Determinants of the Adoption of Physical Soil Bund Conservation Structures in Adama District, Oromia Region, Ethiopia

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Abstract: This study emphasizes the adoption of physical soil bund structures including the major factors influencing the adoption process. The study is based on the data collected from 120 households. Two analytical techniques, descriptive statistics and logistic regression function were employed in analyzing the data. The findings indicate that a host of factors, most of which are policy related, were responsible for poor technology adoption. In this regard, adoptions of technologies are predominantly influenced by economic variables such as land size, livestock holdings and income of the households. Furthermore, institutional factors, such as access to credit, mass media, and extension services as well as the educational level of the farmers are primarily influencing the adoption decision. The results of the study confirm that past extension approaches have been biased against natural resource management. With the exception of physical soil bund structures, other components of soil conservation packages were found to be marginalized. Overall, survey results reveal that integrated natural resource oriented approaches were not adopted. Based on the findings, it is strongly recommended that policy makers and technical institutions should readdress the policy-related issues to facilitate extension systems that will ensure environmentally sustainable development.

Keywords: Adoption; Conservation; Physical Structures; Small Scale Farmers

1. Introduction

The agriculture sector in Ethiopia must nearly double its yields on existing farm land to meet food needs, which are increasing due to the high growth rate of the population. In Ethiopia, agriculture contributes a significant share of family food self-sufficiency and national food security, playing an important role in the development of the national economy. In this regard, the Ethiopian Economic Association contends that agriculture is the mainstay of the national economy, where has accounted for about half (47%) of the Gross Domestic Product (GDP) in recent years and more than 80% of the economically active rural population earning their livelihood from crop and livestock production (EEA, 2005). However, despite its importance for national development and food security, agricultural land productivity is declining as time progresses while the population is increasing at a fast growth rate. The main reason behind the low productivity of farm land is attributed to land degradation which is commonly concerned with soil degradation of the arable land. In Ethiopia in general and in East Shewa Zone in particular, agricultural land has been under continuous cultivation for the past several decades and it is physically and chemically degraded. The Central Rift Valley, (the study area), is among the severely degraded areas, where the severity of the problem is aggravated by erosive agricultural practices.

In this regard, the fundamental attempts for agricultural and rural development necessitate the extension of intervention to promote improved agricultural technologies and appropriate natural resources management. To this end, the Ethiopian government has initiated a massive program of soil and water conservation with the support of international organizations. In addition to these efforts made through conservation related projects, considerable attention has been put in place for the promotion of soil and water conservation practices through national extension package programs as a part of the agricultural development strategy. However, from experiences over the past years it appears to have not made progress with respect to bringing major impacts on the adoption of modern technologies (Wagayehu, 2003). On the other hand, despite widespread soil degradation and a low level of technology adoption, the limited efforts have been made to identify the nature of physical soil bund conservation structures adoption and have not been sufficient to summarize defined conclusions. Therefore, this study examines the adoption of physical soil bund conservation structures and determines the influencing factors in the study community.

2. The Study Methodology

This study was conducted in Adama District in East Shewa Zone, Oromia Regional State, Ethiopia. The target population was farmers who are living in the peasant associations (PAs) of the district who have participated in the extension package program and soil conservation projects. The sampling procedure adopted was stratified cross-sectional sampling method. The district was divided into three sub-groups based on the agro-ecology, and then two PAs were selected from the peasant associations of each agro-ecology. A sampling frame was prepared from a list of farmers on a membership registration book. For data collection purposes, six PAs were included in the study group and 120 farmers (20 from each PA) were selected by random sampling procedure. The selection of sample PAs was also conducted by random sampling procedure within each sub-category of peasant association. Therefore, based on a suggestion made by

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Poate and Daplyn (1993) in the first stage of sampling, six PAs were selected by random sampling techniques in each category and, in the second stage, twenty farmers were selected from each selected PA using simple random sampling technique. In order to maximize the reliability of the results, relevant information was collected from primary and secondary data sources for analytical purposes, as well as for crosschecking of the information. The primary information was collected from sampled farmers by enumerators who administered the structured interview schedule. Finally, data collected from different primary and secondary sources were summarized and transferred into Statistical Package for Social Sciences (SPSS) computer program. Using SPSS sub programs, the descriptive statistical techniques were employed to determine the nature of data for final decisions and recommendations.

