingness of a farmer to participate in conservation agriculture as a measure of adaptation of climate change. The probability of participation in conservation agriculture practices dependent on several household, farm and location characteristics.

The explanatory variables used in the model include different socio-demographic and environmental factors based on the literature on factors affecting the participation of farmers in conservation agriculture. The variables included in the analysis are age of the household, sex of household, household marital status, total family size, level of education, topography of arable land, farming experience, farm size in hectares, extension services and technology promoters, membership in farmer organization, main employment, and active family labor.

3. Results and Discussions

Conservation agriculture is one of the mechanisms of climate change adaptation. This study was also conducted in above stated districts in which 142 respondents were interviewed to know their participation in conservation agriculture. The average age of sample household heads for those who did not participate on conservation agriculture was 38.21 with standard deviation of 12.55. The mean age of respondents who participated on conservation agriculture was 48.58 and the age of respondents who participate on conservation agriculture was deviates from its mean by 13.73. The minimum age of the respondent households was 22 and the maximum age of the respondent was 90 (Appendix 1).

The maximum farm size for those farmers who did not participate on conservation agriculture was 7.250 hectare while it was 4.75 hectare for those who participated on conservation agriculture. As the result of the survey shows the mean farm size of respondents who participated on conservation agriculture was 1.364 hectare which is greater than mean farm size of respondents who did not participate on conservation agriculture which is 1.332 hectare.

The mean years of farming experience of respondent households who did not participate on conservation agriculture was much less than those who participated on conservation agriculture. The t-test values indicated that the farming experience between those who did not participate on conservation agriculture and those who participated on conservation agriculture was significant at 1 percent probability level (Table 1). This shows that farmers with high years of experience highly participate on conservation agriculture than farmers with less years of experience.

The maximum active family labor for respondent household was 13. The mean of active family labor of households, those who participated on conservation agriculture (4.98) was higher than those who did not participate on conservation agriculture which was 2.70. This shows that the size of active family labor in households family size affect participation on conservation agriculture.

The maximum family size for household head those who did not participate on conservation agriculture was 12 and the minimum family size was 2. The mean family size of those who did not participate on conservation agriculture was 5.1 and the family sizes of the household head those who did not participate on conservation agriculture deviates from its mean by 2.229. However, the maximum family sizes of respondent household those who participated on conservation agriculture was 16 while the minimum was 2. The standard deviation of family size of those farmers who participated on conservation agriculture was 2.191.

Table 1 Summary statistics of continuous variables and their mean difference test used binary logit model (n=142)

List of variables	Total respondent		Not participated[2]		Participated[3]		t -Value
	Mean	St. d	Mean	St. d	Mean	St. d	
Age	44.493	14.173	38.21	12.546	48.58	13.729	4.547***
Farm_size	1.352	0.949	1.3318	1.09880	1.3645	.84316	0.200
Experience	26.718	13.186	20.68	11.246	30.65	12.919	4.726***
Family_Labor	4.077	2.070	2.70	1.043	4.98	2.081	7.597***
Family_Size	5.831	2.275	5.11	2.229	6.30	2.191	3.155***
Extension_service_promoters	2.042	2.788	1.7500	2.89357	2.2326	2.71672	1.008

***, ** and * significant at 1%, 5% and 10% respectively

Source: Own Survey, 2013

The highest level of education attained by respondent household who did not participate on conservation agriculture was certificate while the highest level of education attained by household head who participated on conservation agriculture was grade 11-12. The standard deviation of education level of household who participated on conservation agriculture was 1.010 while it was 1.05 for those farmers who did not participate on conservation agriculture. Out of all households who participated on conservation agriculture 50 percent (43 out of 86) were those who attended grade 1-8 while 64.29 percent (36 out of 56) of all who did not participate on conservation agriculture were those who were illiterate (Appendix part 2). According to the result of the household survey conducted from all respondents 86 were participated on conservation agriculture while 56 respondents were those who did not participated on conservation agriculture.

