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Impact of social, institutional and ecological factors on land management practices in mountain watersheds of Nepal

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Abstract

This paper analyses factors influencing the adoption of land management practices in two mountain watersheds of Nepal based on information collected through a questionnaire survey of 300 households. Farmers in both watersheds have adopted several types of structural and biological land management practices to control land degradation. The stepwise multiple linear regression model ran using SPSS revealed 10 variables significantly influencing the adoption of land management technologies. The variables found significant are: extension service, caste affiliation of farmers, household agricultural labor force, landholdings with *fluvents*, *dystrochrepts*, and *rhodustalfs* soils, training on land management, schooling period of the household head, participation in joint land management activities, and landslide density in farmlands. The predicted R value of 0.62, R square of 0.37, and adjusted R square of 0.35 indicate moderate explanatory power of the model as a whole. However, the acceptance of the variables included in the model helps us to draw very useful policy conclusions for sustainable land management. All above mentioned variables have positive influence on the adoption of land management technologies, but remarkably, extension services were revealed as the strongest factor influencing the adoption of technologies. This indicates the positive influence of the extension service provided by the Phewatal Management Project and the need for provision of similar type extension service for farmers elsewhere in the hills of Nepal.

Keywords: Land management; Structural measures; Biological measures; Fertilizers; Determinants of adoption; Stepwise linear regression

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Introduction

There is very high population pressure on land resources in developing countries due to small landholdings and dwindling quality of agricultural lands (Lefroy, Bechstedt, & Rais, 2000). The mountains of Nepal are not an exception where the degradation of land resource base and declining crop yields has been a major challenge to attain food security for farming communities (Keatinge et al., 1999; Paudel, 2001). Particularly in the middle mountains, hereafter referred to as the hills, a typical farm household possesses an average landholding size of about 0.75 ha and yields of rice, wheat, maize and millet range from 1 to 2.3 ton/ha (DA, 1999). Such very low crop yield is attributed primarily to dwindling soil fertility (Tuladhar, 1994). Being aware of the possible threat of food shortage arising from diminishing landholdings, hill farmers have adopted several strategies for securing their livelihood (Blaikie, 1985). Traditionally, expansion of agricultural land into forests and rangelands has been the most popular strategy. Nowadays there is very limited scope for this, owing to the location of most existing forests and rangelands in steep slopes and increasing government and local community restriction on encroachment of these resources. The overwhelming majority of Nepalese hill farmers have, therefore, resorted to land use intensification as an alternative strategy for sustaining their livelihoods. Being concerned about possible adverse effects of land use intensification on crop yield, hill farmers have adopted several biological and structural measures of land management ranging from terrace construction to agroforestry, though the degree of adoption of such measures varies from one farm household to another (Thapa & Weber, 1990). Despite this, farmlands in the hills of Nepal are undergoing degradation, as for some reasons farmers have not been able to manage them effectively (Fleming, 1983; Thapa, 1996; Thapa & Paudel, 2002).

Agriculture is the economic mainstay of the overwhelming majority of hill people in Nepal and will continue to remain so in the near future in view of very slow pace of economic development. However, the on-going land degradation has threatened undermining the sustenance of their livelihood. To prevent such possible situation, it is essential to enable hill farmers to expand and adopt more effective conservation measures by implementing appropriate land conservation programs. Any effort towards this direction should begin from a research that aims at exploring location specific factors influencing the adoption of land management practices. Findings of such research will be helpful for devising appropriate policies and programs conducive to promotion of land management. Realizing such need, this research was carried out in two small watersheds located in the Western Development Region of Nepal (Fig. 1). For two and half decades, farmers in Phewatal watershed were provided with external support such as extension services and subsidy for terrace improvement, so as enabling them to manage land resources effectively. While farmers in the Yamdi-Mardi watershed could not get such external support for land management. Selection of these two watersheds with distinct variation in terms of access to external support was inspired by our interest in, besides others, knowing about the impact of such support on adoption of land management practices, which bears very important policy relevance for sustainable land

