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Farmers' knowledge and adoption of sustainable land-use management systems in Matalom, Leyte, Philippines

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ABSTRACT

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This study compared the knowledge levels betwen adoptors and non-adoptors of sustainable land-use management systems in Matalom, Leyte, investigate the influence of farmers' knowledge and other factors on the extent of adoption of technologies, and identify implications that may enhance technology adoption.

The sustainable land-use management systems considered in this study included contour hedgerow and agroforestry technologies. Thc adoptors of sustainable land-use management systems have significantly higher knowledge than the non-adoptors. Their knowledge is significantly and positively affected by their level of education, attendance to related trainings, and contact with extension agents.

Results of the Tobit regression analysis showed that the extent of adoption of sustainable land-use management systems in the study area is significantly and positively influenced by farmers' knowledge and other factors such as access to credit and membership in *alayon* (labor-sharing group).

Keywords: Farmers' knowledge, sustainable land-use management systems

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INTRODUCTION

Environmental degradation in the form of deforestation, soil erosion, and watershed disruption is an alarming global phenomenon. It is likewise a serious problem in the Philippines. The country has undergone much environmental decline notably in the form of deforestation and soil erosion (Myers, 1988). The destructive practice of shifting cultivation has prevailed, resulting in the rapid destruction and denudation of forest areas (PCARRD, 1986).

In Eastern Visayas, where Matalom, Leyte is located, about 1.05 million hectares or 49.16 percent of the regional area has been classified as forest land (DENR, 1990). The problem of forest and land degradation has been noted in the area caused by both natural and anthropogenic processes. Agricultural transformations had occurred in Matalom over the past 50 years that resulted in the problems of soil erosion and soil infertility. Most farmers in the area have reported a decline in yield of their major crops (rice and corn) by about 25 percent over a decade due to loss in soil fertility brought about by soil erosion.

Recognizing the above-mentioned problem, the Farm and Resource Management Institute (FARMI) of the then Visayas State College of Agriculture (ViSCA) in Baybay, Leyte implemented the International Development Research Centre (IDRC)-funded Upland Agriculture Project in 1990. The project intensively promoted sustainable land-use management systems in the form of soil and water conservation technologies such as contour hedgerow and agroforestry systems. These efforts were geared towards rehabilitating and sustaining upland production systems in the area.

The adoption of sustainable land-use management systems like contour hedgerow and agroforestry systems has been high in some villages but low in others. Aside from knowing the profitability of these soil-conserving technologies, there is also a need to determine the factors that influence the adoption behavior of farmers.

There is also a gap in the adoption literature. How does the knowledge level of farmers about the technology, in general, and not only perceptions on some technology-specific attributes, condition the farmers' adoption behavior? Hence, aside from perceptions on specific technology attributes or preferences for technology characteristics, knowledge of farmers about upland land use and management as well as the economics and environmental or ecological consequences of innovation could play a major role in their adoption behavior. Knowing the influence on technology adoption of said knowledge system and that of other economic, social, institutional,and biophysical factors confronting the farmers would be beneficial for directing appropriate technology development as well as technology diffusion efforts.

This study determined the influence of farmers' knowledge about sustainable land-use management systems in their adoption behavior in Matalom, Leyte. Specifically, this study sought to: 1) compare the knowledge levels between adoptors and non-adoptors of sustainable land-use management technologies; 2) investigate the influence of farmers' knowledge and other factors on the extent of technology adoption; and 3) identify implications that may enhance technology adoption.

MATERIALS AND METHOD

This study was conducted in four upland villages or barangays of Matalom, Leyte where the Soil and Water Conservation Project of FARMI at Leyte State University in Baybay, Leyte has been implemented. Stratified random sampling based on adoption of the various land-use management technologies was used in selecting the respondents. Ten farmer-adoptors and 10 farmer non-adoptors were randomly drawn as respondents in each barangay or a total of 80 respondents. The study utilized primary data that were collected through survey using pretested structured interview schedules.