[2] Farmers who did not participate on conservation agriculture
[3] Farmers who did participate on conservation agriculture

Table 2 Summary statistics of dummy and categorical variables used binary logit model (n=142)

List of variables	Total respondent		Not participated[4]		Participated[5]		χ^2 -Value
	Mean	St. d	Mean	St. d	Mean	St. d	
Education	1.289	1.140	0.66	1.049	1.70	1.007	37.113***
Sex	0.873	0.334	0.79	0.414	0.93	0.256	6.399**
Marital	0.859	0.349	0.768	0.426	0.918	0.275	10.317
Employment	0.852	0.356	0.66	0.478	0.98	0.152	6.396**
Topography	0.521	0.501	0.589	0.496	0.477	0.502	1.721
Membership	0.739	0.440	0.66	0.478	0.79	0.409	2.974*

***, ** and * significant at 1%, 5% and 10% respectively
Source: Own Survey, 2013

Before running the binary logit model all the hypothesized explanatory variables were checked for the existence of multicollinearity problem. VIF (variance inflation factor) and correlation matrix was used for testing the association between the hypothesized variables. The VIF values displayed in table 2 and 3 shows that from all the continuous explanatory variables, age, experience, marital status and family size were with serious multicollinearity problem and rejected from the regression. In solving the problem of heteroskedasticity literatures used robust standard errors (Charles and Rashid, 2007). To address the possibilities of heteroskedasticity in the model, the researchers estimated a robust model that computes a robust variance estimator based on a variable list of equation.

Finally, all hypothesized explanatory variables expect those with multicollinearity problem, were included in the binary logistic analysis. These variables were selected on the basis of available literature and the results of the survey studies. To determine the best subset of explanatory variables that are good predictors of the dependent variable, the binary logistic regressions were estimated, which is available in stata (version 10).

The binary logit model results used to study factors influencing the farmer's participation on conservation agriculture are shown in Table 3 and appendix 6. The model explained about 47.93 percent of the total variation in the sample for participation on conservation agriculture. From the result of classification table 81.69 percent of the values were specified correctly (Appendix 4). This shows observations were reasonably classified. The result of Wald test shows all variables included in the model were jointly significant since the value of χ^2 (51.08) is significant at 1 percent probability level (Appendix 5). Among the explanatory variables used in the model, three variables were significant with respect to participation on conservation agriculture with less than 10 percent of the probability level. The significant explanatory variables on participation in study area are discussed below.

Education is expected to reflect acquired knowledge of environmental necessity. Education has positive impacts on participation on conservation agriculture and was significant at 1 percent level. Consistent with this expectation, binary logistic regression showed educational status of farmers to have a strong power in explaining participation on conservation agriculture. Holding other regressors constant, a change in household head education level by one unit, say one level, will increase the odds of being participated on conservation agriculture by the factor of 0.1382. The possible justification for this finding was that educated farmers tend to conserve their environment, use agricultural extension services and adapt climate change than the illiterates. These are important instruments in boosting production which makes farmers to be wealthier and reverse the environmental problem (Table 3). This result is similar to findings by Fapojuwo *et al.*, (2010) which identified the higher the educational level of the farmer, the higher the tendency of using improved soil conservation techniques. Paulos (2002) identified that literate household heads were more opt to recognize the advantages of soil conservation and were willing to take part in it which is in line with the study.

Households' main employment was significant at 1 percent. The estimated coefficient for dummy variable main employment of household with the odds of being participator in conservation agriculture over non participator was positively correlated. This suggests that the probability of being participator on conservation agriculture increases if one has participated on on-farm employment, other factors being constant. This meant that farmers with on farm employment were more likely to participate on the conservation agriculture practices than those off farm. This is agreeing with the hypothesized idea which says off-farm employee may not participate on conservation agriculture because he/she may not think about environment since his/her income may not directly related to production of crops.

Households with larger number of economically active labor are supposed to be better in conservation agriculture practices, since they are less likely to have shortage of labor which is required to do conservation

[4] Farmers who did not participate on conservation agriculture
[5] Farmers who did participate on conservation agriculture

activities. The coefficient of active family labour was positive and significant at 1 percent probability level. A unit increase in active family labour increased the log-odds of participating on conservation agriculture by 0.2091 when the other variables are held constant (Table 3). Hence, households with more active family labour were better placed to participate on conservation agriculture than those with less active family labour. This might be so because of the practices of conservation agriculture are labour intensive since it requires application of conservation techniques.