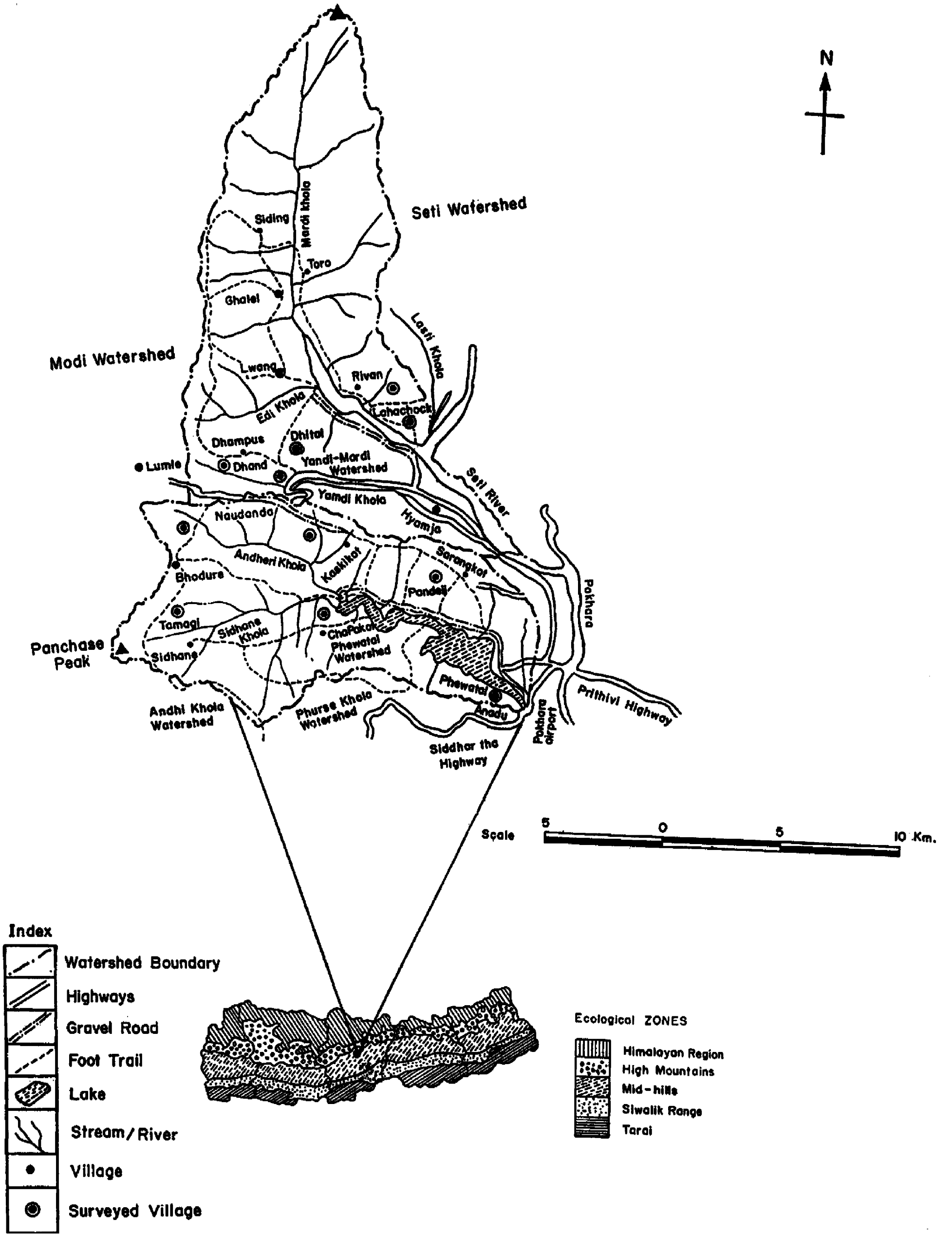

Fig. 1. Location of the study area in Nepal.

conservation. As elsewhere (Ervin & Ervin, 1982), we expected adoption of more measures of land management in Phewatal watershed, because of farmers' access to information and necessary support.

Factors influencing the adoption of land management practices: conceptual perspectives

As to why farmers' land management practices vary from one place to another or from one farm household to another has been a matter of constant concern for researchers, policymakers and planners. Depending on concerned individuals' academic background, professional area of concern and degree of exposure to land management issues, several explanations have been offered. Some of the explanations are very narrow, focused on a specific or few factors. For example, Boserup (1965), Geertz (1963) and Tiffen, Motimore, and Gichuki (1994) considered increased population pressure on land resources as a major factor stimulating farmers to adopt land management practices for maintaining per capita crop production. Other explanations like those given by cultural ecologist are broader, seeing land management practices at a given time and place as a function of constraints imposed by the physical environment, and technological capabilities to reduce and modify those constraints (Ali, 1995; Brookfield, 1972; Turner II and Brush, 1987). According to Schultz (1964), farmers' skill and knowledge about soils, plants, animals, and equipment, what he called "productive art", play an important role in the evolution of land use in any area. Hayami and Ruttan (1971), however, find agricultural land use changes significantly influenced by institutions and technology. Institutions not only govern the processes by which scientific and technical knowledge is created, but also facilitate the application of new management practices.

The above explanations are relevant, but less useful for devising strategies conducive to promoting effective land management practices, as they do not provide comprehensive explanation to the question raised at the beginning of this discussion. Farmers' land management practices are actually influenced by many macro-, meso- and micro-level factors, including availability of resources (natural, human, technological, capital), constraints (biophysical, socioeconomic), and policy environment (including land rights, land tenure, subsidies, taxes, commodity prices, transportation and marketing opportunities) (Rasul, 2003; Rasul & Thapa, forthcoming). This is reinforced by explanations given by Tisdell (1996) and Johnson, Pemberton, and Seepersad (1999) who find adoption of land management practices influenced by a set of interrelated biophysical, socioeconomic and institutional factors. Devising strategies for promotion of land management practices effectively entails in-depth knowledge about interrelationships between and influence of each level of factors. Thus, it is appropriate to start the investigation from the micro-level factors comprising farmers' socioeconomic and institutional characteristics, and physical attributes of landholdings.

Making decision on land management is a complex process which involves several sequential steps, each influenced by various biophysical, personal, socioeconomic and institutional factors. The process starts with farmers perceiving land degradation as a problem, which is influenced by the four major factors mentioned earlier. The decision whether or how to manage land depends on farmers' perception of land degradation as well as on their personal characteristics, socioeconomic condition, institutional support provided and biophysical characteristics of landholdings. These factors also determine the effectiveness and extent of land management practices (Ervin & Ervin, 1982).

