Role of institutional and socio-economic factors on adoption, dis-adoption and non- adoption of soil and water conservation technologies: Empirical evidence from the North Western Ethiopia highlands

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ABSTRACT

Over last four decades the government of Ethiopia in collaboration with consortium of donors has undertaken massive programs of natural resource conservation to reduce environmental degradation, poverty, and increase agricultural productivity and food security. However, the level of adoption of soil and water conservation (SWC) practices remains low. The purpose of this study is to investigate the institutional and socio-economic factors that impede or facilitates adoption , dis-adoption and non-adoption of SWC technologies in the North Western Ethiopian highlands. The descriptive statistics results indicate that sampled households are found in different stages of adoption, i.e., initial adoption (30.5%), actual adoption (21.1%), final adoption (30.9%), non-adoption (13.4%) and dis-adoption (abandonment) (5%). The F-test analysis indicates significant differences among the five adopter categories in terms of household head age , size of cultivable land, number of oxen, and number of farmers participating during collective action. The chi-square analysis shows a significant systematic association among adopter categories in terms of tenure security perception, cooperation with adjacent farm owners, ownership of implements (shovels), perceived problem of erosion, training in SWC, plots slope status and project assistance in SWC intervention. Moreover, the multinomial logit estimates indicate that the adoption stages of the adopter categories are influenced by different socio-economic and institutional factors at different levels of significance.

Key words: Soil and water conservation, adoption, dis-adoption, non-adoption, multinomial logit

INTRODUCTION

The economies of Ethiopia heavily depend on agriculture that is dominated by subsistence smallholder farmers that are partially integrated into markets. The fate of the agricultural sector directly affects economic development, food security and poverty alleviation.. However, the role of this sector in alleviating poverty and food insecurity is undermined by land degradation such soil erosion and nutrient depletion (Shiferaw, 1998; Girma, 2001).

Over the last four decades, the government of Ethiopia and a consortium of donors have undertaken a massive programme of natural resource conservation to reduce environmental degradation, poverty and increase agricultural productivity and food security. However, the adoption rate of SWC measures has been minimal (Shiferaw and Holden, 1998 and 1999; Bewket, 2007; Tefera and Sterk, 2010; Kassie et al. 2010). In the Amhara region in particular, labor intensive SWC technologies have been promoted among farmers to control erosion and increase production. These technologies include line interventions such as stone bund, soil bunds, Fanya Juu bunds[1], and agro-forestry practices. However, most farmers have not adopted these technologies and in some cases farmers have dis-adopted (abandoned) earlier adopted technologies (Tadesse and Kassa 2004; BoARD, 2010). A better understanding of constraints that condition farmers' adoption behaviors are therefore important for designing promising pro-poor policies that could stimulate and sustain SWC measures adoption and productivity change. Most previous adoption studies in Ethiopia and elsewhere are limited in assessing the determinants of adoption versus non-adoption, ignoring factors which influence the different stages of adoption.

The purpose of this study is to investigate the institutional and socio-economic incentives and constraints in the adoption (initial adoption, actual adoption and final adoption, dis-adoption and non-adoption) of line interventions SWC technologies in the North Western highlands of Ethiopia.

METHODOLOGY

Study area

The study was undertaken in three selected watersheds of East and West Gojam Zones of Amhara region, Ethiopia (Debre-Mewi, Anjenie and Dijil watersheds). The zones and the watersheds are selected purposely because of their specific experience with SWC development activities, and their different extent of SWC measures that have actually been implemented. Moreover, the watersheds have diverse physical and socio-economic characteristics. Agricultural systems in these watersheds are small-scale subsistence crop-livestock mixed farming systems.

Data and data collection method

Agro-socio-economic data were collected from primary and secondary sources at regional, zonal, district and farm level. Formal and informal surveys were undertaken to collect primary data. A structured survey and Participatory Rural Appraisal tools (PRA) were used to collect primary data. A two-stage stratified random sampling method was used to select farmers. At the outset, the watershed areas were stratified into

[1] A Fanya juu bund is made by digging a trench and throwing the soil uphill to form an embankment

two categories, i.e., the upper and lower part of the watersheds. From each stratum, farmers were selected randomly. About 113, 60 and 125 farmers were selected randomly from Debre Mewi, Anjenie and Dijil watersheds, respectively.

STATA software is used to analysis the data. F-test and Chi-sqaure analysis is used to analyze the unconditional mean difference between adopter categories and institutional and socio-economic continuous and discrete explanatory variables. Because we have a multiple choice decisions, a multinomial logit (MNL) model is used to analyze econometrically the drivers of different stages of adoption.