In the meantime, Logit statistical model was selected for further data analysis and interpretation. According to Karki and Bauer (2004), this is the most commonly used econometric model with limited dependent variables and is used to examine the relationship between adoption and determinants of adoption. Based on Gujarati (1988) and Bohrnstedt and Knoke (1994), the following Logistic distribution model was selected and employed to determine the odds (probability) of physical soil bund structure adoption decision of the farmers.

$$P_i\,(adoption) = \frac{1}{1+e^{-z_i}} \quad ----------(1)$$

(Probability of technology adoption)

$$1-P_i\,(Nonadoption) = 1-\frac{1}{1+e^{-z_i}} \quad ------(2)$$

(Probability of technology non-adoption)

$$\left[L_i = Log\left[\frac{P_i}{1-P_1}\right] = Z_i = b_0 + b_1x_1 + b_2x_2 + --- + b_nx_n + u_i \;--(3)\right]$$

Thus, the logit (L_i) multiple regression model (logistic distribution) containing 12 predictors (binary and continuous variable) was specified and regressed against dependent binary of soil bund technology adoption. In order to estimate the probability of adoption of the physical soil bund conservation structure, the above model (equation 3) was employed considering that technology adoption is a dichotomous dependent variable and independent variables are socio-economic factors that can influence the adoption process.

3. Results and Discussion

3.1. Demographic Variables and Physical Soil Bund Structures Adoption

The demographic variables considered in this study are age of the family head, educational level, family size, sex and marital status of the respondent. To determine the influence of the age characteristics of the sample households on the adoption of physical soil bund structure, a comparison was made between different age categories of the respondents and was tested using frequency of each category. Results showed that about 78.3% of the respondents were within the age range of 30 to 60 years which is considered to be the effective age group to produce food, whereas 10 and 11.7% were below 30 and above 60 years, respectively (Table 1). These findings are consistent with other findings in Arsi zone (Haji, 2002) which indicated that the proportions of young and older farmers are lower compared to other age categories and the same source contends that the low proportion of this age group is due to lack of access to land resources.

Table 1. Adoption of soil bund in relation to age of the respondents.

Age category	Adopters		Non-adopters		Total	
	Number	Percent	Number	Percent	Number	Percent
< 30 years	10	8.3	2	1.7	12	10.0
30-40 years	35	29.2	7	5.8	42	35.0
41-50 years	22	18.3	6	5.0	28	23.3
51-60 years	22	18.3	2	1.7	24	20.0
> 60 years	9	7.5	5	4.2	14	11.7
Total	98	81.7	22	18.3	120	100.0

More specifically, about 68% of physical soil bund structure adopters were found to be within the age range of 50 and below years, while the remaining 32% of the adopters were found to be above the age of 50 years. These findings are consistent with literature, which confirms that younger farmers are more likely to be adopters of technology. When a comparison is made between the different categories, the farmers within age category of 30 to 40 years were found to be high adopters (of total respondent, 29.2%) of the physical soil bund structures, while only 5.8% of this group had not adopted the technology. On the contrary, out of the total respondents, only 8.3% of the farmers within the age category below 30 years were found to be adopters. The proportion of the older farmers (above 60 years) in the whole sample was about 12% and, within this age category, 9.2% were found to be adopters of soil bund structure technology (Table 1). These findings were also consistent with the findings from North Shewa Zone reported by Mulugeta (2000) which stated that, as the age increases, the decision to invest on land conservation decreases.

Family members are considered to be all persons related to the particular farmer and dependent on family farm land (Mulugeta, 2000). The survey results show that the average family size of the respondents was found to be 6.54 persons which, according to CSA (1995) cited by Mulugeta (2000), is above the national average of 5.17 persons per family and also greater than the regional average of 5.4 persons reported in the CACC (2003). When the adoption situation of the respondent is considered, about 67% of soil bund technology adopters were found to be those respondents with 3 to 8 family size out of the total sample farmers, whereas this group of farmers constitutes about 82% when considered only among the adopters category (Table 2). The proportion of non-adopters in such categories of family size (3 to 8 family members) was found to be 68.2%, whereas the remaining 31.8% are within the family size categories of below three and above eight when considering the non-adopters category only.

Table 2. Adoption of soil bund in relation to family size.

Category of family size	Adopters		Non-adopters		Total	
	Number	Percent	Number	Percent	Number	Percent
< 3 members	1	0.8	3	2.5	4	3.3
3-5 members	29	24.2	5	4.2	34	28.3
6-8 members	51	42.5	10	8.3	61	51.0
9 and above	17	14.2	4	3.3	21	17.5
Total	98	81.7	22	18.3	120	100.0

Based on the survey information, the results related to level of education of the respondent are summarized and presented in Table 3. According to these findings, out of the total sampled households, 80 respondents (about 67%) have formal education. Out of the total adopters, about 65% have formal education, whereas the remaining 35% are adopters with no formal education. Literature on soil conservation, for example, Tesfaye (2003) confirms that the better educated farmers show better positive response to soil conservation technology adoption and better decisions on soil bund retention on their farm land, which is adequately consistent with these findings.