Table 3 Binary logistic regression for conservation agriculture (142)

List of variables	dy/dx	P-value	Odds ratio	p-value
Education	0.1382**	0.021	2.0655**	0.010
Sex	0.22510	0.231	2.7861	0.201
Farm_Size	0.0008	0.986	1.0046	0.986
Family_Labor	0.2901***	0.000	2.9959***	0.000
Employment	0.5156***	0.003	10.1111***	0.007
Topography	0.0111	0.917	1.0596	0.917
Extension_Service_Promoters	0.0218	0.281	1.1216	0.0.271
Membership	-0.1413	0.185	0.4391	0.270
District	0.0970	0.395	1.6623	0.393

Log likelihood = -49.588925 Wald $\chi^2(9)$ = 51.08 Prob > χ^2 = 0.0000 Pseudo R^2 = 0.4793

***, **, and * significant at 1%, 5% and 10% level respectively.

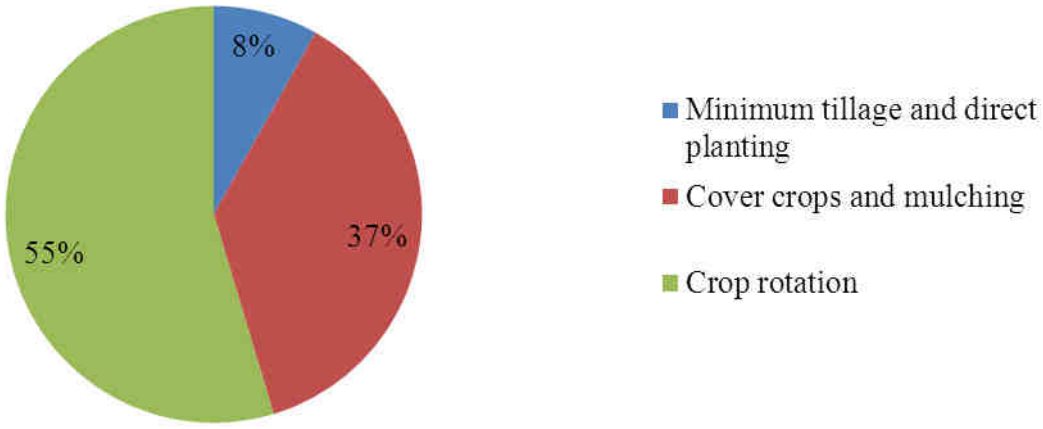
Source: Computed from own survey

Conservation Agriculture can increase the ability of smallholder farmers to adapt to climate change by reducing vulnerability to drought and enriching the local natural resource base on which farm productivity depends. Conservation Agriculture aims at increasing the annual input of fresh organic matter, controlling soil organic material losses through soil erosion, and reducing the rate of soil organic material mineralization (Carlton and Antonio, 2012).

Out of the total 142 respondents 130 were those households who perceive conservation agriculture as an adaptation strategy to climate change. 64 out of 130 households perceived conservation agriculture as an adaptation strategy were those whose average topography of their plots is flat while the rest 66 were those whose average topography of their plots is gentle, steep slope and mountainous.

As illustrated on the following graph about 55 percent of the respondent households adopt the crop rotation technique of conservation agriculture. Cover crops and mulching was undertaken by 37 percent of total household respondent while minimum tillage and direct planting was undertaken by about 8 percent of sample households.

Figure 1 Households undertaking Conservation Agriculture Technique



Source: Own Survey, 2013

Figure 2 Soil conservation based agriculture

4. Conclusion

This study examined the determinants of farmers' participation in conservation agriculture and farmers perception of conservation agriculture as adaptation strategy to climate and used binary logit model to identify the significant variables.

