Ind. Jn. of Agri.Econ.
Vol.65, No.3, July-Sept. 2010

A Study of Socio-Economic Factors Influencing Adoption of Farm Level Soil and Water Conservation Practices in the Riverine Areas of North Bank Plains Zone of Assam

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I

INTRODUCTION

Soil and water are two very scarce important natural resources without which crop production is not possible. Soil degradation due to erosion and the depletion of ground water resources are the two major environmental problems threatening agricultural production and productivity in the riverine belt of Assam. The riverine belt is spread over as the alluvial land forms on the recent flood plain of the river Brahmaputra and its perennial tributaries. These are the riverine land forms and river islands that are periodically formed and eroded due to meandering, braiding and the changing course of the rivers. These land situations are locally known as 'Char land' or 'Chapari' in Assam. Soils are formed on the riverine alluvium deposits brought down from the adjacent Assam Himalayas by the river Brahmaputra and its tributaries. Soils are therefore stratified in nature and the soil textures vary with depth and the top layer of the soil (30-90 cm thickness) has a sandy or silty loam texture which is underlined by thick layers of relatively coarse sands. The profile development is therefore poor and belongs to the order 'entisol' and is subjected to soil erosion due to various reasons.

The North Bank Plains (NBP) zone of Assam comprises a geographical area of 14,421sq km (14.42 lakh hectares), which is 18.37 per cent of the total geographical area of the state. This zone falls in a humid and sub-humid climatic belt with an average rainfall of 2741 mm per year and covers the districts of Sonitpur, Lakhimpur, Dhemaji and Darrang. The net cropped area of these four districts of the zone together is about 5.09 lakh hectares of which only about 11 per cent of land is brought under irrigation and of which about 75,000 ha is in the riverine belt. No systematic and exhaustive surveys on the natural resource land use pattern have been undertaken on the riverine areas. The present study makes an attempt to analyse the socio-economic and institutional factors that influence the adoption of various soil and water conservation practices in the riverine areas of NBP zone of Assam along with exploring the scope for diversification.

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METHODOLOGY

The study was conducted in some selected riverine areas of Lakhimpur and Sonitpur districts of the NBP zone of Assam. The areas selected were Gamiri, Subansirimukh and Dikrang Chapari in Lakhimpur and Baghmari Chapari, Panpur and Lohitmukh in Sonitpur districts. In total 110 farmers, 55 from each district were randomly selected and surveyed and the data collected pertained to the year 2007-08. Pre-tested schedules and questionnaires were used to collect necessary information. A 'Tobit model' was used to analyse the factors based on the variables that influence the adoption of the conservation practices. A number of social variables (viz., age, educational level, and family size), diffusion variables (awareness, perception), physical variables (soil slope, soil characteristics, and farm fragmentation), economic variables (income, farm size, off farm employment) and institutional variable (land tenure) were used in the Tobit model. There is a relationship between soil conservation effort on the one hand and personal and social variables, economic variables, physical factors and institutional variables on the other (Araya and Adjaye, 2001). The Tobit model (Tobin, 1958) specified for the analysis is specified as

$$C_i^* = \beta' X_i + \varepsilon_i^*$$

Where β' is a vector of parameter values; X_i is a vector of regression consisting of personal, socio-economic, institutional, diffusion and physical characteristics and ε_i^* is an error term. Some of the farmers surveyed did not make any conservation effort during the reference year. For the farmers making conservation effort, C_i^* is the actual level of effort in terms of number of days spent on soil and water conservation activities. For those farmers who did not undertake conservation measures C_i^* is an index of their willingness to take up conservation measures. As this characteristic is not observed, the value of C_i^* is considered as zero. Hence C_i , not C_i^* is observed where $C_i = 0$ if $C_i^* < 0$

$C_i = C_i^*$ if $C_i^* > 0$

Thus the conservation effort function becomes $C_i = \beta X_i + \varepsilon_i$

The variables identified and included in the Tobit analysis are shown in Table 1. The dependant variable is conservation effort which is measured as the number of days the farmers spent on various soil and water conservation measures in their farm. The study focuses on various conservation measures such as crop rotation, zero tillage, contour bunding, terracing, etc., adopted by the farmers in the areas.

