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Factors Affecting the Adoption of Soil Conservation Measures: A Case Study of Fijian Cane Farmers

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This study explores the extent to which various factors affect Fijian cane farmers' adoption of soil conservation measures. The significant factors affecting perception of the soil erosion problem include age, education, ethnicity, and extension services. On the other hand, the significant factors affecting soil conservation effort include perception of the erosion problem, net farm income, farm size, land type, and extension services. In general, personal characteristics appear to affect perceptions of soil erosion while the extent of conservation effort is affected by economic and physical factors. The resulting implications for soil conservation policy are discussed.

Key words: Fiji, ordered probit model, soil conservation, soil erosion, sugarcane

Introduction

Fiji is a relatively small Pacific Island country with a population of 824,000. The Fiji Islands comprise some 300 islands covering a land area of approximately 18,400 km^2 (figure 1). The two largest islands, Viti Levu and Vanua Levu, make up 88% of the land area. Approximately 16% of the land is suitable for arable agriculture, and an additional 43% can be used for tree cropping and grazing. For many decades agriculture in Fiji has been the major contributor to gross domestic product (GDP) and exports. In 1994, agriculture's share of total exports was 60%, while its share of GDP was 18%. However, agriculture's contribution to GDP and exports is on the decline, having now been overtaken by tourism and textiles. The tourism sector alone currently contributes about 20% of GDP, while agriculture's share is approximately 15%. Nevertheless, agriculture remains the main source of employment. Sugar production and subsistence farming are the dominant activities in this sector, with the former providing employment for more than 25% of the workforce (Kumar and Prasad, 2002).

Although there is a reasonable level of public awareness about environmental issues in Fiji, recent evidence suggests the problem of land degradation is worsening.[1] Soil loss measurements by the Fiji Ministry of Agriculture, Sugar, and Land Resettlement indicate that the agricultural productive base in many sugarcane areas is declining at a rate well above what would be regarded as economically acceptable (Leslie and Ratukalou, 2002). The main form of land degradation is soil degradation, which occurs

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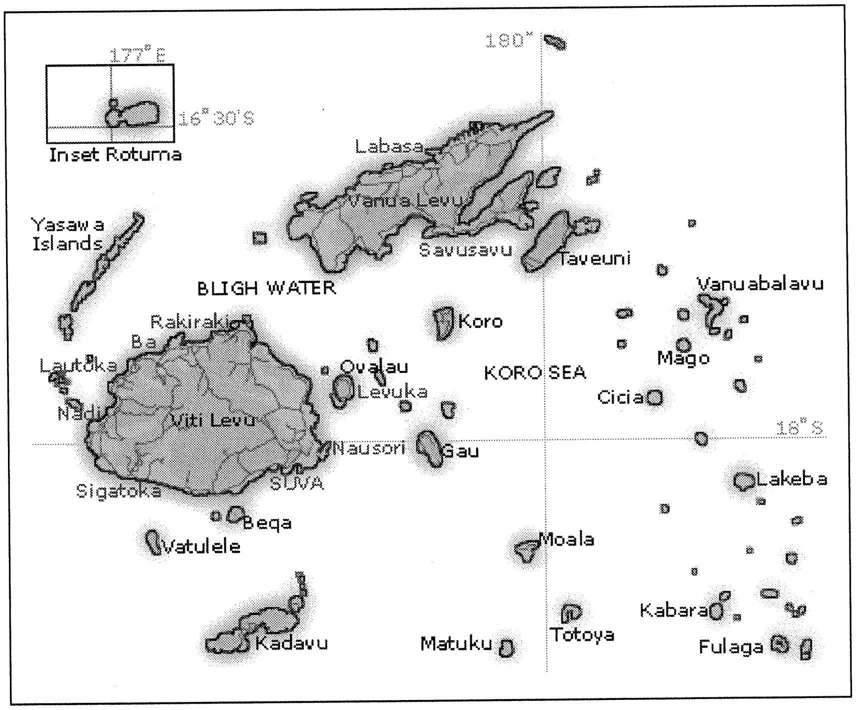
[1] Land degradation consists of soil, biological, physical, and chemical degradation.



Source: http://www.fiji.gov.fj /publish/fiji_map.shtml.

Figure 1. Map of Fiji

from widespread and indiscriminate burning—particularly, but not exclusively, in the sugarcane growing areas. Other causes of soil degradation include deforestation, overgrazing, and expansion of sugarcane and other traditional crops (e.g., dalo and yagona) onto marginal land (e.g., steep slopes).

In a review of a variety of catchments in both the western (dry) and eastern (wet) sides of Viti Levu, the International Union for the Conservation of Nature and Natural Resources (IUCN) estimated soil loss to be between 24 and 79 tons per hectare per annum, which is equivalent to a topsoil loss of 1.6–5.3 mm per annum (IUCN, 1992). Other forms of land degradation include excessive pesticide and fertilizer use in taro and vegetable farming. A serious consequence of land degradation is that the impacts from natural disasters are becoming increasingly more acute—in particular, vulnerability to droughts and flooding. The cost of these natural disasters is conservatively estimated at an average of F$20 million[2] per annum (Swami, 2004). The social costs are even greater when one considers the reduction in rural incomes and the increase in rural unemployment as a result of these climatic events.

Despite the acuteness of the land degradation problem in Fiji, no formal studies have examined the socioeconomic factors influencing the adoption and diffusion of soil conservation technologies. Moreover, the results of studies conducted in other developing countries do not necessarily apply to the Pacific Island countries (PICs) in general, or to Fiji in particular, due to their different geographical, socioeconomic, and environmental

[2] F$1 = US$0.64.

circumstances. Pacific Island countries face unique developmental challenges because they have relatively small populations and fragile island ecosystems. Furthermore, most PICs have a narrow resource base and are remote from major international markets.

To fill this gap in knowledge, the objective of this study is to identify the key factors affecting Fijian cane farmers' adoption of soil conservation measures. The results will be useful in informing the design of effective intervention strategies to address the land degradation problem. Increasing demands on land resources are linked to population growth and limited arable land. Failure to address the land degradation issue would lead to further land degradation, lower yields, and an increase in poverty. Given the crucial role of agriculture in Fiji's economy, it may be argued that the overall goal of sustainable development can be achieved only through sustainable agriculture. The study's results will also have implications for similar small island developing countries.

The issue of adoption of agricultural innovations in general, and soil conservation in particular, has been extensively studied since the 1950s. Yet, most of the studies on this topic have treated adoption of soil conservation as a binary choice decision process in which a farmer either adopts a recommended technology or not. However, the binary specification of the decision problem overlooks the extent and intensity of adoption.

