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Adoption of Soil Conservation Technologies among Farmers in the Upper East Region of Ghana

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Abstract

Soil erosion is one of the most important forms of land degradation that threatens continued and sustained agricultural production in Ghana. The most severely affected areas are the three northern regions especially Upper East Region, where large tracts of land have been destroyed by water erosion leading to soil depth reduction and decline in soil fertility. This study was carried out in Talensi Nabdam District of Upper East Region of Ghana to examine the adoption of soil conservation technologies of rural farmers in the district. A random sample of 350 household was selected from seven communities in the district. Questionnaires administered in the area provided primary data needed for analysis. Descriptive statistics were employed in describing the socio-economic characteristic of farmers. Mean was used to rank the constraints and perception indices were used to analyze for the perception of farmers on the various soil conservation technologies. Probit model was used in the analysis of factors that influenced farmer's decision to adopt soil conservation technologies and among the eight variables fitted in the model, four were found to be significant for stonebunds, three for earthbunds, three for vertiver grass and three for manure. Farmer based organization, household size; extension contact and labour were significant for stonebunds. Education, household size and labour were significant for earthbunds. Gender, household size and extension contact were significant for vertiver grass. Gender, household size and extension contact were significant for manure. Age, marital status and credit have no significant effects on farmers adopting all the conservation technologies.

Keywords: Soil erosion, Soil conservation technologies, Land degradation

1. Introduction

Environmental and natural resources are the major wealth assets for Ghana. Economic growth has been concentrated in a few natural resource dependent sectors; most of the population's livelihoods depend on the country's natural resource base. Natural resources are however diminishing at an alarming rate. Recent estimates of the cost of degradation suggest that an equivalent of 10 percent of GDP is lost annually through unsustainable management of the country's natural wealth (forests, wildlife, fisheries and land resources) (EPA, 2002).

Environmental accounting analyses (World Bank, 2006) estimate that, the current genuine savings rate (a measure of growth that takes environmental factors into account) for Ghana is in fact negative, thus compromising the capacity of the country to fulfill and sustain its full potential for growth. Under reasonable assumptions, the estimated costs of environmental and natural resource degradation are reducing by approximately 1 percent point the potential for economic growth in the country.

Ghana's natural resources upon which so much of the country's economic activity and the population's livelihood depend are disappearing at an alarming rate. More than 50 percent of the original forest area has been converted to agricultural land by slash and burn clearing practices. Despite cocoa land expansion, productivity has declined because of rampant soil erosion. Fish, timber and non-timber forest product stocks are decreasing. However, land degradation is increasingly affecting land resources in Ghana, thus undermining the growth potential. Past studies estimates that 69 percent of the total land surface is prone to severe or very severe soil erosion (EPA, 2002), the main manifestation of land degradation in Ghana. A recent study estimated soil erosion to cost around 2 percent of the national GDP (World Bank et al, 2005) thus is offsetting some of the past achievements of the country in terms of economic growth and limiting the capacity of Ghana to fulfill its full potential for growth.

Evidence suggests that, adopting sustainable land management technologies can reduce soil erosion and enhance productivity. Since 1940's, a number of policy instruments have being used in an attempt to control or mitigate soil erosion in rural areas (Stonehouse, 1991).

Conservation techniques such as terracing, mulching, cover crops, integrated cropping, stonebunds, earthbunds and the use of vertiver grass are practiced by farmers. Although these soil conservation technologies have being developed and promoted in past decades, the adoption of these technologies by smallholder farmers has been resulting in low productivity and income loss to farmers (Ahmad, 2009). It is estimated that up to 40 percent of the world's agricultural land is seriously degraded (Bai, et al, 2008). The major causes of land degradation include land clearance such as clear-cutting and deforestation, Agricultural depletion of soil nutrients through poor farming practices, livestock's including overgrazing, inappropriate irrigation and over drafting, land pollution including industrial waste and quarrying of stone, sand, ore and minerals. The main outcome of land degradation is substantial reduction in the productivity of the land .

2. Materials and Methods

2.1 Data Type, Source and Sampling

The study population comprised of all food crop farmers in the Talensi Nabdam District. Among the 8 districts in the region, Talensi Nabdam district was chosen for the study because it is the largest district in Upper East region; its economy is based on agriculture as well as been noted to serious erosion problem. Random sampling was used to select seven communities and 50 farmers were selected from each of the seven communities. In this study, the farmers were classified into adopters and non-adopters depending on their adoption behavior of soil conservation practices. Adopters were those farmers who put into practice given conservation strategies introduced in their community and used them in a sustained basis. Non-adopters were those who chose not to put into practice most of the strategies or did so but later abandoned them.