Table 3. Adoption of soil bund with respect to level of education.

Level of education	Adopter		Non-adopter		Total	
	No.	%	No.	%	No.	%
No formal education	34	28.3	6	5.0	40	33.3
Adult education	6	5.0	3	2.5	9	7.5
Primary education	35	29.2	10	8.3	45	37.5
Junior-secondary	15	12.5	1	0.8	16	13.3
Secondary education	8	6.7	2	1.7	10	8.3
Total	98	81.7	22	18.3	120	100.0

More specifically, the numbers of those who have primary education were relatively high in both adopters and non-adopters with about 36 and 45% of each category, respectively. On the other hand, survey results show that, out of 71 respondents who have above adult education, nearly 82% adopted physical soil bund structures (Table 3) and this result is more or less closer to the findings of Mulugeta (2000) who reported that 89.7% of farmers who attend formal education were users of physical soil conservation structures. Moreover, Weir and Knight (2000) suggested, indicating that the more educated the farmers, the more rapidly adoption and diffusion would take place in that particular community.

Table 4 provides the sex composition of the respondents as related with farmer's adoption trends of physical soil bund structure in the sampled farmers. Based on the survey results, it was evident that, out of the total of 120 respondents, 78% were found to be male-headed households, while about 22% of respondents were female-headed households. The proportion of households headed by males is substantially higher than that of females, reflecting the fact that males in most Ethiopian societies assume execution of the major roles of the agricultural activities and the head is considered as the main bread winner in the household as well as the one who bears responsibility for the household. In general, the findings of the survey indicate that there is a strong relationship between technology adoption and sex of the respective farmer and this result is consistent with the results reported by Yisehak (2002), who indicated the existence of a significant relationship between sex of the respondents and use of improved seeds in the study community.

Table 4. Adoption of soil bund with respect to sex composition.

Sex category	Adopters		Non-adopters		Total	
	No.	%	No.	%	No.	%
Female	20	16.7	6	5.0	26	21.7
Male	78	65.0	16	13.3	94	78.3
Total	98	81.7	22	18.3	120	100.0

Regarding adoption rate, out of a total of 94 male respondents, about 83% were found to be adopters of physical soil bund structures, whereas the proportion of female adopters in the female category was nearly 77% (Table 4). In addition, about 80% of the adopters were male and 20% were female adopters in the adopters' category of respondents and, in the same manner, the proportion of male respondents was higher than female respondents in the category of non-adopters. Furthermore, the analysis of survey data shows that, among the total respondents, the majority (93.3%) were married, whereas the remaining 6.7% were found to be single household headed, due to either not being married, or being widowed or divorced, and among total non-adopters, the largest proportion (about 82%) of respondents were found to be married and only the remaining 18% of the non-adopters were single farmers. Concerning physical soil bund practices adoption, nearly 96% in the adopter category were married males and the remaining 4% were married female respondents.

3.2. Adoption Status and Comparison of Major Soil Conservation Practices

The overall analysis and comparisons for many introduced soil conservation practices were conducted and are presented in Table 5 in order to determine the status of adoption and make relative comparison between different practices with respect to farmers adoption of each practice which can help the researcher to generate conclusions concerning the attention and support of those particular practices and recommendations which is the ultimate goal of the study. Nearly 82% adoption rate for physical soil bund structures is found to be encouraging by ignoring the resources consumed with respect to the promotion of these practices in the past Food for Work Program (WFP) implementation years.

Contrary to the adoption of soil bunds, the adoption rates of conservation tillage (0.8%), fallowing (2.5%) and use of crop residue (7.5%) were found to be discouraging and they are first, second and third from the last, respectively. The other worst aspect of these practices is that 80.8%, 76.7 and 74.2% of the respondents are not aware of conservation tillage, fallowing and use of crop residue, respectively (Table 5). In these aspects, the findings show that past extension approaches were lacking appropriate packaging and integration of agricultural and natural resources oriented technologies to sustain land resource.

Table 5. Comparison of adoption of different soil conservation practices.