Farmers' individual characteristics, feelings and aspirations considerably influence adoption of technologies (Giampietro, 1997). Those who are literate and have relatively better exposure to society and local institutions are more adaptive than illiterate farmers (Ervin & Ervin, 1982; Rauniyar, 1998; Mehta & Kellert, 1998; Johnson et al., 1999). Demographic characteristics of farm households, including household labor force size (Rauniyar, 1998), and social background, like caste, also play important roles. People whose primary source of income is not agriculture are less concerned about land conservation compared to others whose livelihood derives mainly from agriculture (Ervin & Ervin, 1982; Mehta & Kellert, 1998).

Resource ownership is another important factor determining the adoption of land management practices (Savadogo, Reardon, & Pietola, 1998). Farm operations at relatively large scale reduce the cost of conservation measures and encourage investments in land management (Raquel, 1985; Nelson & Cramb, 1998). Resource rich farmers are normally apt to change, as their accumulated wealth enables them to make investment in conservation measures (Barker, 1997).

Land resources undergo degradation due to landslide, accelerated soil erosion and declining fertility. Most often farmers adopt new land management practices when they realize the effect of land degradation on crop production (Lutz, Pagiola, & Reiche, 1994). In response to the threat of declining crop yield and food security, farmers react in a number of ways and adopt several land management technologies (Gafsi & Brossier, 1997). Normally, they concentrate their conservation efforts in soils which are susceptible to high rates of erosion (Ervin & Ervin, 1982; Paudel, 2001).

Provision of support services including agricultural credit, training and extension services is essential to enable farmers to adopt land management practices at least initially (Gafsi & Brossier, 1997). Line agencies and NGOs can play an important role in providing information to farmers about new technologies (Versteeg, Famdij, Eteka, Gogen, & Kudokpon, 1998). Normally, the adoption rate would be high, if farmers are regularly advised by competent extension agents, with adequate support materials provided in a coordinated way (Barker, 1997; Andesina, Mbila, Nkamleu, & Endamana, 2000).

Research methods

Study area

The study area comprising the Phewatal and Yamdi-Mardi watersheds extends over an area of 23,270 ha (Fig. 1). The climate is monsoon type, with annual average rainfall ranging from 3811 mm at 827 m amsl (above mean sea level) to 5237 mm at 1740 m amsl. Annual mean temperature in the valley floor is 21 °C, with monthly means ranging from 13 °C in January to 26 °C in July. The temperature decreases gradually from the valley floor to the ridge. Mean temperature on the ridge is recorded to be 16 °C, with ranging from 9 °C in January to 20 °C in August.

Located in the northern part of Pokhara valley, the Yamdi-Mardi watershed, hereafter referred to as the "project watershed", extends from the valley floor village of Hemja in the south to the east-west elongated mountain range in the north. The adjoining Phewatal watershed, hereafter referred to as the "non-project watershed", extends from the tail of Phewa lake to the head of Harpankhola, the stream which feeds the lake. A watershed management project was implemented in the Yamdi-Mardi watershed by the Department of Soil Conservation and Watershed Management during 1974/1975–1994/1995, with a total amount of investment of US$ 2.1 million primarily to control siltation of the lake (DSWO, 1997). The project activities were focused on landslide and gully stabilization, terrace improvement and agroforestry intensification. While farmers in the "non-project watershed" have not yet received such external assistance, they are nonetheless managing their landholdings utilizing knowledge and resources available at their disposal.

There is considerable variation in soil properties in the study area. Most soils found fall broadly under *entisols* and *inceptisols* groups, which are classified into five subgroups according to their properties. The *rhodustalfs* is found in the foothills and lower hill slopes between 1100 and 1500 m amsl. According to farmers, this type of soil is most erodible, often crusts over after hoeing and ploughing, and has a problem of phosphorus fixation. Because of high erodibility, this type of soil is subject to severe gully formation and susceptible to landslides.

Fluvents soil is found between 800 and 1200 m amsl in the lower foothills of both watersheds. Formed of recent stream deposition, the texture of this soil is generally coarse sandy with considerable inclusion of gravel. Due to low water holding capacity, this type of soil is not appropriate for crops requiring irrigation. However, it is highly suitable for grass and fodder trees. Farmers consider this soil as the second most erodible soil.

Farmers consider *Dystrochrepts* soil as the third most erodible soil. This is commonly found below 1500 m amsl in south facing slopes of both watersheds. The humid condition creates strong leaching and low base saturation makes surface soil more acidic and consequently this type of soil is less suitable for field crops. Regular leaching in the hill slopes during the rainy monsoon season makes lands with such soil susceptible to landslides and erosion.

The major proportion of farmlands in the study area comprises *umbrepts* soil with dark color, constituting 48% of the total farmlands in the "project watershed" and 53% in the "non-project watershed". This type of soil is commonly found between 1200 and 2200 m amsl, and has low base saturation and high organic matter content in the surface. According to farmers, high oxidation of organic matter limits plant growth in this type of soil. Therefore, regular replenishment of organic matter is essential to maintain soil fertility. Most uplands cultivated with maize and millet have this type of soil, which is considered to be less erodible by farmers.

About 6% of the farmlands in the "project watershed" and 13% in the "non-project watershed" have *molasols*, which are normally found along river terraces and lower hill slopes between 800 and 1500 m amsl. This type of soil has thick dark base and high organic matter content in the top layer. Being extensively used for rice cultivation, farmers consider this soil as the least erodible.