The research design and data collection involved both primary and secondary sources. Primary data were collected from the sampled household by administering questionnaire. The questionnaires captured information on the personal characteristics such as age, educational level, marital status, farmer based organization, credit access, household size, children above 15 years, ethnicity and religion of the farmers in the area. Age was computed in years. Respondents' educational level was examined on the basis of number of years of formal education. The educational levels included; no formal education, primary school, JHS/Middle school/O level/A level or tertiary level. Various questions were prepared to gather information household characteristics such as household size. Farm characteristics such as farm size (ha), soil type, extension contact and labour source were also captured in the questionnaire.

Secondary sources include published and unpublished information about the study area and from the internet. The secondary information was collected from the Ministry of Food and Agriculture, KNUST libraries, and the internet.

2.2 Empirical Model

The decision to adopt or not to adopt a particular conservation practice was analyzed using probit model to analyze for each conservation measure in the area of study and was used to analyze the factors that influence farmer's decision to adopt soil conservation technologies where the unknown parameters will be estimated by using maximum likelihood estimation. The dependent variable Q in this case is a dichotomous variable with a value of 1 for adopters of soil conservation technologies and 0 for non-adopters.

The probit model and its specification are shown below following Rubinfeld (1998) and the independent variable used to estimate the coefficients of the adoption model are also defined. The estimated model is expressed as follows:

$$Q_{ij} = \beta_0 + \beta_1 Edu_{ij} + \beta_2 Age_{ij} + \beta_3 Fz_{ij} + \beta_4 HHs_{ij} + \beta_5 EX_{ij} + \beta_6 RE_{ij} + \beta_7 OWN_{ij} + \beta_8 SEX_{ij} + \beta_9 CRE_{ij} + \beta_{10} ORG_{ij} + \mu_1$$

Where $i =$ is the household head

$j =$ Soil conservation technology

$j = 1, 2, 3$ ....n

$Q =$ Adoption 1, if farmer has adopted j, 0 if otherwise

$EDU =$ Educational (number of years of schooling

$AGE =$ Age of the farmer

$HHs =$ Household size

$EX =$ Extension (1, if farmer received extension contact, 0 otherwise)
$GEN =$ Sex (1, if male, 0 otherwise)
$CRE =$ Credit (1, if farmer access credit, 0 otherwise)
$ORG =$ Farmer's organization (1, if farmer is a member of local group, 0 otherwise)
$\mu_1 =$ Error term capturing unobserved effect
$\beta_0 =$ Intercept

3. Results and Discussion

3.1 Socio-economic characteristics

The socio-economic characteristics of the household have important implications for agricultural productivities especially in the study area, particularly for the adoption of technologies that require human, financial and other physical resources necessary for increasing agricultural productivities. Out of the 350 farmers interviewed in the study, 87% were males and 13% females. The educational level of the farmers is known to affect their farming activities. Agricultural extension experts point out that farmers with higher educational qualification adopt agricultural technological innovations more than those without or with lower educational qualification. Evidence from this study reveals that 7% of the farmers are into primary education, 10% into junior high, 8% into senior high, 1% into teacher training, 1% into tertiary and 72% have no access to formal education. The minimum age of the farmers is 20 and the maximum 86 and the average age is 44. While participation in training courses accelerate the adoption of sustainable conservation practices, 91% of the food crop farmers have never participated in farmer training course on sustainable environmental practices. Extension services are a major source of technical information for farmers, therefore contact or proximity for extension agents increase adoption, about 38% of the farmers received extension contact. Hence influence negatively to the adoption decision of farmers.

3.2 Awareness of Soil Conservation technologies

Farmers tended not to be aware or have low levels of awareness with respect to soil conservation technology. In the study, 86% of the farmers are aware of stonebunds, earthbunds, vertiver grass and manure and 14% are not aware of the conservation technologies. This shows that even though the majority of the farmers are aware of the conservation technologies but their awareness has not influenced perception because the perceived cost/benefit ratio was not attractive.