Conservation practices	Adopters		Non-adopters		No awareness	
	Number	Percent	Number	Percent	Number	Percent
Soil bund	98	81.7	22	18.3	Nil	Nil
Crop rotation	85	70.8	29	24.2	6	5.0
Intercropping	47	39.2	29	24.2	44	36.7
Conservation tillage	1	0.8	22	18.3	97	80.8
Reforestation	74	61.7	31	25.8	15	12.5
Use of crop residue	9	7.5	22	18.3	89	74.2
Contour farming	58	48.3	39	32.5	23	19.2
Area closure	81	67.5	33	27.5	6	5.0
Fallowing	3	2.5	23	19.2	92	76.7

From an agricultural point of view, land is an indispensable factor for crops and livestock production and the proper utilization of land under different components would contribute to the development of national agricultural production (CACC, 2003). However, the results of this study indicate that the attempt to promote proper land utilization to sustain agricultural land productivity looks minimal in the study community.

3.3. Socio-Economic Variables Associated with Soil Bund Adoption

Before moving on to look at the detailed analysis of the farmer's and farm characteristics effect on technology adoption, the usual procedure to test for means differences and tendency of association between variables were conducted using independent T-test and Chi-square test techniques, respectively. The results of these two test statistics are presented in Table 6 for continuous variables and in Table 7 for categorical variables. As shown in Table 6, except land holding, all selected variables were found to be statistically significant, indicating that physical soil conservation technology adoption decisions had significant association with the mentioned respective variables. In this aspect, characteristics of the household, such as age, education level attained by farmers and family size of the respondent, appeared highly significant ($P < 0.01$). Moreover, the remaining variables that are livestock holding and yearly income of the household also were found to be significant ($P < 0.05$) ensuring dependency of physical soil conservation technology adoption on these two variables.

Table 6. Summary of means' difference for discrete explanatory variables.

Continuous variable	Mean for different categories			T-Test	
	Adopters	Non-adopters	Mean difference	T-Value	P-Value
Age of respondent	43.35	54.10	-10.74	-2.829	0.009**
Education level	3.84	1.43	2.41	3.300	0.002**
Family size	6.53	6.05	0.48	0.804	0.003**
Land holding (ha)	2.51	2.66	-0.15	-0.505	0.614ns
Livestock (TLU)	3.81	2.75	1.06	1.278	0.025*
Yearly income (Birr)	3281.23	1905.67	1375.57	2.024	0.045*

*** and * = Significant at P < 0.01and P < 0.05, respectively; ns = Non-significant at P < 0.05.*

Age of the household head is negatively associated with adoption of physical soil bund structure (Table 6), which is similar to other study findings, while the result of the negative association of the landholding was unexpected and uncommon in most of the previous empirical studies. Federe *et al.* (1982) suggested relatively closer or similar results with these findings, stating that farm size is one of the factors on which empirical adoption study is focused but that farm size can have different effects on the rate of adoption depending on the characteristics of technologies and institutional setting of the service delivery system.

On the other hand, the relationships between adoption of physical soil bund structure and other variables, like education level of the household, family size, age, livestock holding and yearly income of the household were found, as expected, to have positive association to adoption. In the meantime, influence of landholding on adoption of physical soil conservation practices appeared to be insignificant in this particular study. According to Wegayehu (2006), age of household head can influence the availability of labor and that is one of the most important factors of production to farmers in rural areas. This, in turn, determines the decision of households as to which soil conservation type to adopt on their farm land and our results are consistent with his findings. In the meantime, it has been realized from literature reviews that many categorical variables practically affect the adoption of soil conservation technologies in the small scale farming systems of Ethiopia in general and in the study community in particular. Table 7 shows detailed investigations of these categorical variables in this study.

Table 7. Association between categorical variable and soil bund adoption.

Categorical variables	Adoption (%)		Chi-square	
	Non-adopters	Adopters	X^2-Value	P-Value
Gender (sex):				
Male	11.7	66.7	4.988	0.026*
Female	5.8	15.8		
Marital status:				
Married	15.0	78.3	57.408	0.000**
Single	2.5	4.2		
Responsibility in PAs:				
Yes, have	2.5	30.0	1.833	0.176ns
No, don't have	15.0	52.5		
Availability of credit:				
Yes, available	14.2	70.0	25.757	0.000**
Not available	3.3	12.5		
Access to mass media:				
Yes, accessible	15.0	69.2	0.007	0.933ns
Not accessible	2.5	13.3		
Sources of information:				
Extension staff	14.2	66.7	17.652	0.000**
Non-extension staff	3.3	15.8		
Main occupation:				
Crop farming	15.0	56.7	13.672	0.000**
Mixed farming	2.5	25.8		

*** and * = Significant at P < 0.01and P < 0.05, respectively; ns = Non-significant at P < 0.05.*

Regarding the effect of sex on technology adoption, Wegayehu (2006) suggested that sex of household determines access to soil conservation technological information provided by extension agents and soil conservation related projects operating in the area. Apparently, the marital status and social participation (responsibility in PAs) would also influence the adoption of any particular technology. The results of this survey indicate a strong association between social characteristics of the farmers and soil conservation technology adoption. The sex of the respondent with Chi-square of 4.99 and the marital status of the household with Chi-square value of 57.41 were found to be statistically significant, ($P < 0.05$) and ($P < 0.01$), respectively. In addition, the main farming system of the respondent also formed part of this study and it was found to be statistically significant with a Chi-square value of 13.67, indicating strong association between soil conservation technology adoptions and farming system. Among the many institutional variables, it was realized that credit facility, with Chi-square value of 25.76, and source of extension information, with Chi-square value of 17.65, were statistically significantly ($P < 0.01$) different (Table 7).