There are three distinct micro agro-ecological zones in both watersheds. Narrow river valleys, interspersed between spurs bifurcated from the mountain range extended latitudinally to the North of valleys, have a sub-tropical type of climate. Farmers have very small landholdings with steadily decreasing size. Average per capita landholdings in the "project watershed" had declined from 0.23 ha in 1978 (Fleming, 1983) to 0.11 ha in 1998. In the "non-project watershed", the landholding size had declined from 0.27 ha in 1978 (Kaski District Land Administration Office, 1979) to 0.12 ha in 1998. Lands are being utilized for mainly irrigated rice and maize cultivation. Hill slopes, with sub-tropical climate in the lower elevations and temperate climate in the higher elevations, are sandwiched between valley floors and the ridges. Rainfed rice is a dominant crop in the lower elevations, and mixed cultivation of maize, millet, vegetables, wheat, beans, potatoes and fruit trees is a common practice in the higher elevations. Ridges, characterized by a temperate climate, are utilized for mainly millet and maize cultivation.

In the past, rice and maize were the staple crops cultivated in valleys. To cope with the ever growing food requirement, farmers had started wheat cultivation since the early 1970s and vegetables, potato, peanuts and lentils since the 1980s. Similarly, on the hill slopes maize and millet were the staple crops until the 1970s. Cultivation of wheat, beans, lentil and vegetables began only during the 1980s.

Field survey

Detailed information on land management technologies adopted by farmers, socioeconomic condition, institutional support, soil type, status of land and approximate distance of farm plots from farmhouses was collected using a structured questionnaire. Additional information was collected through observation and group discussion. The household survey was conducted from April to September 1999. The sample size for the household survey was determined using the sampling method devised by Arkin and Colton (1963). A sample size of 300 households was calculated from a total of 10,836 households in two watersheds, at a 95% confidence level, with a precision level of ±4%. Farmlands in the valley floor have relatively fewer management problems compared to hill slope lands. Thus, only settlements on hill slopes were selected for the survey. There are six village development committees (VDCs) in each watershed. Each VDC is further divided into nine administrative units locally known as wards.

Twelve representative hill slope wards, comprising six wards from each watershed were chosen for the survey. To determine sample size for two watersheds, the total number of households was first determined for the chosen wards, comprising 481 households in the "project watershed" and 448 households in the "non-project watershed". Commensurate with the total number of households in the respective watersheds, 155 households in the "project watershed" and 145 household in the "non-project watershed" were surveyed. On average 26 households were surveyed from each chosen ward in the "project watershed" and 24 households in the "non-project watershed". A systematic random sampling method was adopted to select households for the survey. A list of household heads in all selected wards was systematically numbered from 1 to n. Then every third household was picked up for questionnaire survey. Detailed information on land management practices including construction of terraces, waterways, retention walls and check dams, gully control measures, alley cropping, mulching and application of organic and chemical fertilizers was collected through the household survey. Besides, information on farmers' experience in change in cropping pattern, soil fertility and soil erosion was collected through personal interview and group discussion.

Dependent variable (adoption of land management practices)

Possessing small landholdings and being concerned about possible adverse economic impact of land degradation, farmers in the study area have adopted several land management practices (Table 1). The degree of adoption and diversity of

Table 1
Land management indicators used for construction of the index of adoption of land management practices

Measures	Attributes
Structural measures	Terrace construction
	Construction of waterways
	Gully control
	Construction of retention walls
	Construction of check dams
Biological measures	Alley cropping
	Establish shrub and trees in gullies
	Use live materials in construction
	Mulching practices
Fertility management	Production and use of FYM
	Compost production and use
	Cultivate legume crops
	Use of green manure
	Use of chemical fertilizer

Source: Field survey, 1999.

practices, however, vary from one farm household to another, depending on their socioeconomic condition, biophysical characteristics of lands and institutional support services provided. In this pursuit, they have terraced lands, and constructed water ways, retention walls and check dams. They are also growing perennials together with field crops, and are applying both organic and chemical fertilizers. To determine the overall degree of adoption of land management practices, firstly, 14 common land management practices of farmers were selected (Table 1). Irrespective of the year of adoption, a score of 1.0 was assigned to the practice adopted by farmers and 0.0 to the practice not adopted. Then, all scores were aggregated and divided by 14 to obtain a composite index of adoption of land management practices. This index has been considered as dependent variable.

Selection of independent variables

Initially, 27 variables were selected for the regression analysis (Table 2). A multivariate correlation analysis was done to find out the collinearity of the independent variables. The analysis revealed 17 independent variables with high degree of correlation with each other ($r > 0.5$) and low degree of correlation with the dependent variable. All those variables with high collinearity ($r > 0.5$) were dropped from the regression model. Finally, 10 independent variables with high degree of correlation with the dependent variable and low degree of correlation with each other were included in the model (Table 2). These 10 variables represent one way or another other variables dropped from the model. For example, 'extension' (X_1) included in the model, is associated with 'credit for farming' (X_{22}), as normally, the farmers provided with extension services receive formal credit for investment in agricultural activities, including land management. The second variable 'agricultural labor force' (X_3) included in the model is associated with 'labor input' (X_{12}) and 'out-migration of labor' (X_{24}) dropped from the model. Farmers with relatively small number of household members available for agriculture cannot provide much labor required for land management. Particularly in the study area, this happens due to out-migration of economically active males. Several variables, including 'livestock ownership' (X_{13}), 'food production' (X_{14}), 'crop yield' (X_{15}), 'cropping intensity' (X_{16}), 'farm income' (X_{17}), 'off-farm income' (X_{18}), 'land affected by erosion' (X_{20}), 'land with declining fertility (X_{21}) dropped from the regression model are directly or indirectly linked to three variables, namely, '*Fluvents* soil' (X_4), '*Dystrochrepts* soil' (X_6) and 'landslide density' (X_{10}) retained in the model.