TABLE 1. POPULAR CROPPING SYSTEMS PREVALENT IN THE AREA

Sl. No. (1)	Cropping systems (2)
1.	Deep water rice-broad cast- monocropping
2.	Deepwater rice + *ahu* rice –mixed cropping
3.	Deepwater rice (transplanted)- pea as relay cropping
4.	Pre flood *ahu* rice-post flood *Sali* rice (late transplanted beyond September)
5.	*Ahu* rice-fallow-rapeseed
6.	*Ahu* rice- fallow- pea/*rabi* vegetables
7.	*Ahu* rice -sesamum
8.	*Boro* rice- monocropping
9.	Summer vegetables-ground nut-*rabi* vegetables/potato/maize
10.	Fallow-green gram/black gram
11.	Green manuring-pea/potato
12.	Fallow rapeseed/mustard

III

RESULTS AND DISCUSSION

Cropping Systems

Unlike other situations the riverine situation shows the characteristic feature of cultivating a wide variety of rice crops with emphasis shifting towards rabi oriented cropping systems. The situation is favourable for growing a wide variety of vegetable crops which need less and shallow tillage such as cucurbits including pointed gourd, bitter gourd, cucumber, melon, ridge gourd, tomato, raddish, carrot, potato, lady's finger and colocassia. Direct seeded deepwater rice cultivation as mono cropping is also practiced in some selected low lying situation. Deep water rice, pre-flood autumn, i.e., *ahu* rice and transplanted *kharif*, i.e., *Sali* rice are the major crops in the area. Rice based particularly *ahu* rice based cropping system has been more prominent and not so much of intensive cropping system has been observed. The spring rice (November/December to April/May) popularly known as *boro* rice having high yield potential is also grown in some patches in the area where the farmers have some accessibility to provide irrigation from the nearby river or wetlands. The summer/kharif crops include different classes of rice and the *rabi* season crops include a number of vegetables and oilseeds including rapeseed and mustard. The popular cropping systems prevalent in the study area are indicated in Table 1. The cropping systems followed by the farmers are based on its suitability to the conditions in the pre-flood, post-flood and flood free periods. Another encouraging feature is the growing of green manuring crops comprising *dhaincha* and *sunhemp* in the area.

Farmer's Perception Towards Soil Erosion and Water Degradation

The riverine situation is subjected to soil erosion and water degradation due to sudden submergence caused by flash floods during monsoon and drought situation

during summer season. Awareness of the problems of soil erosion and water degradation is considered as a necessary condition for the adoption of conservation measures. Farmer's perception regarding the effect of soil erosion and water degradation on the yield level of crops are therefore studied and the results are shown in Table 2. Out of 110 respondent farmers 49.09 per cent had the perception that soil erosion and water degradation would reduce the crop yield considerably (Table 2) and 32.72 per cent had the perception that soil erosion and water degradation would moderately reduce the crop yield. About 18.18 percent of the farmer's perceptions are in the negative sense. The status of the farmers adopting the conservation measures is shown in Table 3. There are always strong links between measures for soil conservation and measures for water conservation, and this applies equally in the study areas. Many measures are directed primarily to one or the other, but most contain an element of both. Reduction of surface run-off by structures or by changes in land management will also help to reduce erosion. Similarly, reducing erosion will usually involve preventing splash erosion, or formation of crusts, or breakdown of structure, all of which will increase infiltration, and so help the water conservation. Zero tillage technology is new technology and yet to be popularised for adoption in the area. Only 5 per cent of the farmers adopted the zero tillage technology. Non-availability of zero till drill machines and lack of knowledge about the technology resulted in poor adoption of the technology in the area. Bunding for storage of water in the plots particularly for rice production has been a prevalent practice in the area and about 52 per cent of the farmers followed that practice. System of Rice Intensification (SRI) method has been adopted by about 12 per cent of farmers. SRI method not only saves water but also combines the optimal spacing, age of seedling, planting time, soil aeration and compost to promote root and plant growth. About 11 per cent of the farmers apply irrigation only in the critical stages of crop production through lifting water directly from river or branches or ponds. Use of irrigation water from shallow tube well is though common but not so frequent in the area and the farmers generally go for life saving irrigation in the crop fields. For irrigation *pucca* or concrete channels are not feasible in the area because of the soil characteristics. For kharif rice however boarder method of irrigation is used. Crop rotation with less tilled crops such as pea, black gram, green gram, lentil etc., and with some *rabi* vegetables and maize, rapeseed and niger have been practiced by about 21 per cent of the farmers. Cultivation of green manuring crops such as *dhaincha* and sunhemp which restores the soil fertility naturally is practiced by about 15 per cent of farmers in the area. Surface incorporation of crop residue and organic farming have been followed by about 9 per cent of farmers. These practices which enhance the soil health status and prevent soil degradation therefore need to be popularised in the area. Prevention of soil erosion due to flood however is beyond the control of the farmers and need government involvement in terms of construction of bunds, dikes, spurs, geotubes and other preventive measures.