3.4. Economic Variables and Physical Soil Bund Structure Adoption

The economic variables include the estimated yearly income, land holding and main occupation of the farmers. Concerning family yearly income, the result shows that the minimum income of the respondents who reported was 300 *Birr* and the highest was found to be 23,260 *Birr,* indicating an average household income of

3,038.5 *Birr* with 2,863.0 *Birr* standard deviation and tossing coefficient of variation (CV) of about 94%. Furthermore, the results indicate that about half (45.8%) of the respondents earned a yearly income in the range of 1,000 to 3,000 *Birr*. Those in the yearly income categories of less than 1,000 *Birr* and those with greater than 7,000 *Birr* constitute nearly 15.8 and 7.0%, respectively (Table 8). In general, based on these results, it is possible to predict that the better the yearly income, the more such farmers would adopt the introduced conservation technology to alleviate the land degradation process.

Table 8. Adoption of soil bund with respect to yearly income of households.

Income category	Adopters		Non-adopters		Total	
(*Birr*)	Number	Percent	Number	Percent	Number	Percent
< 1000	8	6.7	11	9.2	19	15.8
1,000-3,000	40	33.3	15	12.5	55	45.8
3,001-5,000	22	18.3	6	5.0	28	23.3
5,001-7,000	6	5.0	4	3.3	10	8.3
7,001-10,000	5	4.2	1	0.8	6	5.0
> 10,000	2	1.7	0	0.0	2	1.7
Total	83	69.2	37	30.8	120	100.0

Coefficient of variation (CV) ≈ 94%

The discussion of this section is based on the results of household farm size summarized in Table 9, in which the overall average landholding of the households was found to be 2.54 ha with corresponding standard deviation of 1.2 ha, leading to about 47% coefficient of variation. The findings indicate that the average farm land holding of the study PAs is greater than one hectare of national average in the country, as reported by EEA (2000) cited in Haji (2002) and as well as the regional average of 1.36 ha per household. In the study group of the district, a total of 64 respondents (53.4%) are reported to be in the range of farm land holding category of 0.5 to 2.5 ha of land and these findings are closer to the 52.1% reported by the CACC (2003) and 39.2% of the respondents were land holders within the range of 2.5 to 4.0 ha (Table 9). The remaining 7.5% includes the holders of less than half and greater than four hectares.

Table 9. Adoption of soil bund structures in relation to land holding.

Land size category	Adopters		Non-adopters		Total	
(ha)	Number	Percent	Number	Percent	Number	Percent
< 0.50	2	1.7	1	0.8	3	2.5
0.50-1.50	27	22.5	5	4.2	32	26.7
1.51-2.50	25	20.8	7	5.8	32	26.7
2.51-4.00	41	34.2	6	5.0	47	39.1
> 4.00	3	2.5	3	2.5	6	5.0
Total	98	81.7	22	18.3	120	100.0

Coefficient of variation (CV) ≈ 47%

With respect to adoption of soil conservation structures, a total of 41 farmers (34.2%) in the land holding category of 2.5 to 4.0 ha were adopters of the introduced physical soil bund conservation practices in the study areas with the corresponding 5.0% of non-adopters. Furthermore, out of the group with farm land size in the range of 0.5-2.5 ha, the adopters and non-adopters constituted 43.2 and 10.0% of the total respondents, respectively (Table 9). The results showed that optimum land size ownership might be the major factor in promoting technology adoption in the small scale farming systems of Ethiopia in general and Adama District in particular.

Moreover, the results of the investigation on different occupational opportunities for farmers considered in the study revealed that crop farming and mixed crop-livestock farming are the two major occupations (Table 7) while livestock farming (pastoralist) is not commonly practiced in this particular farming community. In this respect, the results indicate that about 72% of the total respondents are engaged in crop farming out of which 56.7% were found to be adopters of physical soil bund structures, whereas the rest, 15% of the sample size, were not adopters. On the other hand, out of a total of 120 respondents, 34 (28.3%) were engaged in crop-livestock mixed farming and 30 farmers, 88.2% of this group or 25.8% of the total sample size (Table 7) were found to be adopters of physical soil bund structures.