Independent variables other than caste are self-explanatory and expressed numerically, whereas the caste is a dummy variable created through a scoring method. Following the prevailing social system, a score of three was assigned to the upper castes like Brahamin and Chhetri, two to the middle castes like Gurung and Tamang, and one to the lower castes, including blacksmith and tailor. In view of the latter two caste groups not being fully engaged in agriculture, we considered it sensible to explore the effect of farmers' caste affiliation on adoption of land management technologies.

Table 2
Explanatory variables

Variables	Specification	Mean value
Extension service (X_1)	Frequency of visits by extension workers during 1988–1998	7.0
Caste (X_2)[a]	It is a dummy variable (please see bottom-note of this table)	–
Agricultural labor force (X_3)	Household labor force involved in agriculture (no./household)	2.0
Fluvents soil (X_4)	Ownership of land with *fluvents* soil (Hectare/person)	0.0047
Training (X_5)	Land management training attended by the household head (no. during 1988–1998)	1.0
Dystrochrepts soil (X_6)	Ownership of land with *dystrochrepts* soil (Hectare/person)	0.0253
Period of study (X_7)	Schooling period of the household head (no. of years studied at a school/college)	5.3
Rhodustalfs soil (X_8)	Ownership of land with *rhodustalfs* soil (Hectare/person)	0.0182
Participation (X_9)	Participation in joint land management activities (Workdays/household during 1988–1998)	23.0
Landslide density (X_{10})	Landslide density in farmland (no./hectare)	11.0
Active labor force (X_{11})	Active labor force, aged 11–59, at home (no./household)	4.5
Labor input (X_{12})	Labor input in land management and crop production (workdays/hectare/year)	249
Livestock ownership (X_{13})	Livestock ownership (head/person)	0.6
Food production (X_{14})	Food crop production (kg/person/year)	263
Crop yield (X_{15})	Crop yield (kg/hectare/year) (composite yield of all crops)	3016
Cropping intensity (X_{16})	Ratio of gross cropped area under different crops to net available farmland	1.63
Farm income (X_{17})	Cash income from farm sources (Rs./person/year)	1539
Off-farm income (X_{18})	Net cash income from off farm sources (Rs./person/year, including remittances)	3215
Distance (X_{19})	Mean distance to farm plots from farmhouse (in km)	1.5
Land affected by erosion (X_{20})	Percentage of agricultural land seriously affected by soil erosion	19.0
Land with declining fertility (X_{21})	Percentage of agricultural land with declining soil fertility	30.5
Credit (X_{22})	Credit obtained for farming activities (Rs./person)	514
Institutional membership (X_{23})	Number of family members affiliated with local institutions (no./household)	0.4
Out-migration of labor (X_{24})	Out-migration of active labor force (no/household)	1
Land ownership (X_{25})	Total land ownership (Hectare/person)	0.1198
Umbrepts soil (X_{26})	Ownership of land with *umbrepts* soil (Hectare/person)	0.0600
Molasoil soil (X_{27})	Ownership of land with *molasoil* soil (Hectare/person)	0.0116

[a] According to their social hierarchy, a score of three was assigned to the upper caste people, two to the middle caste people and one to the lower caste people to create this variable.

Model specification

Depending on the objective of the research, a complex analytical model like that of Ervin and Ervin (1982) or a simple linear regression model can be designed to analyze factors influencing adoption of land management. If the objective of the research is to explore factors influencing the entire process of adoption, it is essential to design a model comprising several dependent variables and run it using linear regression as done by Ervin and Ervin (1982). Alternatively, more sophisticated multivariate analytical methods such as Cluster Analysis and Discriminant Analysis can be used to analyze factors influencing land use and management (Rasul, 2003). In our case, the objective of the research is to understand in a very simple way factors explaining the variation in farmers' land management practices, as reflected in the index of land management practices. We consider multivariate linear regression a suitable analytical tool for this purpose. Though simple, findings based on such analysis, which are presented in the following section, bear very useful policy relevance for sustainable management of land resources. Factors influencing the adoption of land management technologies were analyzed using stepwise multiple linear regression, which is useful for the construction of adoption model when both independent and dependent variables are numerical (Hair, Anderson, Tatham, & Black, 1998; Raquel, 1985). As mentioned above, the dependent variable considered in our analysis is a numerical index which is assumed to vary from one household to another. Likewise, all independent variables but caste (X_2) are numerical (Table 2). Caste, originally a qualitative variable, was converted into a dummy variable following the method mentioned above, so as to make this variable compatible with the linear regression model. This type of analysis is an appropriate statistical tool to determine the influence of independent variables on dependent variables, as it allows to examine the contribution of each independent variables to the regression model (Hair et al., 1998; Mehta and Kellert, 1998; Mardia, Kent, & Bibby, 1982). This analysis has a straightforward statistical test, with high ability to incorporate effects of each independent variable on dependent variable.

Most farmers in the "project watershed" were provided with support like extension service, training, and funds for group based land conservation activities like construction of retention walls. Such support was not provided to farmers in the "non-project watershed". In such a situation, it is not possible to examine the influence of institutional factors on adoption of conservation practices by analyzing the two watersheds separately. Therefore, data sets of two watersheds were combined and incorporated into a regression model, which yielded useful results.