Conceptual Framework: Adoption, Dis-adoption and Non-adoption

Our conceptual framework is based on the adoption process of investment in SWC measures (de Graaff et al., 2008, Amsalu and de Graaff, 2007) and from the concept of dis-adoption (abandonment) of the earlier adopted technologies (Niel and Lee, 2001). This framework also incorporates important elements from decision-making processes for the use of soil conservation practices (Ervin and Ervin, 1982), property rights and investment incentives (Besley, 1995) and the role of social capital (Foster and Rosenzweig, 1995; Nyangen, 2008; Njuki et al., 2009).

Adoption is a sequential decision process and it has three major phases, i.e., the acceptance phase, the actual adoption phase and the continued use phase (De Graaff et al., 2008). The acceptance phase generally includes the awareness, evaluation and the trial stages and eventually leads to starting investment in certain measures. The actual adoption phase is the stage whereby efforts or investments are made to implement SWC measures on more than a trial basis. The third phase, final adoption, is the stage in which the existing SWC measures are maintained over many years and new ones are replicated on other fields used by the same farmer. Moreover, some farmers dis-adopted (abandoned) once adopted technologies. Additionally, farmers do not adopt SWC measures for various reasons. Therefore, there are five major categories in the adoption process, i.e., initial adopters, actual adopters, final adopters, dis-adopters and non-adopters (Table 2).

Table 2: Indicators for the respective level of adoption categories for SWC line interventions

Categories	***Indicators***
Initial Adopter	Establishing long term physical SWC measures on 5-25 % of farmarea to be treated
Actual adopters	Continued use SWC for past four years, on at least 25-50% of the farm area to be treated
Final adopters	Continued use, replication and more than 5 years maintained, and in total covering50-100 % of farm area to be treated.
Dis-adopters	Failed to undertake any maintenance and/or have started to remove/abandon the SWC measures
Non-adopters	Never used these type of physical soil and water conservation measures in any plots

RESULTS AND DISCUSSIONS

Adoption categories of soil and water conservation measures

Descriptive analysis results indicate that sample households are found in different categories of adoption (Table 3). Among the sample households, initial adopters (30.5%) and final adopters (30.9 %) hold the largest percentage in the adoption categories. The current mass mobilization campaign program on soil and water conservation may have contributed to the large number of farmers fall in the initial adopter category. Most of the initial adopters have implemented SWC measures in the last two years. About 21.15, and 13.4% of the sample households fall under actual adopters and non-adopters categories. A small number of the sample households have abandoned (dis-adopted)(5%) SWC measures. The main reasons for dis-adoption of SWC measures are: measures were built by mass mobilization without farmers' willingness (37.5%), low social capital (37.5%), free grazing (12.5%), difficulty for oxen ploughing (8.3%) and a reduction of cultivable land through SWC measures(4.2%).

There is also a difference among the adopter categories across the watersheds. Most dis-adopters and non-adopters are found in Debre Mewi watersheds. This may be due to the fact that Debre Mewi watershed has not yet got project assisted SWC interventions, as compared to the other watersheds. In addition, the regular extension program does not undertake rigorous SWC measure activities due to shortage of resources and incentives (cash, tools and training). On the other hand, almost all of the households in Anjenie are final adopter of these type of soil and water conservation practices. This is the result of long term soil and water conservation interventions in the area.

Table 3: The extent of adoption of SWC line interventions, by adoption stage and by watershed

Adoption stage	Watersheds						Total	
	Debre Mewi		Anjenie		Dejil			
	N	%	N	%	N	%	N	%
Initial adopter	42	37.2	0	0	49	39.2	91	30.5
Actual adopter	17	15.0	1	1.7	42	33.6	60	21.1
Final adopter	10	8.8	59	98.3	23	18.4	92	30.9
Dis-adopter	13	11.5	0	0	2	1.6	15	5.0
Non-adopter	31	27.4	0	0	9	7.2	40	13.4
Total	113	100	60	100	125	100	298	100.0

Determinants of adopter categories: Descriptive statistics

Table 4 shows the unconditional mean analysis of the socio-economic and institutional factors determining the different categories of adoption. The F-test analysis shows significant differences among the five adopter categories for age of household head, size of cultivable land[2] (in timad[3]), number of oxen, and number of farmers participating in collective action (during labor shortage time). But there are no significant differences among the adopter categories in number of persons working fulltime in agriculture, actual total farm size [4](in timad), distance from road(in minutes), off-farm income (monthly in Birr), size of corrugated roof.