3.5. Farm Land Related Variables and Adoption of Soil Bund Structures

In this study, farm land related variables include the physical conditions of particular farms, farm land distance from household residence and public facilities. Data of the respondents' farm land condition (erosion status) and farm land distance from the residence of the respondents are presented in Tables 10 and 11, respectively, and farm land distance from other public support providing facilities are also discussed in this section.

Table 10. Observed erosion problem on household farm land.

Category of soil erosion status	Adopters		Non-adopters		Total	
	Number	Percent	Number	Percent	Number	Percent
Very severe	65	54.2	7	5.8	72	60.0
Severe	32	26.7	10	8.3	42	35.0
Minor	1	0.8	3	2.5	4	3.3
No problem	0	0.0	2	1.7	2	1.7
Total	98	81.7	22	18.3	120	100.0

Basically, natural farm land characteristics and the erosive features of the soil represent major factors in dictating human intervention in small scale farming systems. With respect to biophysical condition of the farm land, the overwhelming majority of respondents (95%) reported very severe and severe soil erosion problems, including fertility decline and water logging, whereas only 5% of the total sample had only minor or no soil degradation problems on their farm lands (Table 10). Of the group with very severe and severe soil erosion problems, about 85% adopted physical soil bund conservation practices. On the contrary, only 16.7% of the group with minor or no soil degradation problem adopted the physical soil bund conservation structures, while the remaining 83.3% reported that they had no relevant reason to adopt physical soil bund structures.

Moreover, with respect to farm land distance, out of the total respondents, 63 farmers (53.4%) whose location of farm land is less than 2 km from their home were found to be physical soil bund structures adopters (Table 11). In addition, farmers constituting 24.6% of the total respondents in the 2 to 4 km distance category have adopted introduced technology. Five respondents (4.2%) of the category with farm land located at more than 4 km distance were found to be adopters of soil bunds. In the same manner, about 69% of the total respondents, whose farm land is within the near and medium distance (below 4 km) to development centers, category, were more likely to adopt physical soil conservation structures and, on the contrary, nearly 18% of the respondents in the same distance category to development center were non-adopters of conservation structures.

Table 11. Effect of farm land distance from residence on soil bund structure adoption.

Farm land distance category (km)	Adopters		Non-adopters		Total	
	Number	Percent	Number	Percent	Number	Percent
Not far (< 2 km)	63	53.4	16	13.6	79	67.0
Medium (2-4 km)	29	24.6	5	4.2	34	28.8
Far (above 4 km)	5	4.2	0	0.0	5	4.2
Total	97	82.2	21	17.8	118	100.0

With regards to road infrastructure facility, the results of this study indicate that 42% of the total sample who adopted the physical soil bund structures was those whose farm land distance from road facility were more than 6 km. This value is relatively higher than 39.5% of the total respondents whose farm land is within 4 km distance from primary roads and found to be adopters of the soil bunds. As argued by the EEA (2006), these findings also revealed that under development and poor infrastructure in the country in general and in the study area in particular are raising doubt about the economic feasibility of the technology adoption.

3.6. Institutional Support Related Variables Without Respect to Adoption

This section deals with the influences of institutional support related variables, mainly extension service, access to mass media and farmers' experience in physical soil conservation related projects including level of farmers' participation in the decision making process, on adoption rates of the conservation structures. With regard to extension services delivery, 36.4% of the respondents, confirmed that they were visited 1 to 2 times (days) per month by Development Agents (DAs), followed by 34.8% being visited 3 to 4 days per month. On the other hand, 6% of the total respondents reported no visit by DAs to their home or farm land. The investigation on DAs' visits to farmers shows that the farmers who were visited 3 to 4 days per month amounted to 41 out of whom 97.6% were found to be the adopters implying that the more visits received from development agents, the more likely farmers were to adopt physical soil bund structures to reduce soil degradation process on their farm lands. Out of the total respondents, only a few (2.5%) of non-visited farmers were found to be adopters of the promoted soil bund technology.

In the extension information delivery system, mass media are the most common extension channels to reach even the remotest areas and the majority of rural population in the country. As a result, the survey results reveal that 73.3% of the respondents had access to mass media (Radio, News Papers and Television) and were helped by it to adopt physical soil conservation practices, while the remaining 26.7% had no access to any kind of mass media in the past three to five years. Furthermore, about 82% of the total farmers who had access to radio were found to be adopters of physical soil bund structures to sustain agricultural land productivity.