To pursue the stepwise multiple regression analysis, the dependent variable, adoption of land management technologies, is hypothesized as being influenced by a set of independent variables: $X_1,\ldots,X_n$ (Table 2).

The model is specified as follows:

$$Y = b_0 + b_1X_1 + b_2X_2 + \cdots + b_nX_n$$

where, Y is the dependent variable adoption of land management technologies, b_0 is the intercept, $b_1,b_2,\ldots,b_n$ are the coefficients of explanatory variables $X_1,X_2,\ldots,X_n$.

The model was constructed using the stepwise probability criteria of F to enter $<= 0.050$, and probability of F to remove $>= 0.100$. Independent variables ($X_1,\ldots,X_{10}$, Table 2) entered in the analysis were not significant for deletion.

Results

Prediction of the models

Independent variables ($X_1,\ldots,X_{10}$, Table 2), which had strong correlation with the adoption of land management technologies (Y), were entered step by step in the regression model. All variables included in the model have significantly influenced the adoption of technologies (Table 3).

Table 3
Summary of the model

Model	*R*	*R* square	Adjusted *R* square	Standard error of the estimate
1	0.395[a]	0.169	0.166	0.1401
2	0.475[b]	0.231	0.225	0.1250
3	0.506[c]	0.258	0.250	0.1330
4	0.532[d]	0.282	0.272	0.1311
5	0.555[e]	0.305	0.292	0.1294
6	0.571[f]	0.321	0.306	0.1282
7	0.586[g]	0.337	0.330	0.1270
8	0.599[h]	0.352	0.333	0.1259
9	0.609[i]	0.362	0.341	0.1252
10	0.619[j]	0.374	0.350	0.1243

[a] Predictors: Extension service.
[b] Predictors: Extension service and caste.
[c] Predictors: Extension service, caste and agricultural labor at home.
[d] Predictors: Extension service, caste, agricultural labor force and *fluvents* soil.
[e] Predictors: Extension service, caste, agricultural labor force, *fluvents* soil and training.
[f] Predictors: Extension service, caste, agricultural labor force, *fluvents* soil, training and *dystrochrepts* soil.
[g] Predictors: Extension service, caste, agricultural labor force, *fluvents* soil, training, *dystrochrepts* soil and schooling period of the household head.
[h] Predictors: Extension service, caste, agricultural labor force, *fluvents* soil, training, *dystrochrepts* soil, schooling period of the household head and *rhodustalfs* soil.
[i] Predictors: Extension service, caste, agricultural labor force, *fluvents* soil, training, *dystrochrepts* soil, schooling period of the household head, *rhodustalfs* soil and participation in joint land management activities.
[j] Predictors: Extension service, caste, agricultural labor force, *fluvents* soil, training, *dystrochrepts* soil, schooling period of the household head, *rhodustalfs* soil, participation in joint land management activities and landslide density in farmland.

Both multiple R and R squared values have increased with the addition of independent variables from X_1 to X_{10} (Table 3), and they have reasonable explanatory power in the models. The final model, with 10 independent variables, has moderate level of explanatory power, as the adjusted R square demonstrates 35% variation in the adoption of land management technologies. However, the model is statistically significant with minimum error of the estimate, and it can partly explain the adoption of land management technologies in complex biophysical and socioeconomic situation in the Hills of Nepal (Table 3). The F ratio of explanatory variables in the final model is statistically significant at 0.001 confidence level (Table 4). This indicates that the variables included in the model are correct.

Table 4
Anova of the regression models

Model		Sum of squares	Degree of freedom (df)	Mean square	F ratio	Significance
1	Regression	0.791	1	0.786196807	44.961	0.000
	Residual	5.800	299			
	Total	6.591	300			
2	Regression	1.198	2	0.597183607	37.482	0.000
	Residual	5.393	298			
	Total	6.591	300			
3	Regression	1.376	3	0.457178207	30.644	0.000
	Residual	5.215	297			
	Total	6.591	300			
4	Regression	1.537	4	0.383173307	27.100	0.000
	Residual	5.054	296			
	Total	6.591	300			
5	Regression	1.691	5	0.336168907	24.867	0.000
	Residual	4.900	295			
	Total	6.592	300			
6	Regression	1.791	6	0.298165707	22.977	0.000
	Residual	4.800	294			
	Total	6.591	300			
7	Regression	1.891	7	0.270162707	21.600	0.000
	Residual	4.700	293			
	Total	6.591	300			
8	Regression	1.995	8	0.249159807	20.520	0.000
	Residual	4.596	292			
	Total	6.591	300			
9	Regression	2.064	9	0.229157907	19.539	0.000
	Residual	4.527	291			
	Total	6.591	300			
10	Regression	2.140	10	0.214155807	18.701	0.000
	Residual	4.451	290			
	Total	6.591	300			

Note: Please see bottom note of Table 3 for the name of variables.