The knowledge system analysis was done through a 30-point multiple-choice test answerable by Yes, No or I don't know. This was administered to both adoptors and non-adoptors of the various sustainable land-use management systems. Questions about land use and management as well as the economics and environmental/ecological considerations of the technology were administered to respondents. From this, a farmer knowledge score was defined. The farmer knowledge score in terms of estimate of competency obtained by each respondent for all questions was computed using the formula (Romney *et al.*, 1986):

$$D = \frac{(LT - 1)}{(L-1)}$$

where: D = estimate of competency
L = number of alternative answers to the questions
T = proportion of correct responses

T was obtained by getting the quotient between the number of correct responses and the total number of questions. The knowledge score was used in the regression model for adoption analysis.

Meanwhile, the analysis of adoption of soil conservation measures in this study was undertaken using Tobit regression analysis (Tobin, 1958 and MacDonald and Moffit, 1980). The analysis was done by maximum likelihood employing the LIMDEP software.

The extent of adoption in terms of rank of adopting sustainable land-use management systems is believed to be a function of knowledge of farmers, labor, and credit markets as well as membership in alayon (exchange labor groups). For estimation purposes, the model in this study was expressed as:

$$AS = \beta_0 + \beta_1 (KNOW) + \beta_2 (OFF\text{-}FARM) + \beta_3 (DCREDIT) + \beta_4 (DMEMBER) \quad (2)$$

where: AS = the rank in terms of extent of adoption of sustainable land-use management systems based on land area devoted to each system
KNOW = Knoweldge score of respondents
OFF-FARM = Off-farm income inprevious year (% of total household income)
DCREDIT = Availability of credit dummy, = 1 if availed of credit for technology, 0 otherwise
DMEMBER = membership in *alayon* dummy, = 1, if alayon member, 0 otherwise

The rank in terms of extent of adoption of sustainable land-use management systems was based on the percentage of upland area devoted to different management systems. Each management system was assigned weight. It is believed that in terms of soil conservation, an agroforestry system is more sustainable than a contour hedgerow system. Assigned weights were as follows:

Traditional farming = 0
Contour hedgerow system = 1
Agroforestry system = 3

For each respondent, the rank of extent of adoption of various management systems was obtained as the sum of the weighted upland area devoted to each management system.

The other tools used in analyzing data in this study included descriptive statistics, t-test, and multiple linear regression (to determine the factors that affect farmers' knowledge).

RESULTS AND DISCUSSION

Introduction of sustainable land-use management systems

The problem of low-crop productivity due to declining soil fertility has been evident in the study area. In fact, as early as the 1980s, the area has been a recipient of research and development activities of the Farming Systems Development Project in Eastern Visayas (FSDP-EV), a collaborative project of the Department of Agriculture, Cornell University, and the Visayas State College of Agriculture (ViSCA).

The project introduced various innovations in the locality. These technologies and farm practices included the use of new crop varieties, use of external inputs like inorganic fertilizer and pesticides, application of anapog or lime, and use of contour hedgerows. For the contour hedgerow technology, the project first promoted the use of *Leucaena leococephala* (ipil-ipil) and *Gliricidia sepium* (madre de cacao) as well as *Pennisetum purpureum* (napier grass) as tree and grass hedgerows, respectively. Adoption of the technology took place but the problem of *Psyllid* infestation on *Leucaena* and grazing by astray animals on the grass hedgerows led farmers to abandon their contoured farms.

When the FSDP-EV was phased out,the IDRC-Upland Agriculture Project spearheaded by FARMI was put in place in the early 1990s. The project intensively promoted soil and water conservation technologies by employing sustainable land-use management systems in the form of contour hedgerow and agroforestry systems. The project introduced another grass species, Vetiver grass (*Vetiveria zizanoides*) as well as integration of trees on the upland farms. The project promoted the hedgerow technology not only with the use of grass species but with the integration of tree species as hedgerow materials. It introduced exotic species of trees like *Gmelina arborea* and *Swietenia macrophylla*. In addition, the Federation of Omega Beneficiaries, Incorporated (FOBI), a non-government organizaiton, promoted the agroforestry technology in some selected barangays of the study area towards the late 1990s.

The sustainable land-use management systems included the contour hedgerow and agroforestry technologies. The contour hedgerow technology made use of grass species alone as hedgerow material while the agroforestry technologies integrated trees into the upland farms. Trees were planted either in hedgerows or in blocks.

Adoption of sustainable land-use management systems

The adoptors of sustainable land-use management systems adopted one or both systems. More than one-half (55%) of the adoptors adopted the contour hedgerow technology employing grass species particularly Vetiver grass as hedgerow materials. Likewise, more than three-fourths (85%) of them adopted the agroforestry systems. About 43 percent of the adoptors adopted both land-use systems.