In this study, farmers' experience of soil and water conservation related projects indirectly refers to any form of assistance rendered to the farmers in the area of soil conservation with the ultimate goal to promote adoption of soil conservation technology by avoiding resource limitation. Tables 12 and 13 present summary of survey data of farmers' experience in conservation related projects and level of farmers' participation in planning and evaluation processes, respectively. As indicated in Table 12, the majority (98.3%) of the total respondents were involved in different soil conservation related projects for 5 to 20 years and out of this group, about 83% were found to be adopters of physical soil and water conservation (soil bund) structures.

Table 12. Farmers' experience in soil conservation related projects.

Farmers' experience	Adopters		Non-adopters		Total	
	Number	Percent	Number	Percent	Number	Percent
No experience	1	0.9	1	0.9	2	1.7
< 5 years	4	3.4	2	1.7	6	5.2
5-10 years	39	33.6	14	12.0	53	45.7
11-15 years	13	11.2	0	0.0	13	11.2
16-20 years	17	14.7	1	0.9	18	15.5
> 20 years	22	19.0	2	1.7	24	20.7
Total	96	82.8	20	17.2	116	100.0

Table 13. Level of farmers' participation in planning and evaluation process.

Level of farmers' participation	Adopters		Non-adopters		Total	
	Number	Percent	Number	Percent	Number	Percent
Very good	1	0.8	Nil	Nil	1	0.8
Good	13	11.1	1	0.8	14	12.0
Satisfactory	23	19.7	2	1.7	25	21.4
Poor	37	31.6	5	4.3	42	35.9
Not at all	22	18.8	13	11.1	35	29.9
Total	96	82.1	21	17.9	117	100.0

Concerning participation in planning and evaluation processes of conservation projects, about 66% of the responding farmers reported their participation in same as poor and/or had no participation at all in the process of the development projects (Table 13). However, 76.6% of this particular group was found to be adopters of physical soil bund structures which might be due to the heavy promotion or publicity by the projects regardless of participation. The remaining 34.2% reported that their participation was very good to satisfactory and the adoption rate within this group which was about 93% is a very good indication of the influence of participation on technology adoption.

Furthermore, the survey related to level of farmers' participation went further and included assessment of their participation in problem identification, priority setting and decision making process. In this regard, about 24, 39 and 37% of the relevant respondents confirmed that they had poor participation in problem identification, priority setting and decision making process, respectively. The remaining proportion reported their participation in the mentioned project process as very good, good and satisfactory. In general, the results indicate that there is positive correlation between farmers' participation in the project process and technology adoption. In summary, the findings of the survey indicate that, in the past extension intervention, farmers' participation at different stages of the development project, including soil conservation related projects, was a neglected area.

3.7. Logistic Regression Summary and Discussion.

In this particular study, to look for a suitable model for selecting variables among total independent variables, different techniques and tools were employed to establish a relevant regression line to determine the relationship between dependent and independent variables. The dependent variable, which is adoption of physical soil bund structures, was taken as a categorical (dichotomous) variable with binary representation; while independent variables were a mixture of continuous and categorical variables, in which categorical variables were arranged in a binary manner as indicated in Table 14.

Table 14. Parameter estimate for adoption of physical soil bund structures.

Explanatory variables	Parameter estimates			
	Coefficient	Wald statistics	Exp (B)	P-Value
Constant	1.629	0.901	5.101	0.343 ns
Age of household head (years)	-0.084	7.180	0.919	0.007***
Sex of household head (1)	1.843	4.765	6.317	0.029**
Education level (years)	0.231	2.979	1.260	0.084*
Labor shortage (1)	-0.729	1.226	0.482	0.268 ns
Information source (1)	0.678	0.536	1.969	0.464 ns
Experience in projects (years)	0.043	0.740	1.044	0.390 ns
Farm land distance from development center (km)	0.479	3.713	1.615	0.054*
Land holding (ha)	0.458	1.871	1.580	0.171 ns
Access to mass media (1)	2.724	3.392	15.249	0.066*
Access to training (1)	0.260	0.147	1.297	0.701 ns
Land renting experience (1)	-1.462	3.050	0.232	0.081*
Livestock holding (TLU)	0.130	0.428	1.139	0.513 ns

****, ** and * = Significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively; ns = Non-significant at $P < 0.10$.*

Regarding the fitness of the selected regression line, the model Chi-square (X^2) of 35.39 appeared statistically significant, indicating that including selected explanatory variables significantly reduced the log likelihood ratio of the model when compared with the model established using only intercept. The classification table classified and correctly predicted 95.7% of the adopters and 50% of the non-adopters, whereas the model's overall correct prediction was found to be 87.5%. From regression analysis, access to mass media was found to be the leading variable in influencing the change in odds ratio of the technology adoption. The observed 15.25 odds ratio for accessibility of farmers to mass media (Table 14) indicated that the odds of adoption were higher for each one point increase in respondent's accessibility to any kind of mass media. On the other hand, odds ratio of land renting was smallest of all, in the opposite direction, indicating that with a one point increase on the experience of land renting scale being associated with the odds of disapproving (non-adoption) the technology would increase by a multiplicative factor of about 0.25 point. For the sex (dummy variable), the 6.32 odds ratio means that the odds (probability) of approval of the technology adoption by the farmer would increase by this point as the binary dummy variable changed to one point.