In their seminal paper reviewing adoption of agricultural innovations in developing countries, Feder, Just, and Zilberman (1985) observed that adoption decisions of various innovations are interrelated and noted a dearth of research to address the issue. In this paper, we contribute to the soil conservation adoption literature by considering a range of adoption possibilities including traditional and other types of soil conservation. By estimating a two-stage ordered probit model, this investigation also takes into account the fact that a farmer's perception of the soil erosion problem and the amount of conservation effort are determined simultaneously. To the best of our knowledge, only Doss and Morris (2001), in a study of maize farmers in Ghana,[3] have addressed the simultaneity problem in the soil conservation area.

Earlier studies using this approach in other areas include Brooks, Cameron, and Carter (1998), who investigated the simultaneous relationship between Political Action Committee contributions and congressional votes on U.S. sugar legislation, and Holloway, Barrett, and Ehui (2005), who addressed the simultaneity issue from a Bayesian perspective in their study of milk market participation in the Ethiopian highlands. More recently, Bellemare and Barrett (2006) evaluated the issue of simultaneity between market participation and volume decisions using a sample of Kenyan and Ethiopian households.

The remainder of the paper is organized as follows. The next section briefly reviews the literature on soil conservation, with particular emphasis on developing countries. The research methodology is then discussed, which includes the model specification, estimation issues, and survey design. Next, the empirical results are presented and discussed. The final section gives the study's conclusions and highlights policy implications.

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[3] We thank an anonymous reviewer who drew this study to our attention.

Previous Studies, Hypotheses, and Conceptual Model

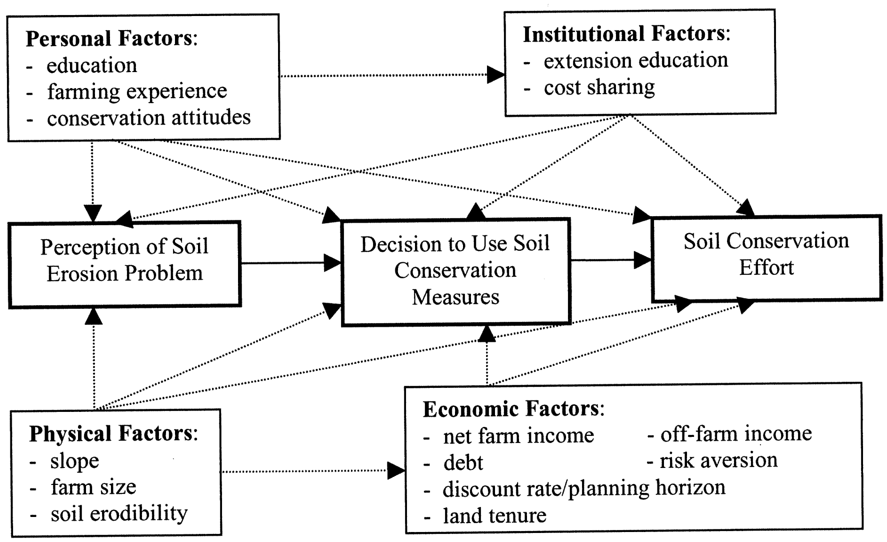
In general, economic theory does not offer much guidance in explaining the factors influencing a farmer's decision to undertake soil conservation. Although the level of a farmer's investment in conservation practices can be derived from the maximization of his/her utility function, the arguments of that utility function are unknown (e.g., see Norris and Batie, 1987; Meyer and Kuh, 1957). However, research conducted since the 1950s indicates economic constraints affect the decision to apply soil conservation measures. For example, a study by Blase (1960) concluded the following factors are significant: off-farm income (interpreted as a means to overcome financial constraints), perception of soil erosion as a problem, and ability to borrow funds. Based on a survey conducted by Carlson et al. (1977), increasing levels of education, farm size, and gross income were moderately associated with a higher number of soil conservation practices. Other studies (e.g., Earle, Rose, and Brownlea, 1979; Nowak and Korsching, 1983) found that farmer characteristics such as age, education, perception of erosion, farm size, off-farm employment, net income, and race affect farmers' adoption of new practices, and in particular, soil conservation practices.

In Sinden and King's (1990) study of farms in Manilla Shire, New South Wales, the farmer's rating as an investor, size and security of farm income, and the presence of institutional programs were significant factors found to encourage adoption of soil conservation practices. However, in another study on the adoption of soil conservation measures in the Northern Province of South Africa, Anim (1999) reported that age, security of land tenure, informal communication, and size of land holding did not appear to be significant determinants of the adoption of soil conservation measures.

Several studies have shown the importance of extension education on the adoption of soil conservation measures (e.g., see Feder and Slade, 1984; Jamison and Moock, 1984; Rahm and Huffman, 1984). Attitudes and factors such as the nature of farm terrain have also been found to affect farmers' soil conservation behavior (Lynne, Shonkwiler, and Rola, 1988). More recently, Doss and Morris (2001) concluded that gender-linked differences in the adoption of modern maize varieties and chemical fertilizers result from gender-linked differences in access to complementary inputs.

Following Ervin and Ervin (1982), we hypothesize that the decision-making process to adopt soil conservation measures begins with a perception of the erosion problem (figure 2). The degree of this perception depends on the farmer's personal characteristics (e.g., age, education, conservation attitudes) and the physical characteristics of the land (e.g., slope). The effect of age on adoption of soil conservation is unclear. Older farmers could adopt conservation because they have more experience, but conversely, they could be less willing to bear the risk of investing in soil conservation due to their shorter planning horizons. Also, younger farmers may be more educated and therefore more involved with innovative farming practices; consequently, they will be more aware of erosion problems and solutions. Higher education levels are hypothesized to be associated with improved knowledge about conservation measures and the productivity effects of erosion. As shown in figure 2, institutional factors such as extension education may also assist in heightening awareness of the soil erosion problem.

Once the erosion problem has been perceived, the farmer decides to adopt a soil conservation practice(s). This decision will be influenced by a combination of personal, institutional, physical, and economic factors. For example, the higher the level of education,



Source: Adapted from Ervin and Ervin (1982).

Figure 2. The decision to use soil conservation

the more information and awareness the farmer possesses regarding the costs and benefits of soil conservation, and therefore the more likely this individual is to adopt a given practice. Institutional factors such as extension programs and the possibility of sharing costs may persuade farmers to adopt particular measures.

The perceived extent of actual or potential physical erosion on the farm may also motivate a farmer to choose a particular measure. Economic factors, such as net farm income, off-farm income, risk aversion, discount rate/planning period, debt status, and land tenure, may either inhibit or enhance a farmer's inclination toward adopting soil conservation. For example, a high level of debt or low net farm income will tend to reduce the probability of adopting a capital-intensive measure, while lack of secure tenure will reduce incentives for investing in conservation measures.

The final step in the process is the determination of soil conservation effort. The choice of soil conservation effort is affected by the four factors outlined above. Personal factors such as education and farming experience affect the proper application and maintenance of soil conservation practices. The choice of how much effort to apply also depends on the physical characteristics of the land such as slope and farm size. However, because measures that are more efficient in reducing erosion are more expensive, the economic factors are hypothesized to more significantly impact the conservation effort.