TABLE 2. FARMERS' PERCEPTION OF THE EFFECT OF SOIL EROSION AND WATER DEGRADATION ON YIELD

Effect on yield (1)	Number of respondents (2)	Relative frequency (3)	Cumulative relative frequency (4)
Considerably reduce yield	54	49.09	49.09
Moderately reduce yield	36	32.72	81.81
Does not reduce yield	20	18.18	100.00
Total	110	100.00	

TABLE 3. SOIL AND WATER CONSERVATION MEASURES ADOPTED BY THE FARMERS IN THE AREA

Measures adopted (1)	Number of respondents (2)	Percentage to total (3)
Zero tillage	6	5.45
SRI cultivation	14	12.72
Bunding for storing water in the field	47	51.81
Irrigation directly by water lifting from river or branches or ponds	12	10.90
Crop rotation with less tilled crops	23	20.90
Green manuring	17	15.45
Terracing	06	5.45
Surface incorporation of crop residue	10	9.09
Organic farming	10	9.09

Tobit Analysis

The explanatory variables used in the Tobit model are given in Table 4. The important variables identified are the age of the respondent farmer, education level, size of the family, farmer's awareness regarding land and water depletion, perception about the effect of soil and water depletion on crop yield, perception about the effectiveness of the soil and water conservation techniques, profitability of the conservation techniques, annual income, number of days of off-farm employment, farm size, land tenure, land fragmentation, slope of land and the size of livestock of the farmer. The respondent farmers of the area are middle aged with the average age of 49.51 years and have some sort of school education up to about 9-10 years of formal education. The average size of the family is about 5.36 persons in the area. About 77 per cent of the farmers of the area are aware of the problems of soil erosion and water depletion and consider it as an important problem demanding attention. Similarly about 74 per cent of the farmers perceive positively the effectiveness and profitability of soil and water conservation techniques. The factors which have negative influence on the adoption of conservation measures are the fragmentation of land, number of livestock activities reared which take extra time and attention, time spent on off farm activities and the growing age of the farmers. Fragmentation of crop lands is associated with lower level of soil and water conservation measures. Larger the number of plots a farmer cultivates the greater is the amount of time and costs involved in taking up conservation measures.

TABLE 4. EXPLANATORY VARIABLES USED IN THE TOBIT MODEL

Variable (1)	Description (2)	Mean or average (3)	Sign (4)
Age	Age of the farmer (years)	49.51	-
Education	Number of years of formal education	9.62	+
Family	Size of family (in number)	5.36	+
Awareness	Awareness about land and water degradation (1=aware; 0= not aware,	0.77	+
Percpyld	Perception of effects of soil and water degradation on crop yield (1=very important and urgent, 2=important but not so urgent, 3 = less important, 4 = not a problem)	2.45	+
Percptec	Perception of effectiveness of soil and water conservation techniques (1=effective, 0=not effective)	0.74	+
Profit	Perception of profitability of conservation techniques (1=highly profitable, 0=not profitable)	0.74	+
Income	Annual income from crops (in rupees)	1,18,000.00	+
Offemp	Number of days spent on off farm employment	61.23	-
Farm	Farm size (in hectare)	2.32	+
Landten	Land tenure (1=owned land, 0=leased in land)	0.67	+
Livestock	Number of livestock owned	4.62	-
Frag	Number of fragmented plots (i.e., in different areas)	4.13	-
Slope	Steepness of crop land (0=flat land, 1=moderate to steep)	0.32	+

Though a number of variables were included in the analysis through the Tobit model, all the variables did not meet the statistical significance level. Hence, the non-significant variables like age, education, percptec, income, farm size, livestocks and fragmentation were excluded and the model was re run to get more realistic results (Table 5). An earlier run of the Tobit model with all explanatory variables indicate that among the social variables only the coefficient of family size is significant. The education level is not sufficient enough to justify the tests of significance in the area as the overall education level is low and in most cases limited to school level only. The coefficients of the diffusion variables 'Percpyld' and 'Profit' show the expected signs and are significant. However, the 'Percptec' is found to be non significant. The hypothesis that the extent of soil and water degradation is positively related to the level of conservation efforts is rejected at 5 per cent level of significance. The coefficients of income and farm size are found to be statistically not significant. The reason may be that the farmers in the area are also engaged in other off farm works including fishing in the rivers or bills from which they earn some additional cash. The institutional variable 'land tenure' indicated the expected sign and is significant at 10 per cent level. Farmers with permanent 'land patta' demonstrated more inclination towards adoption of conservation measures as compared to 'periodic patta' holders.