3.3 Percentage of Farmers with Training of soil Conservation Technologies

Demonstration plots on soil and water conservation were another important aspect in influencing farmer's decision to adopt a technology as it offered practical experience of the technology. However, less than half of the survey, 9% reported having a demonstration plot on soil and water conservation technologies. Out of the 350 farmers sampled, 9% received training on stonebunds, earthbunds, vertiver grass and manure which was mounted by extension staff, NGO, game and wildlife conservation from 2002 to 2009 and 91% did not receive training. The survey results indicate the reasons for the adoption and non-adoption of the four conservation technologies such as stonebunds, earthbunds, vertiver grass and manure as shown in table 1 above. The was high response for the high cost of labour for construction and maintenance of structures 30.61% for non-adopters as compared to that of adopters (24.92%). The inherent problems associated with the soil conservation structures such as unavailability of material was considered to be the major reasons for non-adoption by about 28.57% as compared to that of adopters (23.26%). Other reasons cited for adoption and non-adoption of the conservation technologies include flat nature of land for non-adopters 18. 37% and adopters 11.96%, labour shortage for non-adopters 16.33% and adopters 33.22% and lack of Government assistance 6.12% for non-adopters and 6.64% for adopters.

Table 1. Reasons for non- adoption and adoption of the conservation technologies

Reasons	Frequency of non-adopters	% of non-adopters	Frequency of adopters	% of adopters
High cost of labour	15	30.61	75	24.92
Labour shortage	8	16.33	100	33.22
Flat nature of the farmland	9	18.37	36	11.96
Lack of government assistance	3	6.12	20	6.64
Unavailability of material	14	28.57	70	23.26
Total	49	100	301	100

Table 2. Descriptive of variables used in the probit model

Variable	Variable definition	Mean	Standard deviation
Dependent variables			
Stonebunds	1 if farmer adopts stonebunds, 0 otherwise	0.80	0.403
Earthbunds	1 if farmer adopts earthbunds, 0 otherwise	0.16	0.37
Vertiver grass	1 if farmer adopts vertiver grass, 0 otherwise	0.163	0.37
Manure	1 if farmer adopts manure, 0 otherwise	0.074	0.26
Explanatory variables			
Age	Farmers age (years)	43.78	11.67
Male	1 if male, 0 otherwise	0.87	0.34
Married	1 if married, 0 otherwise	0.93	0.26
Education	Number of years of schooling	2.71	4.62
FBO	1 if farmer belongs to farmer based organization, 0 otherwise	0.29	0.46
HHS	Number of people in the household	5.64	2.20
Credit access	1 if farmer access credit,0 otherwise	0.03	0.21
Family labour	1 if family labour, 0 otherwise	0.88	0.33
Extension contact	1 if farmer received extension contact, 0 otherwise	0.92	0.28

Table 3. Probit Estimates on Adoption of Soil Conservation Technologies

Variable	Stonebunds	Earthbunds	Vertiver grass	Manure
Age	0.0672(-1.51)	0.00247 (0.05)	0.202 (0.42)	0.0625 (-1.37)
Age2/100	0.652(1.43)	-0.0228 (-0.46)	0.284 (-0.56)	0.0638 (1.46)
Male	0.428(-1.43)	0.224 (0.75)	5.470*** (4.81)	0.765*** (-2.72)
Married	0.332(0.97)	0.278 (0.69)	0.933 (1.56)	0.504 (1.02)
Education	0.00047 (0.03)	0.343** (1.95)	0.00761 (0.41)	-0.238 (-0.85)
FBO	-0.923*** (-5.33)	0.183 (-0.95)	-0.0672 (-0.34)	0.409 (-1.49)
HHS	0.157*** (3.43)	0.0820* (1.88)	0.140*** (2.93)	0.0905* (1.68)
Extension contact	-0.664** (-1.94)	-0.202 (-0.69)	-0.525** (-1.89)	-0.687** (-1.99)
Credit	0.547(2.21)	0.500(1.11)	-0.768(-0.17)	0.274(0.41)
Family labour	0.413* (1.81)	-0.382* (-1.64)	0.0613 (0.23)	0.258 (0.69)
R^2	0.8432	0.6535	0.5245	0.7425
Log likelihood	-16.37371	-143.72977	-136.17353	-84.024293
Total observation	350	350	350	350

Note: * significant at 10%, ** significant at 5% and *** significant at 1%

3.4 Determinants of adoption of soil conservation technologies

Table 2 describes the variables used in the probit model. The dependent variables were adoption of stonebunds, earthbunds, vertiver grass and manure. The dependent variables take the value of 1 (for adopting) and 0 (for not adopting). The explanatory variables of importance in this study are those variables which were thought to influence on likelihood and intensity of adoption of stonebunds, earthbunds, vertiver grass and manure. These explanatory variables are defined as follows:

Gender of household head: This was coded as a dichotomous variable with 1= male and 0= female. Studies have shown that access to resources and services (information, credit) vary by gender. It was hypothesized that the variable could positively or negatively influence the adoption of soil conservation technologies.

Farmers education: This was measured based on the number of years of schooling. It was expected to positively influence adoption decision of farmers.