Table 5
Coefficients of independent variables included in the regression model# 10

	Unstandardized coefficients		Standardized coefficients	t	Significance
	B	Standard error	Beta		
(Constant)	0.325	0.024		13.400	0.000
Extension service (X_1)	1.144E-02	0.002	0.305	5.873	0.000
Caste (X_2)	1.220E-02	0.007	0.096	1.773	0.077
Agricultural labor force (X_3)	1.675E-02	0.006	0.142	2.824	0.005
Fluvent soil (X_4)	1.755	0.548	0.164	3.205	0.002
Training (X_5)	1.227E-02	0.005	0.122	2.467	0.014
Dystrochrepts soil (X_6)	0.489	0.172	0.143	2.839	0.005
Schooling period (X_7)	5.865E-03	0.002	0.146	2.829	0.005
Rhodustalfs soil (X_8)	0.485	0.189	0.128	2.574	0.011
Participation in joint land management activities (X_9)	7.893E-04	0.000	0.114	2.254	0.025
Landslide density (X_{10})	5.230E-04	0.000	0.109	2.211	0.028

Determinants of adoption of land management technologies

Results of the regression analysis revealed that adoption of land management technologies is significantly influenced by 10 independent variables. They are: frequency of visit by extension workers (X_1), farmers' caste affiliation (X_2), agricultural labor force size (X_3), ownership of land with *fluvents* soil (X_4), attendance of land management training (X_5), ownership of land with *dystrochrepts* soil (X_6), schooling period of household head (X_7), ownership of land with *rhodustalfs* soil (X_8), participation in joint land management activities (X_9) and landslide density in farmland (X_{10}). Of these, frequency of visit by extension workers appeared as the most influential variable explaining nearly 50% of the total variation explained (Table 3). This combined with the caste affiliation of watershed settlers explained 64% of the variation. Notably, variables X_1,...,X_5, explained nearly 90% of the total variation (Table 3), which is an indication of the importance of these variables in influencing the adoption of land management practices. Rest five variables X_6,...,X_{10} have not much explanatory power, though the direction of their relation with the dependent variable bear important policy implications.

As expected, all independent variables have a positive influence on the dependent variable (Table 5). There is a tendency to increasing the adoption of technologies with increasing availability of extension service, attendance of training on land management, farmers' caste, agricultural labor force size, schooling period of the household head and participation in joint land management activities. Likewise, farmers' adoption of land management increases with increasing landslide density, and the size of landholdings with relatively high erosion, landslide and leaching prone soils like *fluvents*, *dystrochrepts* and *rhodustalfs* (Table 5).

Discussion

Results of the regression analysis indicate that the adoption of land management technologies in the study area is influenced by several institutional, social and ecological factors. The following sections explain how these factors have influenced the adoption of land management technologies.

Institutional factors

Extension service provided to and training attended by farmers are institutional factors significantly influencing the adoption of land management technologies. The Phewatal Watershed Management Project, as mentioned above, has been implemented for two decades. The project had made provision of extension service and farmers' training for the promotion of conservation technologies. Extension officials had frequent contacts with the farmers and conducted training on natural resources conservation. Being intermediaries between the concerned agency and the farmers, extension workers made farmers aware of the advantages of locationally suitable land use and management technologies, and persuaded them to adopt. Likewise, trainings organized by the project have also contributed to promote the adoption of land management technologies. Small farmers hesitate to adopt new technologies, partly due to their suspicion about the benefits of technologies, and partly due to other socioeconomic constraints. Extension workers and training programs help to clarify whatever the suspicion or doubts farmers may have, and motivate them to adopt conservation technologies. This is why, as experienced elsewhere (Ison, 2000), there is tendency to increasing the adoption of land management technologies with increasing extension service (Table 5). Since any extension service and farmers' training was not arranged in the "non-project watershed", we can conclude that the Phewatal Watershed Management Project had positively influenced the adoption of land management technologies particularly in its command area.

Social factors

Farmers' caste affiliation, agricultural labor force size, household head's schooling period and farmers' participation in joint land management activities are social factors significantly influencing the adoption of land management technologies. Regarding farmers' caste affiliation, those belonging to the upper caste have adopted more technologies (Table 5). This happened because agriculture is the economic mainstay of these farmers. They cannot fulfill even their subsistence requirements, if they do not take proper care of land. Other castes like the Gurungs do not depend much on farming, because they are earning substantial amounts of income from pensions and remittances. Agriculture is the least preferred profession of Gurung and Magar people, as they derive considerable proportion of income from pensions and remittances from abroad (Biot, Blaikie, Jackson, & Jones, 1995; Vansittart, 1993; Seddon, Blaikie, & Cameron, 1979; Messesrchmidt, 1976). Particularly, the lower caste people depend on wage labor, pottery, weaving, leatherwork, metalwork, and woodcarving as the major sources of earnings. Possessing tiny landholdings that provide very little income, they are less interested in agriculture. Therefore, these people do not pay much attention to land management.

Agricultural activities in the study area are highly labor intensive. Besides collection of fodder and fuelwood, farmers have to plough land twice or thrice depending on the crop, slice terrace risers, cultivate crops, take out weeds and harvest crops. The labor requirement is substantially increased, if farmers want to improve terraces, construct check dams and retention walls, and apply adequate amounts of green manure and compost to their farmlands. Therefore, there is a tendency to increased adoption of land management technologies with an increased number of household members engaged in agriculture. Despite their willingness, farmers with a relatively small agricultural labor force cannot take care of farmlands effectively. It is beyond their capability to meet the labor requirement for all kinds of conservation practices. This also partly explains why the Gurungs and the lower caste people, who have relatively small labor force engaged in agriculture, have not been able to adopt as many conservation practices as the upper caste people. Most Gurung households in the study area have at least one adult male member working in other countries, including India, Singapore and UK. Likewise, the majority of household members belonging to the lower caste are engaged in non-farming activities. Therefore, the adoption of land management technologies is low among these people.