Empirical Model, Variables, and Data

Model Specification

In the past, analytical models such as probit and logit models have been used to analyze farmers' adoption decisions (e.g., see Jamison and Moock, 1984; Rahm and Huffman, 1984; Lapar, Lucila, and Pandey, 1999; Anim, 1999). However, a farmer's decision to use a particular technology is not necessarily binary (i.e., yes/no), but may be multivariate in nature. As pointed out by Lynne, Shonkwiler, and Rola (1988), and Dorfman (1996), using a binary dependent variable could lead to the loss of useful economic information contained in the interdependent and simultaneous adoption decisions. Here, the adoption decision is presented as a choice from a set of alternatives.

To operationalize the conceptual model described in figure 2, we specify a set of equations comprising perception of the soil erosion problem and adoption of soil conservation practices. From the conceptual framework, it can be seen that a farmer's perception of the soil erosion problem and the decision to adopt a conservation measure are assumed to be interrelated. Specifically, a farmer's perception of the soil erosion problem depends on personal characteristics such as educational level and experience. However, adoption of soil conservation technology also depends, inter alia, on the perception of the problem. Thus, the perception variable could be endogenous, and hence simultaneously determined with the variable for soil conservation effort. To address this problem, we estimate the following latent variable system with discrete choices.

Perception of the soil erosion problem is specified as

$$(1) \qquad \mathbf{Y}_{1j}^{*} = \mathbf{X}_{1j}'\boldsymbol{\beta}_2 + \varepsilon_{1j},$$

and the soil conservation effort is designated by

$$(2) \qquad \mathbf{Y}_{2j}^{*} = \mathbf{X}_{2j}'\boldsymbol{\beta}_2 + \mathbf{Y}_{1j}^{*}\boldsymbol{\gamma}_1 + \varepsilon_{2j},$$

where $\mathbf{Y}_{1j}^{*}$ indicates farmer j's perception of the soil erosion problem, $\mathbf{Y}_{2j}^{*}$ denotes farmer j's soil conservation effort, $\mathbf{X}_{1j}'$ is a vector of variables explaining the farmer's perception of the soil erosion problem, $\mathbf{X}_{2j}'$ is a vector of variables explaining the farmer's soil conservation effort, $\boldsymbol{\beta}_1$ and $\boldsymbol{\beta}_2$ are vectors of coefficients, $\boldsymbol{\gamma}_1$ is a vector of coefficients of perception, and ε_{1j} and ε_{2j} are error terms that are assumed to be normally distributed.

For perception of the soil erosion problem, the observed category of $\mathbf{Y}_{1j}$ for a given farmer is determined from $\mathbf{Y}_{1j}^{*}$ using the rule:

$$(3) \qquad \mathbf{Y}_{1j} = \begin{cases} 0 \text{ if } \mathbf{Y}_j^{*} \le \gamma_1, \\ 1 \text{ if } \gamma_1 < \mathbf{Y}_j^{*} \le \gamma_2, \\ 2 \text{ if } \gamma_2 < \mathbf{Y}_j^{*} \le \gamma_3, \\ 3 \text{ if } \gamma_3 < \mathbf{Y}_j^{*}, \end{cases}$$

where the γ_js are unknown cut-points or threshold parameters. (Further details on the categories are given in the next section.) Ordering is preserved in this specification in the sense that $\mathbf{Y}_{1j}^{*} < \mathbf{Y}_{1k}^{*}$ implies $\mathbf{Y}_{1j} < \mathbf{Y}_{1k}$. It follows that the probability of observing a given value of $\mathbf{Y}_{1j}$ is given by:

$$(4) \qquad \begin{aligned} P(\mathbf{Y}_{1j} = 0 \mid \mathbf{X}_{1j}, \boldsymbol{\beta}, \gamma) &= F(\gamma_1 - \mathbf{X}_{1j}'\boldsymbol{\beta}), \\ P(\mathbf{Y}_{1j} = 1 \mid \mathbf{X}_{1j}, \boldsymbol{\beta}, \gamma) &= F(\gamma_2 - \mathbf{X}_{1j}'\boldsymbol{\beta}) - F(\gamma_1 - \mathbf{X}_{1j}'\boldsymbol{\beta}), \\ &\ldots \\ P(\mathbf{Y}_{1j} = 3 \mid \mathbf{X}_{1j}, \boldsymbol{\beta}, \gamma) &= 1 - F(\gamma_4 - \mathbf{X}_{1j}'\boldsymbol{\beta}), \end{aligned}$$

where $F(\cdot)$ is the cumulative distribution function of ε_{1j}.

The observed category of $\mathbf{Y}_{2j}$ for a given farmer is determined from $\mathbf{Y}_{2j}^*$ using the rule:

$$\text{(5)} \qquad \mathbf{Y}_{2j} = \begin{cases} 0 \text{ if } \mathbf{Y}_{2j}^* \le \gamma_1, \\ 1 \text{ if } \gamma_1 < \mathbf{Y}_{2j}^* \le \gamma_2, \\ 2 \text{ if } \gamma_2 < \mathbf{Y}_{2j}^* \le \gamma_3, \\ \quad \cdots \\ J \text{ if } \gamma_j < \mathbf{Y}_{2j}^*. \end{cases}$$

The probability of observing a given value of $\mathbf{Y}_{2j}$ for a randomly selected farmer is determined in the same manner as in equation (4). Following expected utility theory, it is assumed a farmer will choose a given soil conservation practice if the expected utility of doing so is greater than the expected utility of the existing soil conservation practice.

Equations (1) and (2) are estimated as an ordered probit model (Greene, 2003), using a two-step approach. We first estimate $\mathbf{Y}_{1j}^*$ as a function of the independent variables ($\mathbf{X}_{1j}'$). In the second step, the predicted value of $\mathbf{Y}_{1j}^*$ is used as a variable on the right-hand side of equation (2). The model's parameters (including the threshold parameters) are estimated using NLOGIT 4.0 (Econometric Software, Inc., 2007). Two different variables are used to measure soil conservation effort. They both involve discrete choices, including "zero" for no soil conservation effort. (More details of this are provided in the next section.)

The estimated coefficients of equations (1) and (2) do not directly represent the marginal effects of the exogenous variables on the probabilities of the dependent variables. Instead, the marginal effects of changes in the independent variables (e.g., see Greene, 2003) are given by:

$$\text{(6)} \qquad \begin{aligned} \partial P(Y_j = 0)/\partial X_j &= -\phi(\mathbf{X}_j'\boldsymbol{\beta})\boldsymbol{\beta}, \\ \partial P(Y_j = 1)/\partial X_j &= \left[\phi(\gamma_{j-1} - \mathbf{X}_j'\boldsymbol{\beta}) - \phi(\gamma_j - \mathbf{X}_j'\boldsymbol{\beta})\right]\boldsymbol{\beta}, \\ &\vdots \\ \partial P(Y_j = J)/\partial X_j &= \phi(\gamma_{J-1} - \mathbf{X}_j'\boldsymbol{\beta})\boldsymbol{\beta}, \end{aligned}$$

where $\phi(\cdot)$ denotes the standard normal density function.