The average age of non-adopters and dis-adopters is higher compared to the other categories. This can be explained by the fact that older farmers have a short planning horizon compared to younger colleagues. Similarly, the average size of total cultivated land of dis-adopters and non-adopters is smaller than the other categories. This might affect adoption of physical SWC measures as these measures take productive land out of production. On the other hand, initial adopters, actual adopters and final adopters have a larger number of farmers participating in collective action (during the time of labor shortage) as compared to non-adopters and dis-adopters. This indicates the importance of labor for adoption of soil and water conservation practices. Labor inputs constitute the largest costs of SWC line interventions.

The chi-square analysis shows a significant systematic association among adopter categories in tenure security, ownership of implements (shovels), perceived problems of erosion, training in SWC, cooperation with adjacent farm owner, slope status and SWC program in the area by NGO's. On the other hand, there is no a systematic association among adopter categories in education status, perceived problem of erosion and profitability of SWC, social position in formal institutions.

Initial adopters (81.3%), actual adopters (88.3%) and final adopters (81.5%) feel more tenure secure than dis-adopters (66.7%) and non-adopters (67.5 %). This shows that households who feel tenure insecurity may not invest or maintain the soil conservation measures. Their perceived tenure insecurity might shorten their planning horizons and lead to maximizing immediate profits. Dis-adopters (26.6%) and non-adopters (47.5%) have fewer shovels compared to other adopter categories. Conservation equipment are a prerequisite for construction and maintenance of SWC measures. Higher percentages of initial adopters (95.6%), actual adopters (100%) and final adopters (100%) perceived the problems of soil erosion compared to dis-adopters (93.3%) and non-adopters (90.0%). Farmers' decisions on SWC investments can be determined by their knowledge of soil erosion problems. Moreover, initial adopters (28.7%), actual adopters (49.2%) and final adopters (46.7%) have more training exposure on SWC compared to the other adopter categories. Training is one means to create awareness about the problems of erosion and the benefits of SWC measures to motivate farmers to investment in SWC measures.

Dis-adopters (40.0%) and non-adopters (36.8%) have percentage-wise less collaboration with adjacent plot owners compared to other categories of adopters. This shows the social components of SWC measures particularly the importance of cooperation and willingness of the adjacent farmers to invest in and continuously use of SWC measures. Moreover, dis-adopters and non-adopters are less exposed to project assisted SWC interventions as compared to the other categories. This indicates the importance of project assisted SWC interventions for diffusion and adoption of soil and water conservation measures. This is probably because farmers can have access to training and tools and knowledge to implement SWC measures.

The above unconditional mean comparisons of individual socio-economic and institutional variables show that there are differences in some of these variables by adoption status. However, systematic analyses that consider all variables together is important to examine if these variables differently influence each group of adopters.

[2] Actual cultivable land refers to the annual crop production area

[3] Timad is a local unit which is equal to 0.25 ha

[4] Total farm size includes the cultivated land, grazing land, woodland and bare land

Table 4: Descriptive statistics of the explanatory variables for the adoption of SWC line interventions

Variables	Mean of Adopter Category					
	Intial Adopter	Actual adopter	Final Adopter	Dis-adopter	Non-adopter	F- value
Age of HH head (in years)	43.51	43.28	45.55	46.00	51.95	0.004*
Family size (persons)	5.79	5.83	5.98	5.46	5.62	0.749 NS
Persons working fulltime in agriculture (in numbers)	2.14	2.18	2.30	2.13	2.00	0.211NS
Total Farm size(in timad)	4.35	5.11	4.81	4.26	4.70	0.225 NS
Cultivable land(in timad)	3.76	4.75	4.43	3.16	3.73	0.003*
Average plot size (Total farm size/ No.parcel)	0.76	0.94	1.16	0.87	0.92	0.001*
Distance from road (in minutes)	13.57	14.26	16.96	12.13	16.40	0.366NS
Number of oxen	1.94	1.98	2.03	1.20	1.50	0.001*
Number of farmers participating in collective action	5.87	6.08	7.05	3.71	3.30	0.046**
Off-farm income (monthly in Birr)	72.63	34.34	49.94	53.66	71.58	0.565NS
Size(No. of sheets) of corrugated roof	56.74	57.08	53.32	53.26	53.26	0.766NS
	Percentage proportion across adopter categories					**χ2- value**
Tenure security -Yes	81.3	88.3	81.5	66.7	67.5	0.076***
- No	18.7	11.7	18.5	33.3	32.5	
Having shovels -Yes	54.9	70.0	75.0	26.7	47.5	0.000*
- No	45.1	30.0	25.0	73.3	52.5	
Perceived problems of erosion -Yes	95.6	100	100	93.3	90.0	0.013**
- No	4.4	0	0	6.7	10.0	
Is SWC profitable ? -Yes	94.5	97.8	96.7	100.0	100.0	0.326NS
-No	5.1	2.2	3.3	0	0	
Training in SWC -Yes	28.6	49.2	46.7	13.3	17.9	0.000*
- No	71.4	50.8	53.3	86.7	82.1	
Social position in formal institutes-Yes	13.2	6.8	9.9	6.7	0	0.168NS
-No	86.8	93.2	90.1	93.3	100	
Cooperation with adjacent farmers - High	40.4	42.4	67.0	20.0	28.9	0.000*
- Medium	24.7	33.9	26.4	40.0	34.2	
- Low	34.8	23.7	6.6	40.0	36.8	
Plots slope status -Flat	11	1.7	4.3	20.0	30.0	0.000*
- Medium	45	61.0	50.0	60.0	52.5	
- Steep	44	37.3	45.7	20.0	17.5	
Education status-Illiterate	46.2	46.7	39.1	53.3	60.0	0.265NS
- Literate	53.8	53.3	60.9	46.7	40.0	
SWC program in the area - Yes	41.2	70.0	85.9	6.7	10.0	0.000*
- No	58.8	30.0	14.1	93.3	90.0	