Households with more active family labour were better placed to participate on conservation agriculture than those with less active family labour. Educated farmers tend to conserve their environment, use agricultural extension services and adapt climate change than the illiterates. The households main employment was significantly affect participation on conservation agriculture at probability level less than 5 percent probability level. Farmers with on farm employment were more likely to participate on the conservation agriculture practices than those off farm.

Education affects smallholder farmers to adapt climate change through taking different measures. So, NGOs, government and policy makers should encouraged ways through which smallholder farmers develop their knowledge on adaptation of climate change through adoption of conservation agriculture.

Adaptation measures undertaken in the study area were soil conservation, planting of crop varieties, planting trees, and participating on irrigation. In order to change the damaged environment because of many environmental problems, the government and the policy makers should focus more on these adaptation measures through giving different training for both household farmers and the development agents. The respective government organs at all levels should focus on protection of planted trees on past different occasions.

The crop rotation technique of conservation agriculture was implemented more than any other techniques of conservation agriculture. The full implementation of conservation agriculture requires simultaneous execution of the three techniques; minimum tillage and direct planting, cover crops and mulching and crop rotation. In order to adapt to climate change all these techniques have their own role. Therefore, the government and NGOs should play their role in implementation of these conservation agriculture techniques and encourage the practices of conservation agriculture.

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Appendix 1

Summary of variables included in the study

Variable	Obs	Mean	Std. Dev.	Min	Max
age	142	44.49296	14.17307	22	90
education	142	1.288732	1.139746	0	5
family_size	142	5.830986	2.275281	2	16
sex	142	.8732394	.3338823	0	1
farm_size	142	1.351585	.9485677	.1	7.25
no_of_rela~s	142	7.415493	4.48677	0	24
experience	142	26.71831	13.18573	5	57
marital	142	.8591549	.349093	0	1
employment	142	.8521127	.3562449	0	1
membership	142	.7394366	.4404958	0	1
family_labor	142	4.077465	2.069961	0	13
information	142	.6830986	.4669156	0	1
farmer_ext~n	142	.7253521	.4479166	0	1
farm_income	142	7797.746	5695.917	1170	39960
nonfarm_in~e	142	4043.831	3813.691	0	27550
livestock_~p	142	.7605634	.4282502	0	1
extension_~p	142	.5985915	.4919185	0	1
credit	142	.4295775	.4967681	0	1
distance_i~t	142	15.84894	14.97311	.5	85
distance_o~t	142	13.4757	12.80922	.5	85
local_agro~o	142	.4507042	.4993253	0	1
increase_t~e	142	.6549296	.477074	0	1
decrease_t~e	142	.0492958	.2172512	0	1
nochange_t~e	142	.0633803	.2445082	0	1
decrease_p~n	142	.6338028	.4834696	0	1
increase_p~n	142	.0774648	.2682738	0	1
nochange_p~n	142	.056338	.2313895	0	1
extension_~s	142	2.042254	2.787696	0	12
topography	142	.5211268	.5013218	0	1

.

Source: Computed from own survey (2013)

Appendix 2

VIF test conducted for variables included in binary logit model

vif, uncentered

Variable	VIF	1/VIF
age	52.01	0.019227
experience	33.48	0.029872
sex	18.71	0.053450
marital	18.69	0.053492
family_size	12.73	0.078524
family_labor	10.82	0.092391
employment	7.96	0.125674
membership	5.37	0.186102
farm_size	3.87	0.258397
education	3.01	0.332610
topography	2.17	0.460037
extension_~s	1.91	0.524666
Mean VIF	14.23	

Appendix 3

Correlation Matrix

corr participation_ca age education sex marital farm_size experience family_labor family_size employment topography extension_service_promoters membership district