Measuring the Dependent Variables

To measure perception of the soil erosion problem (*PERCEP*), 610 randomly selected field survey respondents[4] were asked to indicate the extent of soil erosion on their land. Possible responses to this question (and their values) are as follows: 0 = not a problem, 1 = low, 2 = moderate, and 3 = severe.

To measure soil conservation effort (*EFFORT*), the respondents were presented with a hypothetical scenario in which the government proposes to introduce a program of

[4] Survey respondents are more fully described in the "Data" section which follows later.

planting vetiver grass strips on farmers' land to reduce soil erosion. It was pointed out that although the grass would reduce the planting area, it would increase the harvest in the long run as the land became more fertile due to less soil erosion. The respondents were then asked whether they would participate in the program. The possible response to this soil conservation decision was either a yes (= 1) or no (= 0). Farmers who agreed to participate in the program were then asked to indicate how many vetiver grass strips per acre they would volunteer to plant on their land. Ideally, measurement of soil conservation effort should be related to either physical units of conservation or expenditures on soil conservation practices. However, this type of information required more detailed data that were not feasible to incorporate into the survey, given time and resource constraints.

As a robustness check, another measure of soil conservation effort (*PRAC*)—the number of soil conservation practices used on-farm—also was tested. To measure this variable, the respondents were asked to indicate what soil conservation practices they have used on their farms. The number of conservation practices used per farmer ranged from zero (none) to a maximum of four. The most commonly used soil conservation measure in the study area is trash conservation, followed by contour planting. Other practices include crop rotation, vetiver grass, and traditional conservation.

Measuring the Independent Variables

The independent variables were chosen to best represent the four categories of factors (personal, economic, physical, and institutional) hypothesized to affect the decision to use a soil conservation practice, and the amount of soil conservation effort. The rationale for selecting the various variables is as follows.

■ Factors Affecting Perception of the Soil Erosion Problem

The personal variables considered here are age (*AGE*), educational level (*EDUC*), farming experience (*EXPER*), and ethnicity (*ETHN*), while the institutional variables are access to extension services (*EXTN*) and distance from a research station (*DIST*). The empirical evidence concerning the effect of age on adoption is mixed. Earlier studies (e.g., Bultena and Hoiberg, 1983; Gould, Saupe, and Klemme, 1989; Polson and Spencer, 1991) have reported that age has a positive effect on adoption. However, more recent studies (e.g., Adesina and Zinnah, 1993; Baidu-Forson, 1999; Bekele and Drake, 2003) have shown that age has no statistically significant effect on adoption. Therefore, the effect of age cannot be determined a priori. Education and experience are expected to have positive effects on perception of the soil erosion problem because farmers who are more educated have greater access to information on soil conservation measures, and experienced farmers are more knowledgeable about soil erosion and its effects.

We also cannot determine a priori the effect of ethnicity on perception of soil erosion and adoption of soil conservation. The two main ethnic groups in Fiji are indigenous Fijians and Indo-Fijians. The latter were originally recruited from India by the Colonial Sugar Refining Company to work as indentured laborers in the late 19th century. Upon abolition of the indenture system in 1920, they were offered plots for sugarcane farming. Given that Indo-Fijian farmers have generally been in sugarcane farming longer than indigenous Fijian farmers, it is possible they are more aware of the erosion problem.

A confounding factor is that some Indo-Fijian farmers have not had their farming leases renewed, and therefore have no security of tenure. Consequently, it is likely they would have less incentive to invest in soil conservation measures.

Participation in an extension program (*EXTN*) is used to represent institutional factors. Based on innovation-diffusion theory, it is hypothesized that farmers who have participated in extension programs would be more knowledgeable about the effects of soil erosion and therefore would be more likely to perceive the erosion problem and adopt soil conservation (e.g., see Kebede, Gunjal, and Coffin, 1990; Baidu-Forson, 1999). *EXTN* is measured as a binary variable where 1 = attendance at an extension program on soil conservation and 0 = nonattendance. We also test the effect of distance from a research station (*DIST*) on perception of the soil erosion problem. Proximity to a research station is hypothesized to enhance awareness of the soil erosion problem through the demonstration effect. In addition, the following economic and physical variables are included: net farm income (*FINC*), farming status (*FSTAT*), land ownership (*OWN*), farm size (*AREA*), and class of land (*CLASS*).

■ Factors Affecting Soil Conservation Effort

A number of factors are hypothesized to affect soil conservation effort. These are perception of the extent of the soil erosion problem, net farm income, farming status, land ownership, farm size, and class of land. As indicated earlier, perception (or awareness) of the soil erosion problem is the crucial first step in the decision-making process to adopt conservation. Studies by Ervin and Ervin (1982) and Norris and Batie (1987) report that perception impacts positively on soil conservation adoption and effort. The level of net farm income is expected to affect soil conservation effort because farmers with higher net income are less likely to be financially constrained to adopt soil conservation measures. The effect of farming status on soil conservation effort cannot be determined a priori. Full-time farmers are more likely than part-time farmers to make more soil conservation effort because they spend longer periods on the farm. Yet, because full-time farmers do not have a diversified income, they may perceive a greater risk of investing in soil conservation.

Previous studies have shown that farmers who own their land are more likely to adopt soil conservation and expend more conservation effort than those who do not own their land. The issue here has more to do with security of tenure than ownership per se. Most of the Indo-Fijian farmers have leases that were granted under the 1976 Agriculture and Landlord Tenants Act (ALTA), enacted on September 1, 1977. Following revisions to ALTA, all leases granted since this date had a minimum duration of 30 years. Farmers with leases granted before this date were entitled to a single extension of 20 years. Upon expiration of the 30-year lease or 20-year extension, there is no automatic right of renewal.[5]

The other variables hypothesized to affect soil conservation effort are farm size and class of land. Farm size is expected to have a positive effect on perception of the soil erosion problem and conservation adoption for two reasons. First, farmers with smaller sized plots are likely to make less conservation effort than those with larger sized plots

[5] ALTA leases began expiring in 1997, and it was expected that over 80% of the leases would expire by 2005. Between 1997 and 1999, only 26% of leases were renewed (Lal, Lim-Applegate, and Reddy, 2001).