Furthermore, seven explanatory variables (education level, source of information, farm land distance from development center, land size, farmers' experience in conservation related projects, livestock holding and farmer training) make a different contribution to odds ratio in the expanded model varying between greater than one and less than two, indicating positive association between predictors and technology adoption. On the other hand, three of the explanatory variables-age, labor shortage and experience of land renting-influence the odds ratio of technology adoption by less than one factor, indicating negative association between explanatory variables and binary technology adoption. In general, eleven explanatory variables, except farm land distance from development center, provided similar association as predicted and, out of the variables, farm land distance moved in the opposite direction to hypothetical assumption which suggests negative association with technology adoption. Overall, out of the selected twelve explanatory variables, 50% were found to be significant at different probability levels. In this regard, the age of respondents was statistically highly significant ($P < 0.01$), sex of household head was statistically significant ($P < 0.05$), and the remaining four explanatory predictors (farm land distance, education, access to mass media and land renting) were found to be statistically significant ($P < 0.1$) among the variables attaining significance at different statistical significance levels (Table 14). The model results confirm that the educated farmers are more likely to adopt physical soil bund structures compared to those who did not attain formal education due to the fact that educated farmers would have more access to information. This indicates that farmers with formal education are likely to be aware of soil degradation severity which motivates them to seek appropriate innovation in order to mitigate the degradation process.

4. Conclusion

The survey results indicated that a majority of respondents perceived soil erosion and soil fertility decline as the major threats to their farm land sustainability, since the problem of soil degradation is very serious on crop land. However, despite the widely prevailing problems of farm land degradation, adoption of most of the biological and physical soil conservation technologies appeared minimal. Basically, practices such as crop rotation, intercropping, fallowing, conservation tillage and crop residue management are essential components of soil conservation packages to enhance soil fertility of farm lands, but the adoption rate of those practices was found to be poor compared with soil bund structure indicating lack of appropriate packaging of the technologies in the farming system.

Due to lack of emphasis on extension service delivery systems in the past extension package program implementation, almost all soil conservation practices have been marginalized throughout the past many years, leading to non-sustainable farm land productivity. According to the findings of this study, participation of the farmers in extension package programs has improved the use of agricultural technologies among the farming community in previous years, but integration of agricultural technologies with environmentally-sound technologies and management is lower than the theoretical recommendations, leading to natural resources degradation and threats to environmental sustainability.

The study further revealed that almost all predicted socio-economic factors appeared to influence the adoption of soil bund structures in the small farming communities. In this regard, participation of farmers in soil conservation programs and adoption of introduced technologies are predominantly influenced by economic variables such as land size, livestock holdings and yearly income of the households. As confirmed by the findings of the study, farmers with greater resources are more likely to participate in the program and then adopt the introduced technologies compared to resource-poor farmers. Furthermore, institutional factors, which are mostly concerned with access to credit, mass media and extension services, primarily affect the physical soil bund structures adoption. Moreover, educational level of the farmers was also observed to facilitate the technology promotion process and the adoption decisions of the farmers. In this regard, farmers with a higher educational level were found to be greater technology adopters compared to non-educated farmers.

The survey findings further revealed that participation of farmers in the decision-making process of the development project was poor which is contrary to stated principles in national strategy. In reality, most of the approaches lacked elements of participation and were not encouraging the farmer's active participation in decision-making process. Overall, based on the evidence of this and other empirical studies, many policy-related issues need to be considered to promote economically and environmentally-sustainable development in the small-scale farming system. Generally, according to the study results, most of the major soil conservation practices that are important for packaging with physical soil bund conservation structures were found to be neglected. Hence, based on the findings of the present study, it is recommended that policy makers and technical departments should pay particular attention to those practices that have been marginalized in the past implementation years and follow an integrated intervention approach in order to mitigate soil resource degradation. Furthermore, appropriate policies and emphasis should be in place to facilitate farmers' accessibility to education, mass media and institutional support which ultimately influence technology adoption in the small-scale farming community.

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