	part~_ca	age	educat~n	sex	marital	farm_s~e	experi~e	family~r	family~e	employ~t	topogr~y	extens~s	member~p	district
particip~_ca	1.0000													
age	0.3587	1.0000												
education	0.4462	0.0754	1.0000											
sex	0.2123	0.0508	0.3019	1.0000										
marital	0.2118	0.0113	0.4060	0.7585	1.0000									
farm_size	0.0169	0.1746	0.0288	0.1014	0.0992	1.0000								
experience	0.3709	0.9365	0.0767	0.0804	0.0175	0.2206	1.0000							
family_labor	0.5403	0.3915	0.2580	0.0451	0.0839	-0.0347	0.4342	1.0000						
family_size	0.2576	0.2370	0.2733	0.1210	0.1395	0.1094	0.3109	0.6187	1.0000					
employment	0.4351	0.2477	0.1932	0.0798	0.1165	0.0788	0.2598	0.3138	0.1702	1.0000				
topography	-0.1101	-0.2151	0.0203	0.0161	0.0171	0.0743	-0.2255	-0.1759	-0.0404	-0.0817	1.0000			
extension_~s	0.0849	-0.1174	0.0140	0.1734	0.1884	0.2385	-0.0892	-0.1309	0.0928	0.1492	0.1415	1.0000		
membership	0.1447	0.2502	0.0379	0.1596	0.0825	0.3204	0.3365	0.3256	0.2813	0.2498	-0.1194	0.0841	1.0000	
district	-0.0349	0.1118	-0.1002	0.0107	0.0519	0.0493	0.1014	-0.1138	-0.1160	-0.1669	-0.1704	0.3039	-0.0956	1.0000

Appendix 4

Classification Table

estat classification

Logistic model for participation_ca

Classified	True D	True ~D	Total
+	72	12	84
-	14	44	58
Total	86	56	142

Classified + if predicted Pr(D) >= .5
True D defined as participation_ca != 0

Sensitivity	Pr(+| D)	83.72%
Specificity	Pr(-|~D)	78.57%
Positive predictive value	Pr(D| +)	85.71%
Negative predictive value	Pr(~D| -)	75.86%
False + rate for true ~D	Pr(+|~D)	21.43%
False - rate for true D	Pr(-| D)	16.28%
False + rate for classified +	Pr(~D| +)	14.29%
False - rate for classified -	Pr(D| -)	24.14%
Correctly classified		81.69%

Appendix 5

Wald Test for Binary Logit Model

test education sex farm_size family_labor employment topography extension_service_promoters membership district

```
( 1)  education = 0
( 2)  sex = 0
( 3)  farm_size = 0
( 4)  family_labor = 0
( 5)  employment = 0
( 6)  topography = 0
( 7)  extension_service_promoters = 0
( 8)  membership = 0
( 9)  district = 0

           chi2(  9) =   51.08
         Prob > chi2 =    0.0000
```

Appendix 6

Stata Result of Binary Logit Model

logit participation_ca education sex farm_size family_labor employment topography extension_service_promoters membership district, vce(robust) level(96) or

```
Iteration 0:   log pseudolikelihood =  -95.23388
Iteration 1:   log pseudolikelihood = -57.032798
Iteration 2:   log pseudolikelihood = -50.925806
Iteration 3:   log pseudolikelihood = -49.687026
Iteration 4:   log pseudolikelihood = -49.589764
Iteration 5:   log pseudolikelihood = -49.588925
Iteration 6:   log pseudolikelihood = -49.588925

Logistic regression                               Number of obs   =        142
                                                  Wald chi2(9)    =      51.08
                                                  Prob > chi2     =     0.0000
Log pseudolikelihood = -49.588925                 Pseudo R2       =     0.4793
```

participation_ca	Odds Ratio	Robust Std. Err.	z	P>|z|	[96% Conf.	Interval]
education	2.06551	.5797863	2.58	0.010	1.160548	3.676136
sex	2.786101	2.233281	1.28	0.201	.537085	14.45276
farm_size	1.00465	.2566818	0.02	0.986	.5944721	1.697844
family_labor	2.995982	.8477099	3.88	0.000	1.675591	5.356861
employment	10.11106	8.696019	2.69	0.007	1.728583	59.14294
topography	1.05966	.5861323	0.10	0.917	.3402592	3.300069
extension_~s	1.121598	.1168547	1.10	0.271	.9055456	1.389197
membership	.4391115	.3277715	-1.10	0.270	.0947979	2.033999
district	1.662349	.9898557	0.85	0.393	.4893457	5.647138

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