Table 1. Definitions of the Variables in the Empirical Model

Variable	Definition	Unit of Measure
Dependent Variables:		
PERCEP	Perception of soil erosion	0 = not a problem, 1 = low, 2 = moderate, 3 = severe
EFFORT	No. of grass strips to be planted/hectare	Number
PRAC	No. of conservation practices used on-farm	Number
Independent Variables:		
AGE	Age of farmer	Years
EXPER	Farming experience	Years
EDUC	Education	Years
ETHN	Farmer's ethnicity	0 = indigenous Fijian, 1 = Indo-Fijian
FINC	Net farm income	Fiji dollars
FSTAT	Farming status	0 = part-time, 1 = full-time
OWN	Owns farmland	0 = no, 1 = yes
AREA	Area of farm cultivated	Acres
CLASS	Class of land	1 = flat, 2 = gentle, 3 = quite steep, 4 = marginal (steep)
DIST	Distance to a farm research station	Kilometers
EXTEN	Attended extension program	0 = no, 1 = yes

because the conservation structures take proportionally more space on smaller plots, and the future economic benefits may be insufficient to offset the decline in production caused by the structures. Second, larger farms may be expected to have greater levels and increased quality of management, which implies they are more likely to perceive the problem and take conservation action.

The Ministry of Agriculture, Sugar, and Land Resettlement recognizes four land types: first class to fourth class. First-class land is fairly flat, suitable for the farming of many different types of crops, and generally requires no improvement. Second-class land has a flat to gentle slope, third-class land is quite steep and suited to only certain types of crops, and fourth-class land is steep and classified as marginal land. It is assumed here that these four land classes are directly related to the soil erosion potential of a given piece of land. Therefore, farmers are predicted to exert more soil conservation effort the steeper is the slope of their land. Because it is unreasonable to assume a constant impact on the dependent variable for each change of land class from one to the next, *CLASS* is represented by the following categorical variables: *CLASS*1 (1 = flat, 0 = otherwise); *CLASS*2 (1 = gentle, 0 = otherwise); and *CLASS*3 (1 = quite steep, 0 = otherwise). We also include the set of personal and institutional characteristics used in equation (1), the perception equation.

Table 1 summarizes the definitions and measurements of the variables used to estimate the empirical models.

Data

The data for this study were obtained from a field survey carried out in 2005 in the Nadi catchment located in the western part of Viti Levu (see figure 1). The sample comprises

Table 2. Descriptive Statistics for Variables Used in the Empirical Models

Variable	Indigenous Fijian Mean (N = 146)	Indo-Fijian Mean (N = 464)	Total Sample Mean (N = 610)	Total Standard Deviation
Dependent Variables:				
PERCEP	0.62	0.42	0.46	0.71
PRAC	0.72	0.97	0.91	0.69
EFFORT	0.78	0.29	0.40	0.60
Independent Variables:				
AGE	49.91	52.18	51.65	12.67
EXPER	15.63	30.62	27.11	15.63
EDUC	8.49	8.33	8.37	3.26
ETHN	0.24	0.76	1.00	0.44
FINC	1,296	1,899	1,759	1,753
FSTAT	0.90	0.82	0.84	0.37
DIST	29.31	27.52	27.96	6.11
OWN	0.53	0.21	0.29	0.92
AREA	6.69	8.92	8.43	6.81
CLASS	2.20	2.48	2.41	0.85
EXTN	0.18	0.02	0.06	0.24

610 farmers randomly selected from the records of the Fiji Sugar Corporation (FSC) and stratified according to ethnicity. The FSC records also were used to obtain information on the area of sugarcane cultivated. Respondents were asked, in face-to-face interviews, questions about their farm operation, use of conservation measures, perceptions of erosion, and a number of personal characteristics.

Table 2 presents a summary of the main characteristics of the sample. Approximately 24% (146) of the sample farmers were indigenous Fijians, while 76% (464) were Indo-Fijians. Indigenous Fijians are relatively new to sugarcane farming, and the average length of farming experience is 15.6 years for this group, compared to 30.6 years for Indo-Fijians. The indigenous Fijian farmers tend to be younger (49.9 years versus 52.2 years) and relatively more educated (8.5 years versus 8.3 years) than their Indo-Fijian counterparts. Indo-Fijian farmers tend to cultivate larger plots (8.9 acres on average) compared to indigenous Fijians (6.7 acres), and therefore have higher net farm incomes (F$1,899 versus F$1,296). The majority of the sample farmers (84%) are full-time farmers. Slightly over half of the indigenous Fijian farmers (53%) own their land, while about 21% of the Indo-Fijians own their land. Those Indo-Fijians who own land would be among the older farmers (or their parents) who acquired land before the passing of ALTA. Finally, relatively more indigenous Fijian farmers (18%) have attended extension programs than Indo-Fijian farmers (2%).

Results and Discussion

A correlation matrix for pairs of independent variables is presented in table 3. It can be seen here that age has a fairly high negative correlation (r = −0.50) with education—i.e., the older farmers tend to be less educated. Also, as expected, farm ownership is

Table 3. Correlation Matrix of the Independent Variables

	AGE	*EXPER*	*EDUC*	*ETHN*	*FINC*	*FSTAT*	*DIST*	*OWN*	*AREA*	*CLASS*	*EXTN*
AGE	1.00										
EXPER	0.14	1.00									
EDUC	−0.50	−0.01	1.00								
ETHN	0.08	0.07	−0.06	1.00							
FINC	0.00	0.05	0.05	0.17	1.00						
FSTAT	0.15	0.00	−0.19	−0.11	0.01	1.00					
DIST	−0.06	−0.01	0.09	−0.14	−0.08	0.09	1.00				
OWN	−0.05	−0.03	0.01	−0.68	−0.11	0.12	0.13	1.00			
AREA	0.01	0.03	−0.02	0.17	0.43	0.10	−0.03	−0.12	1.00		
CLASS	−0.05	−0.04	0.07	0.11	0.04	−0.06	0.06	−0.10	0.00	1.00	
EXTN	−0.05	−0.03	0.00	−0.27	−0.02	0.07	−0.01	0.11	0.08	−0.05	1.00

negatively correlated with ethnicity ($r = -0.68$), while net farm income is positively correlated with farm size ($r = 0.43$). In the remaining cases, the correlation coefficients are low, with the absolute values of most falling below 0.2. These findings suggest the problem of multicollinearity among the variables is not serious.

Tables 4–6 present the estimation results for equations (1) and (2). The marginal effects defined in equation (6) are useful for indicating the direction of change of Y_j following a change in X_j. This usefulness arises because the signs of the estimated β coefficients only show the direction of change for the highest and lowest values of Y_j.[6] In this analysis, the coefficients are interpreted as designating the general direction of change for Y_j in response to an increase in X_j. This provides some indication as to whether the estimated signs of the coefficients concur with our a priori expectations.

The coefficient estimates for the perception equation [equation (1)] are reported in the upper panel of table 4, while the marginal effects of the significant variables are reported in the bottom panel. Looking first at the coefficients, it can be seen that the key variables affecting perception of the soil erosion problem are age, education, ethnicity, extension, distance from a research station, net farm income, and farm size. Older farmers are more likely to perceive the soil erosion problem, ceteris paribus. The marginal effects reveal that a one-year increase in age increases the probability of perceiving a severe erosion problem by 0.0042, but reduces the probability of not perceiving a problem by 0.0029.[7] The coefficient on experience has the expected positive sign but is not statistically significant. Educational attainment has a significant positive effect on perception of the soil conservation problem, which is confirmed by the marginal effects. An interaction term for age and education is included to account for the high correlation between these two variables. However, it is found not to be statistically significant.