The earliest adoption from among the technologies included in this study was noted in 1990 for both technologies (Figure 1). A more rapid adoption took place after 1992. During this period, the Upland Agriculture Project of FARMI was in place.

The adoption of the technologies has been observed to be continuously taking place through the years. This implies the increasing awareness and interest among upland farmers to rehabilitate their upland areas.

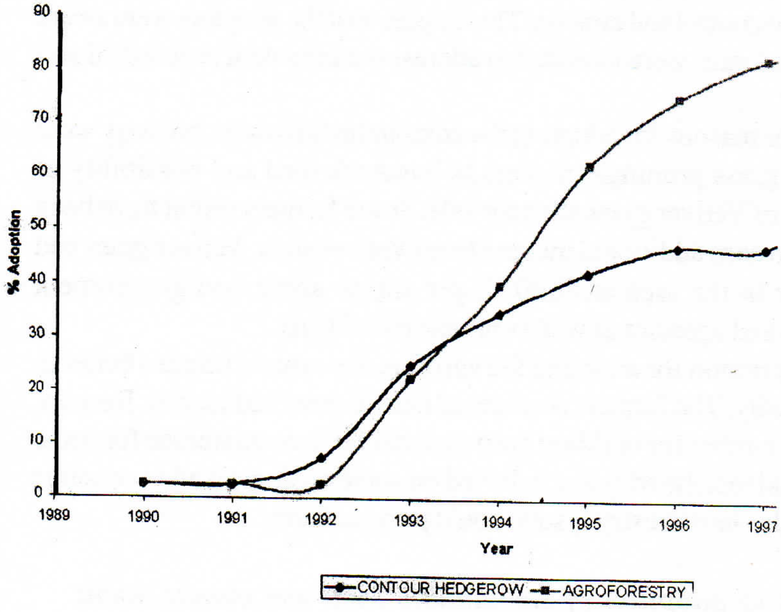

Figure 1. Cumulative adoption (in percent) by year of sustainable land-use management systems, Matalom, Leyte, Philippines (1999)

Reasons for adoption of sustainable land-use management systems

The adoptors of the sustainable land-use management systems disclosed several reasons for engaging in these systems. The foremost reason they cited was the need to control soil erosion. This implies that the adoptors were aware that the technologies were intended to address the prevalent problem of soil erosion.

The other reasons for adopting the contour hedgerow technology were utility of the grass prunings (napier) as livestock feed and possibility of reproduction of Vetiver grass slips for sale. Some farmers might have been encouraged to earn additional income from Vetiver slips. Vetiver grass had been for sale in the area at PhP0.50 per slip to some non-government organizations and agencies as well as private individuals.

Another reason for adopting the agroforestry system implies belief in financial security. The farmers considered trees as reserved capital. Besides, trees provide lumber for building purposes and serve as guarantee for some bank loans. Indeed, the adoptors believed on some ecological and economic benefits that the agroforestry system could provide them.

Constraints to adoption of sustainable land-use management systems

For their part, the non-adoptors cited reasons for not engaging in any of the sustainable land-use management systems introduced in the area. It was noted that the tenure status of the upland farmers influenced their decision-making with regard to non-adoption of innovations like contour hedgerow and agroforestry systems whose benefits are not easily realized.

Other reasons for their non-adoption of the contour hedgerow technology included reduction of the cropped area, limited farm parcels, lack of knowledge about the technology, and unavailability of hedgerow materials. Meanwhile, the other reasons for non-adoption of the agroforestry technologies included fear that trees would shade on crops, limited farm parcels, unavailability of tree seedlings, and difficulty in plowing contoured area.

Knowledge of farmers on sustainable land-use management systems

Table 1 shows the mean response scores of both adoptors and non-adoptors as compared with the scientific score for each of the questions asked. It can be noted that the mean response scores of the adoptors were generally closer to the scientific scores than the mean response scores of non-adoptors. This implies that the adoptors were more knowledgeable than the non-adoptors about the topics/questions asked. This is supported by the significantly higher mean scientific scores of adoptors than non-adoptors for all questions (Table 2). The adoptors had 90 percent mean scieitfic score as compared with only 56 percent by the non-adoptors.