Credit was an important variable that was expected to fuel adoption of soil conservation technology. This was assumed to be proxy to financial access which assists farmers to purchase inputs to adopt soil and water conservation. It was also a dichotomous variable, 1= yes (access to credit) and 0 = (no access to credit).

Household size: It was anticipated that the larger the family size, the bigger the pool of labour availability. The variable was expected to increase the probability of adoption of soil conservation technology.

Access to extension contact: This is a dichotomous variable, 1=yes (had access to extension contact), 0= otherwise (had no access to extension contact)

The average adoption rate for the conservation technologies are 0.80, 0.16, 0.163 and 0.074 for stonebunds, earthbunds, vertiver grass and manure respectively.

The average age of the household heads was 43.78 and been males of 87%. About 93% of the farmers are married. Almost 72% of the farmers have no access to formal education whiles 28 percent have access to formal education. On average, about 29% of the farmers belong to farmer based organization. The average household size is 5.64. Also on average 0.03 of the farmers have no access to credit. Furthermore, about 88% of the farmers depend on family labour and 92% of the farmers have no access to extension contact.

3.5 Results of Probit Analysis

The model was estimated for four most common conservation technologies adopted by the farmers in the district: stonebunds, earthbunds, vertiver grass and manure. These conservation practices were separately used as dependent variables. The nine independent variables were included in all the four conservation technologies. The results of the probit models of the decision to practice the four conservation practices are presented in table 3. In each case the goodness of fit statistics for the models with all the independent variables are adequate. The high likelihood of the observed results indicates that the models are reliable and the classification results show that they were correctly classified in stonebunds, earthbunds, vertiver grass and manure.

The formation of the four adoption models were influenced by a number of working hypotheses. Farmer's age can increase as well as decrease the probability of adoption of technologies. Older farmers may have more experience that allows them to adopt improved technologies, while young farmers might be less risk-averse and therefore more willing to adopt improved technologies. Age therefore may positively or negatively influence adoption of soil conservation technologies.

The number of adults who can work in the farm is an indication of the availability of labour for conservation works and is therefore hypothesized to positively influence adoption of improved conservation practices. Availability of information through extension/training seminars is necessary for a farmer to be aware of the new technologies as well as how to use them. Extension education is therefore hypothesized to positively influence the decision of farmers to adopt recommended soil conservation practices

Among the eight variables fitted in the model, four were found to be significant for stonebunds, three for earthbunds, three for vertiver grass and three for manure. Farmer based organization, household size, extension contact and labour were significant determinants for adoption of stonebunds. But farmer based organization and extension contact have negative signs.

Education, household size and labour were significant for earthbunds. Gender, household size and extension contact were significant for vertiver grass. Gender, household size and extension contact were significant for manure. Age, marital status and credit have no significant effects on farmers adopting all the conservation technologies.

Farmers who participate in local organization are less likely to adopt stonebunds since it negatively influenced their decision.

Frequency of extension visit positively affected continued adoption of soil conservation technology. Extension agents remind farmers of the need to adhere to recommended measures. In the study, access to extension contact negatively influences adoption decision of farmers to adopt stonebunds, vertiver grass and manure.

3.6 Perception Results on Soil Conservation Technologies

The technologies perceived to be relevant by the farmers include stonebunds, earthbunds, vertiver grass and manure. With the four perception statements; soil conservation control erosion, soil erosion increase yield, soil erosion increases the fertility of the soil and soil erosion increases soil water retention.

The perception that soil conservation controls erosion has the greatest percentage of 67.42% and highest perception index which indicate that farmers have a strong perception towards the adoption of soil conservation technologies. Approximately 53.7% of the farmers strongly agree that soil conservation increases yield. This implies that the farmers have a strong perception in the adoption of soil conservation technologies.

Furthermore, 57.14% of the farmers agreed that soil erosion increases the fertility of the soil. Finally, the perception statement that soil conservation increases soil water retention has the highest percentage of 52% of the farmers agreeing to the perception statement.

3.7 Constraints Results on Adoption of Soil Conservation Technologies

From table 5, inadequate credit has the least mean score which indicate that it is the most serious problem faced by the farmers, high prices of inputs and the other constraints were also identified by the respondence as the most serious problem that hindered their extent of adoption of stonebunds, earthbunds, vertiver grass and manure. Farmers may be unable to raise sufficient funds to invest in the technology because of lack of capital, limited access to credit or temporary cash flow problems. This also concerns funds to pay extra labour when the technology requires activities during peak periods of normal field work. Certain soil conservation technologies are inherently long-term requiring security of tenure over land for an extended period of time. Many farmers are resource poor and may lack land security thus is unable to invest in soil conservation technologies but even where tenure security is given, benefits might only accrue after some years. Poor performance of extension services are often blamed for limited spread of technologies. This is in many cases wrong as real winners often spread without much effort through informal communication networks.