The coefficient on ethnicity is positive and statistically significant. Bearing in mind this is a binary variable with 0 = indigenous Fijian farmers and 1 = Indo-Fijian farmers, the positive sign implies that when we control for key intervening variables (e.g., experience, education, age, and extension), Indo-Fijian farmers are more likely to perceive the

[6] In at least one case, $P(Y_j = 0)$ (and probably more if there are more than three outcomes), the partial effects have exactly the opposite signs from the estimated coefficients.

[7] It is assumed here that all other variables are kept at their mean levels.

Table 4. Regression Estimates for the Perception of the Soil Erosion Problem

Variable	Coefficient	z-Statistic
Constant	-0.0059	-0.010
AGE	0.0143*	1.719
EXPER	0.0006	0.744
EDUC	0.0919*	1.676
*AGE*EDUC*	-0.0013	-1.156
ETHN	0.3029***	2.721
EXTN	0.0013**	2.504
DIST	-0.0013***	-2.665
FINC	0.768×10^{-4}***	2.830
FSTAT	-0.0002	-0.674
OWN	0.0005	0.609
AREA	-0.0252***	-3.400
*CLASS*1	-0.1665	-0.971
*CLASS*2	0.2288	1.303
*CLASS*3	-0.0613	-0.629
Threshold Parameters:		
γ_1	0.7574	15.867
γ_2	1.9620	31.065
γ_3	2.1025	32.316
No. of Observations	602	
Log-likelihood	-751.38	
Wald χ^2 Statistic (14 df)	52.30	
p-Value	0.000	

	Marginal Effects			
Variable	Prob ($Y_j = 0$)	Prob ($Y_j = 1$)	Prob ($Y_j = 2$)	Prob ($Y_j = 3$)
AGE	-0.0029	-0.0024	0.0010	0.0042
EDUC	-0.0184	-0.0152	0.0067	0.0269
ETHN	-0.0664	-0.0473	0.0309	0.0828
EXTN	-0.0003	-0.0002	0.0001	0.0004
DIST	0.0003	0.0002	-0.0001	-0.0004
FINC	0.0000	0.0000	0.0000	0.0000
AREA	0.0050	0.0042	-0.0018	-0.0074

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively. The dependent variable is perception of soil erosion (*PERCEP*), where 0 = not a problem, 1 = low, 2 = moderate, and 3 = severe.

soil erosion problem compared to indigenous Fijian farmers. This result is not unexpected given the former have more farming experience than the latter.

Both institutional variables (*EXTN* and *DIST*) are statistically significant. Extension education has a positive effect on perception of the soil erosion problem, confirming the findings of previous studies. Farmers who live closer to a research station are more likely to be perceptive of the soil erosion problem due to the benefit of the demonstration effect. Of the economic variables, net farm income is statistically significant, whereas farming status and land ownership are not. However, the coefficient and marginal effects for net farm income are very small, suggesting it exerts a relatively small impact on perception.

Of the physical variables, class of land has no statistically significant effect, while farm size has a significant effect. As indicated by the marginal effects for farm size, individuals who farm smaller plots are more likely to perceive the soil erosion problem compared to those who farm larger plots. For example, a unit increase in farm size increases the probability of not perceiving a soil erosion problem by 0.005, but reduces the probability of perceiving a serious erosion problem by 0.0074.

A Wald χ^2 test for the null hypothesis that all the independent variables in the model are jointly zero yielded a test statistic of 52.30 with a p-value of 0.000, convincingly rejecting the null hypothesis. Therefore, there is an overall significant relationship between the independent variables and perception of soil erosion.

Table 5 presents coefficient and marginal effects estimates for soil conservation effort [equation (2)]. It can be seen here that personal characteristics such as age, education, farming experience, and ethnicity do not appear to exert a significant influence on the extent of soil conservation effort. As hypothesized, the coefficient on perception has a positive and significant sign. Although the marginal effects are small in magnitude, they confirm that an increase in perception of the soil erosion problem increases a farmer's probability of making a greater soil conservation effort. Contrary to expectations, only one of the economic variables (net farm income) is statistically significant, while the others (farming status and farm ownership) are not. Based on the marginal effects for net farm income, an increase in farm income increases the likelihood of making a higher level of soil conservation effort.

Physical characteristics of the farm (*AREA* and *CLASS*) are found to be significant determinants of soil conservation effort. Farm size has a positive and significant effect on soil conservation effort, and the marginal effects indicate farmers with smaller plots are less likely to undertake soil conservation. This could be due to their higher short-term opportunity cost of investing in such measures. Also, as suggested by Feder and O'Mara (1981), the positive sign for the coefficient of farm size may be due to fixed transactions and information acquisition costs. They show that, at a given point in time, there may be a critical farm size level below which new technology may not be adopted. The coefficients on *CLASS*2 and *CLASS*3 are statistically significant, while that of *CLASS*1 is not. The marginal effects for the two significant variables imply that farmers cultivating more marginal land have a higher probability of making greater soil conservation effort, ceteris paribus. Of the institutional variables, distance to a research station has the expected sign but is not statistically significant. However, all things being equal, access to extension education increases the likelihood of a farmer making a higher level of soil conservation effort.

A Wald χ^2 test for the null hypothesis that all the independent variables are jointly zero gave a test statistic of 133.84 with a p-value of 0.000. Therefore, the model variables significantly improve prediction accuracy of soil conservation effort.

Finally, table 6 reports results for the second measure of soil conservation (*PRAC*), which utilizes the number of soil conservation practices already in use on-farm. This model provides a consistency check on the key explanatory variables affecting adoption of soil conservation measures. Perception of the soil erosion problem, net farm income, class of land, and ethnicity significantly affect soil conservation effort.