Factors affecting knowledge of upland farmers

Among the independent variables included in the model, attendance in trainings, contact with extension agents, and education of the upland farmers significantly and positively influenced their knowledge scores (Table 3).

Attendance in related trainings had a strong positive and significant influence on the knowledge scores of the upland farmers. This implies that those who attended related trainings had higher knowledge scores. This could be attributed to the fact that most trainings conducted were facilitated by FARMI and FOBI with topics on soil conervation mesures to check the problem of soil erosion.

Contact with extension workers had likewise strong positive and significant influence on the knowledge scores of the upland farmers. This implies that those who had contact with extension workers had higher knowledge scores. Contact with extension workers could have provided the upland farmers the opportunity to discuss and learn relevant upland farming issues like appropriate sustainable land-use systems.

Moreover, education of the upland farmers had a positive and significant influence on their knowledge scores. The coefficient value of education (1.16) implies that a 1-year increase in formal education increases the knowledge

Table 1. Knowledge scores of adoptors and non-adoptors of sustainable land-use management systems, Matalom, Leyte, Philippines, 1999.

TOPIC	MEAN RESPONSE		SCIENTIFIC SCORE
	Adoptor	Non-adoptor	
1. Soil is an important resource necessary in farming.	1.0	1.0	1.0
2. Topsoil can be lost by soil erosion.	1.0	1.025	1.0
3. Soil can regenerate by itself.	1.075	1.55	1.0
4. In general, the rate of soil regeneration is faster than soil degradation.	1.925	1.875	2.0
5. The more the vegetative cover of the soil, the lesser is the rate of soil erosion.	1.075	1.475	1.0
6. The steeper the area cultivated, the faster is the rate of erosion.	1.0	1.05	1.0
7. Continuous open cultivation in the uplands hastens the process of soil erosion.	1.25	1.60	1.0
8. Deforestation/kaingin doesn't contribute to soil erosion.	2.0	1.925	2.0
9. When the soil is eroded, nutrients in the soil are also washed away.	1.05	1.05	1.0
10. Soil erosion reduces crop productivity.	1.0	1.05	1.0
11. Plowing along the contour hastens soil erosion.	2.0	2.0	2.0
12. Eroded soil contributes to sedimentation of dams, rivers, lakes and canals.	1.05	1.10	1.0
13. Eroded soil contributes to increased incidence of flooding.	1.225	1.80	1.0
14. Soil erosion affects the quality of water in rivers and lakes.	1.075	1.35	1.0
15. Putting an area to fallow is beneficial.	1.025	1.10	1.0
16. The longer the fallow period, the better for the soil.	1.0	1.05	1.0

Continuation of Table 1

TOPIC	MEAN RESPONSE		SCIENTIFIC SCORE
	Adoptor	Non-adoptor	
17. Soil erosion is an important environmental problem that needs to be controlled/prevented.	1.025	1.05	1.0
18. Soil conservation measures should not be adopted as long as the soil is still productive.	1.90	1.60	2.0
19. Contour hedgerows and agroforestry systems help control soil erosion and its consequences.	1.0	1.20	1.0
20. Mixture of grasses and trees as hedgerow strip is better than grass alone.	1.075	1.80	1.0
21. Contour hedgerow technology is labor intensive.	1.675	2.0	1.0
22. Economic returns from contour hedgerow and agroforestry systems are not easily realized.	1.05	1.775	1.0
23. Contour hedgerow and agroforestry systems are economically beneficial in the long run.	1.025	1.675	1.0
24. Contour hedgerow and agroforestry systems help maintain and restore the productivity of the land.	1.0	1.175	1.0
25. Use of tree crops provide higher returns from the land compared to traditional native crops.	1.075	1.80	1.0
26. Tree litter increases soil cover and hence reduces soil erosion.	1.20	1.65	1.0
27. Trees strengthen and stabilize earth's structures for erosion control through the binding action of roots.	1.0	1.0	1.0

Continuation of Table 1

TOPIC	MEAN RESPONSE		SCIENTIFIC SCORE
	Adoptor	Non-adoptor	
28. Trees provide capital reserve that could be used in times of emergency.	1.0	1.60	1.0
29. Trees need to be replanted when cut or harvested.	1.0	1.0	1.0
30. Agroforestry does better than contour hedgerows in controlling soil erosion.	1.025	1.275	1.0

score by 1.16 percent. This could be due to the fact that formal education also increases one's knowledge or competence.