TABLE 5. ESTIMATED COFFICIENTS OF TOBIT ANALYSIS EXCLUDING NON-SIGNIFICANT VARIABLES

Variables (1)	Normalised coefficient (2)	Standard error (3)	t-ratio (4)
Family	0.0785	0.0038	2.6785**
Awareness	-0.4476	0.0375	-4.8795**
Percpyld	0.6675	0.1218	4.4066**
Profit	0.3633	0.3566	1.6732*
Offemp	-0.0432	0.0008	-4.1324**
Landten	0.6577	0.1775	2.4367**
Constant	-0.7235	0.3466	-2.3764**
Log-likelihood function		-967.88	
Mean square error		326.87	
Mean absolute error		1.9785	
Squared correlation between observed and expected values		0.1399	

**and* indicate significance at 5 and 10 per cent level for a one tailed test.

NB. Variables age, education, percptec, income, farm, livestock, frag are excluded due to non-significance.

The variables showing the physical characteristics of the farm i.e., number of livestocks reared, fragmentation of plots and slope of land all demonstrated expected signs but only the coefficient of slope is found to be significant. From the results it can be concluded that the data support the hypotheses formulated about the relationships of these variables with conservation efforts. The hypothesis that the younger farmers spend more time and energy in soil and water conservation measures is based on the fact that the younger farmers possess higher level of education and are more concerned about the problems of soil erosion and water degradation. Age is hypothesised to have negative impact on the adoption of conservation measures as the younger farmers are more likely to take risks and perceive increased profits from such measures (Soule *et al.,* 2000 and Khanna *et al.,*1999). As the F-statistic and R^2 as tests for goodness of fit are not valid in Tobit analysis hence these are not indicated. The squared correlation coefficient between the expected and the actual values of the dependant variable is 0.13. After excluding the non-significant variables, the Tobit model demonstrated the coefficients as shown in Table 5. Though there are no changes in the significance levels as in the earlier run of the model but slight reduction in the standard errors have been observed thereby indicating more reliable estimates. These coefficient estimates are used to compute the elasticities of conservation effort and the results are shown in Table 6. It can be concluded from Table 6 that in general the conservation effort is relatively inelastic with respect to the key variables. The negative elasticity of the variable 'offemp' justify the non-significance of the variable 'income' as observed in the estimates of the earlier run of the model with all the variables. The variable 'awareness' which also demonstrate negative elasticity is due to the low level of education of the farmers of the locality and non-exposure to the advances and development of various conservation measures.

TABLE 6. ELASTICITIES CALCULATED AT MEANS OF SIGNIFICANT VARIABLES

Variables (1)	Elasticity of: Adoption index (2)	Elasticity of: Expected level of soil and water conservation effort (3)	Total Elasticity (4)
Family	0.9633	0.4537	1.417
Awareness	-0.4365	-0.1768	-0.6133
Percpyld	0.5766	0.3126	0.8892
Profit	0.7867	0.4236	1.2103
Offemp	-0.4763	-0.2243	-0.7006
Landten	0.1785	0.8546	1.0331

IV

CONCLUSIONS

The Tobit analysis indicates that the important and significant variables influencing soil and water conservation practices are the family size, perception of the profitability of conservation methods, perception about the effect of soil erosion and water depletion on crop yield, off farm employment and the land tenure system. Availability of farm labour has significantly influenced the adoption of conservation practices. Thus the variable family size has direct influence on the conservation effort. This finding is evinced by the negative relationship between conservation effort and off-farm employment. The institutional variable of land tenure has also significantly influenced the adoption of conservation practices. Farmers with permanent 'land patta' demonstrated more inclination towards adoption of conservation measures as compared to 'periodic patta'. There are always strong links between measures for soil conservation and measures for water conservation, and this applies equally in the study areas. Zero tillage technology is the new technology and yet to be popularised for adoption in the area. Emphasis on reduced tillage however is prominent from the cropping system followed. Bunding for storage of water in the plots particularly for transplanted *kharif* rice production has been a prevalent practice in the area. The variables showing the physical characteristics of the farm, i.e., number of livestock reared, fragmentation of plots and slope of land all had a negative influence on the adoption of conservation measures. Awareness of the problems of soil erosion and water depletion is considered as a necessary condition for the adoption of conservation measures. Farmers training and education programmes in respect of soil and water conservation aspects need to be emphasised. Extension mechanism should reach the common farmers in educating them about the positive benefits of conservation measures such as zero tillage, SRI methods, terracing, contour bunding, ridge tillage and organic production, etc. Land tenure system in the area should be systematically studied and implemented for the benefit of the farmers. Development of suitable infrastructures for soil and water conservation based on agronomic practices and fragmented holding should also be

research priority areas. Further as the riverine area is interwoven by a number of river tributaries hence emphasis on integrated command area development including micro watershed management practices might definitely be considered as viable strategies. More public funding and government involvement in terms of construction of bunds, dikes, spurs, geotubes and adoption of other advanced technologies to prevent serious soil erosion in the river touching areas during monsoon is very essential.

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