Table 5. Regression Estimates for Soil Conservation Effort

Variable	Coefficient	z-Statistic
Constant	0.8233**	1.977
PERCEP	0.0003**	2.062
FSTAT	0.0006	1.041
FINC	0.0002***	4.146
OWN	-0.0008	-0.937
AREA	0.0787***	5.191
*CLASS*1	-0.2312	-1.160
*CLASS*2	0.2285**	2.001
*CLASS*3	0.4598***	3.912
AGE	-0.0039	-0.720
EXPER	0.0018	0.797
EDUC	-0.0186	-0.909
ETHN	-0.805×10^{-4}	-0.081
EXTN	0.0996***	3.296
DIST	-0.0001	-0.268
Threshold Parameters:		
γ_1	1.2294***	14.384
γ_2	1.7499***	14.600
γ_3	3.0829***	7.099
No. of Observations	577	
Log-likelihood	-425.23	
Wald χ^2 Statistic (14 df)	133.84	
p-Value	0.000	

	Marginal Effects			
Variable	Prob ($Y_j = 0$)	Prob ($Y_j = 1$)	Prob ($Y_j = 2$)	Prob ($Y_j = 3$)
PERCEP	-0.0001	0.0000	0.0000	0.0001
FINC	-0.0001	0.0000	0.0000	0.0001
AREA	-0.0268	-0.0041	0.0021	0.0000
*CLASS*2	-0.0785	0.0124	0.0065	0.0001
*CLASS*3	-0.0088	-0.0041	0.0126	0.0003
EXTN	-0.0347	0.0056	0.0030	0.0001

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively. The dependent variable is *EFFORT*, defined as the number of grass strips to be planted on-farm divided by farm size.

The results obtained so far can be summarized as follows. Personal characteristics, such as age, education, ethnicity, and access to extension education, are among the important variables affecting the perception of the soil erosion problem in this sample of farmers. Once a decision has been made to adopt soil conservation, the level of soil conservation effort is determined by a number of factors including the extent of perception of the erosion problem, the physical characteristics of the land (e.g., farm size, land type), net farm income, and access to extension education. There is some evidence to suggest the farmer's financial situation influences his/her conservation effort, which implies the issue of cost or affordability is crucial in any adoption strategy.

Table 6. Regression Estimates for Number of Conservation Practices Used On-Farm

Variable	Coefficient	z-Statistic
Constant	0.1530	0.444
PERCEP	0.0003***	2.620
FSTAT	0.0003	0.763
FINC	0.762×10^{-4}***	2.708
OWN	-0.0005	-0.637
AREA	-0.0087	-1.085
*CLASS*1	-0.5003***	-2.642
*CLASS*2	-0.1894*	-1.738
*CLASS*3	0.6878***	6.342
AGE	-0.0015	-0.348
EXPER	-0.0001	-0.168
EDUC	0.0256	0.389
ETHN	0.3378***	2.835
EXTN	0.0003	0.648
DIST	0.0003	0.560
Threshold Parameters:		
γ_1	1.7230***	21.797
γ_2	2.6302***	23.151
γ_3	3.1491***	10.293
No. of Observations	602	
Log-likelihood	-540.16	
Wald χ^2 Statistic (14 df)	110.97	
p-Value	0.000	

	Marginal Effects		
Variable	Prob ($Y_j = 0$)	Prob ($Y_j = 1$)	Prob ($Y_j = 2$)
PERCEP	-0.0001	0.0000	-0.0001
FINC	0.0000	0.0000	0.0000
AREA	0.1783	-0.0881	-0.0902
*CLASS*2	0.0593	-0.0156	-0.0437
*CLASS*3	-0.2098	0.0439	0.1659
EXTN	-0.1120	0.0399	0.0721

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively. The dependent variable is *PRAC*, defined as the number of soil conservation practices used on-farm, where 0 = none, 1 = one, and 2 = two to four.

This issue is particularly important given the current high levels of debt.[8] Policy makers could consider combining measures such as subsidies and some form of cost-sharing arrangements with improved extension education in order to encourage adoption of soil conservation technology.

[8] For example, in 2004, the ratio of arrears to loan portfolio for the Fiji Development Bank, a major agricultural lender, was 7.42% (Fiji Development Bank, 2004).

Conclusions and Policy Implications

The primary aim of this paper was to examine the factors affecting Fijian cane farmers' adoption of soil conservation measures. This was undertaken within a conceptual framework in which the decision-making process begins with a perception of the problem, followed by a decision of whether or not to adopt soil conservation, and the amount of effort to apply. A model was first specified and used to estimate the factors explaining perception of the soil erosion problem. Next, two models were used to estimate soil conservation effort.

This study departs from previous investigations in a number of ways. First, in estimating adoption of conservation technology, we consider a range of measures rather than a binary choice. Second, we assess the interrelationship between perception of the soil erosion problem and soil conservation effort, thereby adopting an estimation approach that accounts for the endogeneity between these two variables. The study results reveal that the significant factors affecting perception of the soil erosion problem are age, education, ethnicity, extension services, distance to a research station, net farm income, and farm size, while the significant variables affecting soil conservation effort are perception of the erosion problem, net farm income, farm size, land type, and extension education.

The study's findings point to variables that could be targeted in efforts to promote perception of the soil erosion problem. With the recent expiration of farm leases, there has been an increase in the number of indigenous Fijians taking up sugarcane farming. Our results indicate these farmers are less likely to be aware of the soil erosion problem and therefore should be targeted by extension services. There is also a need for such programs to target younger and less experienced farmers who are less likely to be aware of the long-term productivity impacts of soil erosion. Previous research (e.g., see Feder, Just, and Zilberman, 1985) suggests that a large number of potential variables, such as access to credit, access to scarce inputs, and wealth, can directly or indirectly influence adoption of new technology. While most of these variables could be targeted in efforts to improve adoption of soil conservation technology, our results show that any such programs should be combined with soil conservation awareness and education programs to better achieve the objective. Although not an issue investigated in this study, there also is a strong case for the design of innovative cost-sharing schemes involving the government and farmers in view of the fact that soil erosion has external effects.

In general, there is a need to increase the resources available for soil conservation to assist extension officers in increasing their on-farm visits. Moreover, personal experience indicates that proper training of agricultural extension personnel is required in order to equip them with up-to-date research information to be able to advise farmers on appropriate conservation practices. Given differences in erosion rates, soil type, slope, and climatic factors, an individualized program rather than a "one-size-fits-all" approach is necessary for extension education. This requires additional human and financial resources.

In the face of stretched budgetary resources, soil conservation does not appear to be at the top of the government's spending priorities. A recent report (Leslie and Ratukalou, 2002) documents serious under-resourcing of the line ministries with responsibilities for agriculture and forestry, and the lack of expertise in the areas of agricultural extension in general, and soil conservation in particular. Because a reduction in soil erosion could generate significant public as well as private benefits, there is a need for the government to explore avenues, perhaps with donor assistance, to devote more resources to addressing the problem. There also is an urgent need for education and extension programs targeting land users and the general public to inform them about the need for conservation and ways of improving soil productivity. This program also should target the school system and provide quality teaching materials on the sustainable use of land and soil resources.

To conclude, it is useful to highlight areas where this study could be expanded in future work. First, future studies might use a more representative measure of soil conservation effort. Such a variable could include expenditures (both labor and capital) on soil conservation measures or estimates of some physical measure of effort (e.g., relative area of conservation structures). Other independent variables proposed for consideration in future work include farmers' attitudes and personal values toward soil conservation, and some measure of the farmer's discount rate and planning period. Although age has been suggested as a proxy for these variables, it is not a reliable measure and has not provided satisfactory results in the past.