Factors affecting extent of adoption of sustainable technologies

Among the explanatory variables considered, knowledge score, membership in *alayon*, and access to credit significantly and positively influenced the extent of adoption of sustainable land-use management systems (Table 4). The knowledge of upland farmers in indeed important in their decision-making of adopting sustainable land-use management systems. As upland farmers become more knowledgeable on upland land-use management as well as on the economic and environmental/ecological considerations of the technologies, they become more inclined to adopt more sustainable systems. They might have known well the benefits (e.g. control of soil erosion) that they

Table 2. Scientific scores (percent) of adoptors and non-adoptors of sustainable land-use management systems, Matalom, Leyte, Philippines, 1999

Items	Adoptors	Non-adoptors	Both
Mean***	90.00	55.63	72.81
Std. Dev.	8.77	19.65	22.97
Minimum	80	0	0
Maximum	100	100	100

*** - Significant at 1% level

Table 3. Ordinary least squares (OLS) estimates of multiple regression model for knowldege scores of adoptors and non-adoptors of sustainable land-use management systems, Matalom, Leyte, Philippines, 1999

Variable	Coefficient	Standard Error
Intercept	47.8158***	3.5681
MemberOrg	-8.3093[ns]	6.7100
AttendTrng	25.1090***	5.9898
ExtContact	20.2157***	5.2495
Education	1.1569*	0.6796
F-value	37.47	
R^2 value	0.67	

*** - significant at 1% level
* - Significant at 10% level
ns - not significant

Table 4. Tobit estimates of factors affecting rank of extent of adoption of sustainable land-use management systems, Matalom, Leyte, Philippines, 1999.

Variable	Coefficient	Standard Error
Intercept	-3.2842***	1.1589
Knowledge score	0.0355***	0.0118
Membership in alayon	1.1839***	0.3514
Off-non-farm income	-0.0029	0.0079
Credit	0.6829***	0.2758
Sigma	0.9098***	0.1044
Log-likelihood Function (unrestricted)	-61.8294	
Log-likelihood Function (restricted)	-102.0521	
Likelihood ratio	80.4454	
Critical Chi-square	9.4877	

*** Significant at 1% level

could derive from engaging in more sustainable systems.

Membership in the *alayon* also positively and significantly influenced the extent of adoption of sustainable land-use management systems. *Alayon* is an indigenous labor group that was rehabilitated by FARMI in the area. The farmer-members agree among themselves to work together in the various farm operations through labor exchange. The farmer for whom the job or activity is done had an obligation to pay back each farmer-worker with the equal amount of time.

This positive and significant effect of membership in *alayon* could have been due to the fact that alayon members were priority participants in related trainings and recipients of start-up seedlings and other planting materials provided by the project. Besides, establishment activities for the various introduced technologies were carried out through alayon efforts.

Access to credit positively and significantly influenced the extent of adoption of sustainable land-use management systems. This implies that the more access the farmers have to credit services, the more sustainable are their farming system. In order to adopt more sustainable farming systems, the farmers need capital. They need to invest on tree seedlings and hedgerow materials. More access to credit service would provide them with the opportunity of availing additional capital to invest on more sustainable technologies.

Meanwhile, the off non-farm income of upland farmers was found to have negative, although not significant, influence on the extent of adoption of sustainable land-use management system.

Marginal changes on extent of adoption

The estimated marginal effect coefficient of knowledge score (0.0155) in Table 5 indicates that at 1 percent increase in knowledge score results into (a) 0.0155 increase in the rank of extent of adoption among adoptors and non-adoptors [$\partial E(Y)/\partial X$], (b) 0.0154 increase in the rank of extent of adoption for those with positive (above limit) rank of extent of adoption (adoptors) [$\partial Ey^*/\partial x$], and (c) 10% increase in the probability of adopting the technology by the non-adoptor [$\partial F(z)/\partial X$]. The knowledge score coefficient of 0.0061 suggests that a 1 percent increase in knowledge score would bring about an increase in the rank of extent of adoption of those above the limit (adoptors)

Table 5. Marginal effects of factors affecting the rank of extent of adoption of sustainable land-use management systems, Matalom, Leyte, Philippines, 1999.