The schooling period of farm household heads is another important social factor influencing the adoption of land management technologies. In the rural context of Nepal, household heads are the ones who take decisions on the major matters, including land management. Farm household heads who have opportunity to study in formal educational institutions for a long period acquire more knowledge and strengthen their analytical capability. Besides, their capability to seek information and get necessary support from government and non-government organizations is also improved. This is why there is a tendency to increased adoption of technologies with increased schooling period of farm household heads (Table 5). Better educated farmers are aware of several kinds of land conservation measures through their good personal contacts with agencies involved in land management. Illiterate and low educated farmers cannot get such opportunities, which inhibits them from the adoption of conservation technologies.

Farmers' participation in joint land management activities, like check dams and retention walls construction, and gully stabilization, is the fourth influential social factor (Table 3). The construction of conservation measures like check dams, retention walls and waterways requires substantial amounts of labor, financial and material resources, which is beyond the affordability of an individual farm household. However, farmers who organize themselves in groups and pool their personal resources together for common benefit can manage to undertake such activities. Therefore, there is a tendency towards increasing the adoption of land management technologies with increasing farmers' participation in joint land management activities (Table 5).

Ecological factors

Being a mountainous area, ecological conditions in the study area vary even with a short distance. There are several types of soils that vary in physical and chemical properties, depending on parent materials, altitude and slope gradient. Farmers are not aware of chemical properties of soils. But they are well aware of the productive value and problems associated with all types of soils, and have adopted appropriate conservation measures to control the degradation of problem soils. The specific example is farmlands with *fluvents*, *dystrochrepts* and *rhodustalfs* soils. Farmers are well aware that farmlands with such soils are prone to high rates of erosion, leaching and landslides under the influence of heavy rainfall and steep slope gradient. Farmers have established shrub formations, and constructed waterways, retention walls and check dams to control soil erosion and landslides, wherever they have felt necessary. This is why there is a tendency towards increased adoption of land management technologies with increased land area with *fluvents*, *dystrochrepts* and *rhodustalfs* soils (Table 5).

Landslides are a common feature in the study area. Farmers frequently complain that every year heavy rain combined with steep slope gradient and weak rock structure trigger landslides, which badly affect their crop productivity if repair works are not done immediately (Paudel, 2001). To prevent and mitigate the impact of landslides, farmers have constructed retention walls and waterways, and reinforced terrace risers using logs and stones. This is why there is a tendency to increased adoption of land management practices with increased density of landslides (Table 5).

Conclusion

Being concerned about the vulnerability of lands to degradation and its adverse impact on their economic condition, farmers in the study area have adopted assorted types of land management technologies. The degree of adoption of technologies varies from one farmer to another, depending on several ecological, social and institutional factors. The specific factors significantly influencing the adoption of technologies are extension service, farmers' caste affiliation, agricultural labor force size, landholdings with *fluvents*, *dystrochrepts* and *rhodustalfs* soils, farmers' training, schooling period of farm household head, participation in joint land management activities, and landslide density in farmlands. Extension services, which have the strongest influence on adoption of technologies, and training on land management were arranged only by the Phewatal Watershed Management Project. This is an indication of the positive contribution made by the project, though this is limited to the "project watershed".

The findings of this study have important policy implications for sustainable land management in the study area. Any future land management initiative should aim at enabling watershed settlers to adopt practices conducive to increase income as well as to enhance land conservation. Farmers have adopted several land management practices passed on to them by their forefathers. However, they admit that the traditional practices in their present form cannot help to manage farmlands effectively and to improve production.

Despite farmers' efforts, farmlands in the study area (Paudel, 2001) and elsewhere in Nepal (Thapa, 1996) are undergoing degradation due to the arable agriculture that requires regular hoeing and ploughing of lands on steep slopes. This entails the promotion of ecologically suitable and economically viable non-arable types of land use that do not disturb soil structure frequently. But due to several socioeconomic and institutional constraints, farmers will not be able to shift entirely to this type of land use in the near future (Thapa, 1996). A pragmatic approach to effective land management should therefore be to mitigate the adverse effects of the current land use in the short-run and enable farmers to adopt non-arable land use in the long-run.

Promotion of land management practices in Nepal has so far been the responsibility of the Department of Soil Conservation and Watershed Management (DSCWM). The Department of Agriculture (DoA), which is the agency responsible for agricultural production promotion, is little concerned about land management, though most of the policymakers and program executioners of this agency are well aware of the effects of land degradation on agricultural production. Agricultural extension services provided and training courses organized by DoA are very much focused on dissemination of information on improved varieties of seeds and breeds of livestock, application of fertilizers, and treatment of crop and livestock diseases. On the other side, activities of DSCWM have been confined to small watersheds of selected districts due to lack of required human and financial resources. Most of the watershed management projects carried out by DSCWM, like in the Phewatal watershed, are supported by external agencies, and this agency has not been able to continue conservation activities after the withdrawal of the external support (Thapa, 2001). In view of the important roles of extension services and training in promotion of land management practices, as justified by the findings of this study, on the one side, and the inability of the DSCWM in providing required extension services to farmers in all watersheds, promotion of locationally suitable and socially acceptable land management practices should be an integral part of agricultural production promotion strategy of DoA. As this Department has got a multi-layer and well organized extension system, the agricultural extension workers based at villages can play an important catalyst role in promotion of appropriate land management practices. Besides, they can organize workshops and training courses to enable farmers to adopt management practices. This entails reorientation of the entire agricultural extension policy. Consistence with such policy, there is need for provision of training on land management for all levels of extension agents.

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