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References

Adesina, A. A., and M. Zinnah. "Technology Characteristics, Farmers' Perceptions, and Adoption Decisions: A Tobit Model Application in Sierra Leone." *Agr. Econ.* 9(1993):297–311.

Anim, F. D. K. "A Note on the Adoption of Soil Conservation Measures in the Northern Province of South Africa." *J. Agr. Econ.* 50(1999):336–345.

Baidu-Forson, J. "Factors Influencing Adoption of Land-Enhancing Technology in the Sahel: Lessons from a Case Study of Niger." *Agr. Econ.* 20(1999):231–239.

Bekele, W., and L. Drake. "Soil and Water Conservation Behaviour of Subsistence Farmers in the Eastern Highlands of Ethiopia: A Case Study of the Hunde-Lafto Area." *Ecol. Econ.* 46(2003):437–451.

Bellemare, M. F., and C. B. Barrett. "An Ordered Tobit Model of Market Participation: Evidence from Kenya and Ethiopia." *Amer. J. Agr. Econ.* 88(2006):324–337.

Blase, M. G. "Soil Erosion Control in Western Iowa: Progress and Problems." Unpub. Ph.D. diss., Dept. of Agr. Econ., Iowa State University, Ames, 1960.

Brooks, J. C., A. C. Cameron, and C. A. Carter. "Political Action Committee Contributions and U.S. Congressional Voting on Sugar Legislation." *Amer. J. Agr. Econ.* 80(1998):441–454.

Bultena, G. L., and E. O. Hoiberg. "Adoption of Agricultural Innovations in Developing Countries." *J. Soil and Water Conserv.* 38(1983):281–284.

Carlson, J. E., M. McLeod, R. William, and D. A. Dillman. "The Farmer, Absentee Landowners, and Erosion: Factors Influencing the Use of Control Practices." Idaho Water Resources Institute, Moscow, 1977.

Dorfman, J. H. "Modeling Multiple Adoption Decisions in a Joint Framework." *Amer. J. Agr. Econ.* 78(1996):547–557.

Doss, C. R., and M. L. Morris. "How Does Gender Affect the Adoption of Agricultural Innovations? The Case of Improved Maize Technology in Ghana." *Agr. Econ.* 25(2001):27–39.

Earle, T. R., C. W. Rose, and A. A. Brownlea. "Socioeconomic Predictors of Intention Towards Soil Conservation and Their Implications in Environmental Management." *J. Environ. Mgmt.* 9(1979): 225–236.

Econometric Software, Inc. *NLOGIT 4.0.* Plainview, NY: Econometric Software, Inc., 2007.

Ervin, C. A., and D. E. Ervin. "Factors Affecting the Use of Soil Conservation Practices: Hypotheses, Evidence, and Policy Implications." *Land Econ.* 58(1982):277–292.

Feder, G., R. E. Just, and D. Zilberman. "Adoption of Agricultural Innovations in Developing Countries: A Survey." *Econ. Develop. and Cultural Change* 33(1985):255–298.

Feder, G., and G. T. O'Mara. "Farm Size and the Adoption of Green Revolution Technology." *Econ. Develop. and Cultural Change* 30(1981):59–76.

Feder, G., and R. Slade. "The Acquisition of Information and the Adoption of Technology." *Amer. J. Agr. Econ.* 66(1984):312–320.

Fiji Development Bank. *Annual Report.* Suva, Fiji, 2004.

Gould, B. W., W. E. Saupe, and R. M. Klemme. "Conservation Tillage: The Role of Farm and Operator Characteristics and the Perception of Erosion." *Land Econ.* 65(1989):167–182.

Greene, W. *Econometric Analysis*, 5th ed. Upper Saddle River, NJ: Prentice-Hall, 2003.

Holloway, G., C. B. Barrett, and S. Ehui. "Bayesian Estimation of the Double Hurdle Model in the Presence of Fixed Costs." *J. Internat. Agr. Trade and Develop.* 1(2005):17–28.

International Union for the Conservation of Nature and Natural Resources (IUCN). "Environment: Fiji, the State of the Environment Report." Asian Development Bank, Suva, Fiji, 1992.

Jamison, D., and P. R. Moock. "Farmer Education and Farm Efficiency in Nepal: The Role of Schooling, Extension Services, and Cognitive Skills." *World Develop.* 12(1984):67–86.

Kebede, Y., K. Gunjal, and G. Coffin. "Adoption of New Technologies in Ethiopian Agriculture: The Case of Tegulet-Bulga District, Shoa Province." *Agr. Econ.* 4(1990):27–43.

Kumar, S., and B. Prasad. "Fiji's Economic Woes: A Nation in Search of Development Progress." *Pacific Econ. Bull.* 17(2002):1–23.

Lal, P., H. Lim-Applegate, and M. Reddy. "The Land Tenure Dilemma in Fiji: Can Fijian Landowners and Indo-Fijian Tenants Have Their Cake and Eat It Too?" *Pacific Econ. Bull.* 16(2001):106–119.

Lapar, M., A. Lucila, and S. Pandey. "Adoption of Soil Conservation: The Case of the Philippine Uplands." *Agr. Econ.* 21(1999):241–256.

Leslie, D., and I. Ratukalou. *Rural Land Use Policy Statement for Fiji.* Suva, Fiji: Ministry of Agriculture, Sugar, and Land Resettlement and Secretariat of the South Pacific Community/German Technical Co-operation, 2002.

Lynne, G. D., J. S. Shonkwiler, and L. R. Rola. "Attitudes and Farmer Conservation Behavior." *Amer. J. Agr. Econ.* 70(1988):12–19.

Meyer, J. R., and E. Kuh. *The Investment Decision.* Cambridge, MA: Harvard University Press, 1957.

Norris, P. E., and S. S. Batie. "Virginia Farmers' Soil Conservation Decisions: An Application of Tobit Analysis." *S. J. Agr. Econ.* 19(1987):79–80.

Nowak, P. J., and P. F. Korsching. "Social and Institutional Factors Affecting the Adoption and Maintenance of Agricultural BMPs." In *Agricultural Management and Water Quality*, eds., F. Schaller and G. Bailey. Ames, IA: Iowa State University Press, 1983.

Polson, R. A., and D. S. C. Spencer. "The Technology Adoption Process in Subsistence Agriculture: The Case of Cassava in Southwestern Nigeria." *Agr. Systems* 36(1991):65–78.

Rahm, W., and W. Huffman. "The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables." *Amer. J. Agr. Econ.* 66(1984):405–413.

Sinden, J. A., and D. A. King. "Adoption of Soil Conservation Measures in Manilla Shire, New South Wales." *Rev. Marketing and Agr. Econ.* 58(1990):179–192.

Swami, S. "Watershed Management in Fiji." Paper presented at workshop titled "Trade Liberalization, Agriculture, and Land Degradation in Fiji: Implications for Sustainable Development Policies." Suva, Fiji, 15–16 April 2004.