Variable	Marginal Effect[1] coefficient ∂E(y)/∂x	Decomposition of Marginal Effect[2]			
		∂E(y*)/∂x	∂F(z)/∂x	F(z) x [∂E(y*)/∂x]	E(y*) x [∂F(z)∂x]
Intercept	-1.4330***	-1.4217	-1.2936	-0.5600	-0.8737
Knowledge Score	0.0155***	0.0154	0.0140	0.0061	0.0095
Alayon	0.5166***	0.5125	0.4663	0.2019	0.3149
Off-Non-farm Income	-0.0013	-0.0013	-0.0011	-0.0005	-0.0007
Credit	0.2980***	0.2956	0.2690	0.1174	0.1817

*** Significant at 1% level

1 The marginal effect was decomposed into:

F(z) (∂E(y*)/∂x) : This is the change in 'y' of those above the limit, weighted by the probability of being above the limit.

E(y*) [∂F(z)∂x] : This is the change in the probability of being above the limit, weighted by the expected value for those respondents above the limit.

∂E(y)/∂x : This is the effect on the rank of adoption of a one unit change in th eindependent variable for those respondents above the limit.

∂F(z)∂x] : This is the change in the probability of being an adoptor for every unit of change in the explanatory varibale. Tis is equivalent to f(z) β/o.

weighted by the probability of adopting the technology (by a non-adoptor) by 0.0061. Moreover, the knowledge score coefficient of 0.0095 implies that a knowledge score increased by 1 percent, would bring about an increase in the probability of adopting the technology (by non-adoptors), weighted by the expected value of the rank of extent of adoption, by 0.0095.

The interpretation of dummy variables is framed in terms of the sample instead of individual household since the dummy variable is the proportion of the sample for which it has a value of one (1). A 0.01 mean percentage increase in respondents who are members of the *alayon* would increase the expected value of rank of extent of adoption by 0.5166. Moreover, the rank of extent of adoption for those above the limit (adoptors) would increase by 0.5125, and the probability of adopting the technology by non-adoptors would increase by 46.63%.

In the same manner, a 0.01 mean percentage increase in the respondents who have access to credit would increase the expected value of rank in extent of adoption by 0.2980. This would represent a 0.2956 (0.2556) increase in rank of extent of adoption for adoptors and a 26.90% increase in the probability of adopting the technology by non-adoptors.

CONCLUSION

Membership in the *alayon* was the most influential factor that positively influenced the extent of adoption of upland farmers of the soil-conserving technologies. It was followed by availability of credit, and then by the knowledge of upland farmers about sustainable land-use management systems. Hence, the better access to credit and membership in the alayon and the higher are the farmer knowledge on upland land use and management as well as on the economic and environmental/ecological considerations of the technologies, the higher is the probability of adopting sustainable upland farming practices by the farmers.

The adoptors of sustainable land-use management systems (soil conserving technologies) have significantly higher knowledge about upland land use and management as well as about economic and environmental/ ecological consequencies of management practices compared to the non-adoptors. Knowledge is significantly affected by the upland farmers' attendance in related trainings, contact with extension agents, and the level of education.

IMPLICATIONS

1. Membership in the *alayon* is the most influential in the adoption of soil-conserving technologies like contour hedgerow and agroforestry systems. This indigenous organization needs to be further developed. Moreover, training and extension efforts should be encouraged to deal with local organizations like *alayon*.

2. Since knowledge of the upland farmers on the economic and

environmental/ecological consequencies of management practices influence their adoption behaviour, there is a need to further boost this factor. Some training programs or farmer field schools to improve farmers' knowledge of sustainable land use management system could be instituted in upland areas.

3. Access to credit also significantly influence the adoption behaviour of the upland farmers. Establishing species like grasses and trees require labor and other capital inputs and these investments are not always within the resources of farmers. They should then be provided with better access to credit. Moreover, low-interest credit should be provided to them, especially to the small and marginal ones.

4. Tenure has been identified in this study and other related studies (e.g. Lapar *et al.*, 1999) as one of the reasons for non-adoption of soil-conserving technologies. Benefits from these technologies are often realized only after a long period. As such, there is a need for policies that would assure that tenant farmers would have a share of the long-term benefits of these technologies.

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