***, ** , *****significant at 1, 5 and 10% level of significance, respectively. NS= Not significant

Econometric result

Determinants of Initial, actual and final adoption and dis-adoption

Results of the multinomial logistic regression show tenure security, ownership of shovel and project assistance SWC intervention have positive and significant influence on initial, actual and final adoption stages of SWC. On the other hand, age and off- farm activities have a significantly negative effect for the three categories. Initial adoption stage decrease with residence distance to road and increase with plots slope. Number of persons full time involved in agriculture, number of farmers participating in collective action (during labor shortage time), cooperation with adjacent farm owner and average plots size(ratio of total farm size divided by number of plots) have a positive and significant influence on the final adoption stage of adoption categories. Physical conservation measures need more space so that households with larger plot size and/or non-fragmented plots likely to adopt such measures. Dis-adoption phase is influenced negatively by age and number of persons full time involved in agriculture.

CONCLUSION AND RECOMMENDATION

Farmers have a good understanding about the problems of soil erosion and the benefits of SWC measures. This is could be due to the result of the severity of the land degradation problems and the commitment of the government to avert degradation. But the adoption stages differ from farmer to farmer due to socio-economic and institutional factors. This is because farmers make rational decisions to maximize their expected utility.

The result of the analysis indicates that tenure security is an important factor that affects the probability of investing in soil conservation technologies. Secure land rights increase the planning horizon of farmers to undertake long term investments. Therefore, the land policy should provide long-term and lasting tenure security to the peasant. The initiatives which have been undertaken by the regional government to address the problem of

tenure insecurity through a land certification is a promising approach. But there is a need to investigate the impact of the land certification on tenure security and soil and water conservation investments. The study results also show that ownership of shovels and project assistance for SWC interventions are very important for different stages of adoption. This implies that there is a need for technical support and resources (equipment for SWC measures) for farmers in order to facilitate the adoption process. In addition, the results of the study indicate that availability of labor is very important for continued use of soil and water conservation measures. Specifically, the maintenance costs for the final adoption stage are very important. This implies that conservation structures need to be made less labor demanding by reducing the maintenance costs, i.e., by stabilizing bunds through biological measures.

The study reveals that social capital and specifically cooperation with adjacent farm owners is an important factor for the final adoption and dis-adoption stages of SWC measures. This means that conservation on one farm will have little spillover impact when farm land in adjacent farm areas is not conserved. This implies that the adjacent farm owners need to work together to avert the problems of erosion. Thus, a watershed approach at community level is the remedy for the problems of cooperation between adjacent farms. This is because during watershed approaches, SWC measures are implemented equally at community level. The average plot size (ratio between farm size and total number of plots) is influencing the final adoption stage positively. The average plot size indicates the fragmentation of the farm plots. Land fragmentation may weaken farmer's interest and motivation for investing in SWC practices. In dispersed and fragmented small plots, the cost of investing in SWC measures may not be worth. Either land consolidation or alternative SWC measures is important to enhance the productivity of farm land. In order to reduce dis-adoption (abandonment) of SWC measures, there is a need to establish SWC measures with the willingness of farmers (with participation) and to introduce cost effective (reducing loss of land) SWC measures.

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