Table 4. Perception of farmers on the various conservation technologies

Perception statement	Number of Responses				
	Strongly agree (Score=1)	Agree (Score=0.5)	Neutral (Score=0)	Disagree (Score=-0.5)	Strongly disagree (Score= -1)
Soil conservation control erosion	236 (67.42%)	113 (32.2%)	0 (0%)	1 (0.29%)	0 (0%)
Perception index					0.83
Soil conservation increases yield	188 (53.7%)	157 (44.85%)	4(1.14%)	1 (0.29%)	0 (0%)
Perception index					0.76
Soil conservation increase fertility of the soil	146 (41.71%)	200 (57.14%)	2 (0.57%)	1 0.29%)	1 (0.29%)
Perception index					0.61
Soil conservation increase soil water retention	153 (43.71%)	182 (52%)	13 (3.71%)	1 (0.29%)	1 (0.29%)
Perception index					0.69

Table 5. Constraints in the adoption of soil conservation technologies

Constraints	Mean score	Rank
Inadequate credit	3.22	1st
High prices of inputs	3.54	2nd
Inadequate inputs	4.10	3rd
Inadequate practical help	6.97	4th
Inadequate knowledge on how to apply practices	6.98	5th
Inadequate advice or guidance on how to apply practices	7.08	6th
Inadequate material	7.17	7th
Inadequate implements and tools to apply practices	7.31	8th
Inadequate information on possible practices	7.46	9th
Low increase in short term productivity	7.60	10th
Inadequate support from family/friends to help in adoption	8.03	11th
Land tenure	8.54	12th

4. Conclusions and Recommendation

The study revealed that there were higher adoption rate for stonebunds 79.75%. Low adoption rate for earthbunds 16%, vertiver grass 7.4% and manure 16.3%. The study also revealed the reasons for the adoption and non-adoption of the four conservation technologies such as stonebunds, earthbunds, vertiver grass and manure. The was high response for the high cost of labour for construction and maintenance of structures 30.61% for non-adopters as compared to that of adopters (24.92%). The inherent problems associated with the soil conservation structures such as unavailability of material was considered to be the major reasons for non-adoption by about 28.57% as compared to that of adopters (23.26%). Other reasons cited for adoption and non-adoption of the conservation technologies include flat nature of land for non-adopters 18. 37% and adopters 11.96%, labour shortage for non-adopters 16.33% and adopters 33.22% and lack of Government assistance 6.12% for non-adopters and 6.64% for adopters.

Among the eight variables fitted in the model, four were found to be significant for stonebunds, three for earthbunds, three for vertiver grass and three for manure.Farmer based organization, household size; extension contact and labour were significant for stonebunds. Education, household size and labour were significant for earthbunds. Gender, household size and extension contact were significant for vertiver grass. Gender, household size and extension contact were significant for manure. Age, marital status and credit have no significant effects on farmers adopting all the conservation technologies. A number of constraints that hindered their adoption of these technologies have been identified which are rank from the highest to the least and the most serious been lack of access to credit. The farmers have a positive perception towards the adoption of the conservation technologies

In view of the findings of this study, the following recommendations have been made;

Farmer's dependence on personal savings which often is inadequate and unreliable is likely to affect their rate of adoption; hence Government policies should be directed towards addressing the needs of farmers by making credit available to these small scale farmers.

Agricultural research policy should enhance existing agricultural technologies since farmers' awareness of the technology significant affect their perception to the relevance of the agricultural technology.

Training on soil conservation practices is an essential issue as it raises farmer's awareness on the potential damage of soil erosion. Hence the is the need for more training on soil conservation practices in the study area as 91 percent did not receive training and 9 percent said they received training.

Lack of knowledge is cited as a hindrance to adoption, the farmers should be made to know this practices and how best to integrate or in corporate this practices in their agricultural activities for better living as well as protect the environment.

It is generally true that access to information sources and communication channels and adequate number of extension education increase awareness about the effects and consequences of sustainable soil conservation practices among farmers while providing them with required knowledge. Positive motivation towards sustainable soil use on the part of these food crop farmers may enhance further adoption

The was low extension staff to farmer ratio and lack of regular interaction between farmers and agricultural extension staff who were the most reliable source of information to the farmers practicing this technology which contributed negatively to farmers decision to adopt those technologies. Therefore there is the need to provide extension education support to promote adoption of improved soil conservation technologies through the provision of knowledge and skills to small holder farmers.

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