Willingness to adopt soil conservation measures:

A case study of Fijian cane farmers

by

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Abstract

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 are age, ethnicity, and extension education, while the significant factors affecting soil conservation effort are perception of the erosion problem, age, ethnicity, and extension education. Contrary to theoretical expectations, economic and physical factors do not significantly affect soil conservation behaviour in this sample of farmers. The resulting implications for soil conservation policy are discussed.

Keywords: Soil erosion, soil conservation, sugarcane, Tobit model, Fiji

1. 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 a further 43% can be used for tree cropping and grazing. For many decades agriculture in Fiji has been the major contributor to 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 now contributes about 20% of GDP, while agriculture's share is about 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).

[Figure 1]

Although there is a reasonable level of public awareness about environmental issues in Fiji, recent evidence suggests that the problem of land degradation is worsening.[1] Soil loss measurements by the Fiji Ministry of Agriculture, Sugar, and Land Resettlement indicates that the agricultural productive base in many sugar cane areas is running down at a rate that is well above what would be regarded as economically acceptable (Leslie and Ratukalou, 2002). The main form of land degradation is soil degradation, which occurs 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 crops (e.g. dalo and yagona) on to marginal land (e.g. steep slopes). In a review of a variety of catchments in both the western (dry) and eastern (wet) side of Viti Levu, the IUCN estimated soil loss to be between 24 and 79 tons per hectare per annum, which is equivalent to a topsoil loss of 1.6-5.3mm 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 per annum (Swami, 2004). The social costs are even greater when one considers the reduction in rural incomes and increase in rural unemployment as a result of these climatic events.

Despite the acuteness of the land degradation problem in Fiji, there have been no formal studies to examine the socio-economic factors that may influence the adoption and diffusion of soil conservation technologies. It may be argued that the results of

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

studies conducted in other developing countries do not necessarily apply to Fiji due to her unique geographical, socioeconomic, and environmental circumstances. Therefore, the objectives of this study are to investigate the extent to which various factors affect Fijian cane farmers' adoption of soil conservation measures and to discuss the policy implications. Demands on land resources are increasing due to population growth and limited arable land. Failure to address the land degradation problem 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 it is only with sustainable agriculture that the overall goal of sustainable development can be achieved. The study's results will also have implications for similar small island developing countries.

The remainder of the paper is organised as follows. The next section briefly reviews the literature on soil conservation, with particular emphasis on developing countries. Section 3 discusses the research methodology which includes the model specification, estimation issues, and survey design. The empirical results are presented and discussed in Section 4, while Section 5 concludes.

2. Previous studies, hypotheses and conceptual model

In general, economic theory does not offer much guidance in explaining the factors that influence a farmer's decision to undertake soil conservation. Although the level of a farmer's investment in conservation practices can be derived from the maximisation 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 that economic constraints affect the decision to apply soil conservation measures. For example, a study by Blase (1960) found that 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. A survey by Carlson et al. (1977) found that 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 et al., 1979; Nowak and Korsching, 1983) have 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, in particular, soil conservation practices.

In a study of farms in Manilla Shire, New South Wales, Sinden and King (1990) found that the farmer's rating as an investor, size and security of farm income, and the presence of institutional programs are significant factors that 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) found that factors such as 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). It has also been found that attitudes and factors such as the nature of farm terrain also affect farmers' soil conservation behaviour (Lynne et al., 1988).

Following Ervin and Ervin (1982), we hypothesise 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 not clear. On the one hand, older farmers could adopt conservation because they have more experience. But on the other hand, 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, and consequently, will be more aware of erosion problems and solutions. Higher education levels are hypothesised to be associated with improved knowledge about conservation measures and the productivity effects of erosion. As shown in the diagram, institutional factors such as extension education may also assist in heightening awareness of the soil erosion problem.

Once the farmer has perceived the erosion problem, he/she decides to adopt a soil conservation practice(s). This decision is affected by personal, institutional, physical, and economic factors. For example, the higher the level of education, the more information and awareness the farmer has regarding the costs and benefits of soil conservation, and therefore the more likely to he/she is to adopt a given practice. Institutional factors such as extension programs and the possibility to share costs may persuade farmers to adopt particular measures.

[Figure 2]

The perceived extent of actual or potential physical erosion on the farm may also persuade 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 towards 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 affect 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, owing to the fact that measures that are more efficient in reducing erosion are more expensive, we hypothesise that conservation effort will be more significantly affected by the economic factors.

3. Empirical models, variables and data

3.1 Model specification

In the past, analytical models such as Probit and Logit models have been used to analyse farmers' adoption decisions (e.g. see Jamison and Moock, 1984; Rahm and Huffman, 1984; Lapar 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 has been pointed out (e.g., Lynne et al. 1988; Dorfman, 1996), using a binary dependent variable could lead to the loss of useful economic information contained in the interdependent and simultaneous adoption decisions. In this study, we use an extension of the Tobit model (Tobin, 1958) to analyse the soil conservation behaviour of the sample farmers.

We assume that farmers respond to their circumstances within a utility-maximising framework. Let U_{i1} represent the perceived utility from adopting a soil conservation measure, while U_{i0} represents utility from the traditional farming practice. Also, let X_i represent the set of socioeconomic, institutional, and physical factors which influence the adoption decisions of farmer *i*. Although not directly observable, the utility function of a given farmer (*i*) from using a given measure (*j*) can be written as:

$$U_{ij} = G_i(X_j) + e_{ij}, \quad j = 1,0;\ i = 1,\ldots,n \qquad (1)$$

Where G_i is a farm-specific function, e_{ij} is a disturbance term with zero mean and constant variance, and 1 represents adoption of a soil conservation measure and 0 represents non-adoption. The i^{th} farmer adopts, i.e. $j = 1$, if $U_{i1} > U_{i0}$. Assuming that *G* is linear, we can express the underlying stochastic model by the following relationship:

$$Y_j = X_j'\beta + \varepsilon_i \quad \text{if } X_j'\beta + \varepsilon_i > 0, \quad i = 1,\ldots, n \qquad (2a)$$

$$Y_i = 0 \qquad \text{if } X_j'\beta + \varepsilon_i \leq 0 \qquad (2b)$$

where Y_j is the dependent variable, X_j' is a vector of independent variables, β is a vector of coefficients, and ε_{ij} are independently and identically distributed error terms assumed to be normal with zero mean and constant variance σ^2.

Rather than frame the expected utility of adoption as a binary choice, the above specification implies continuous choice over some predetermined interval. This allows us to consider the intensity of soil conservation effort once the initial decision to adopt has been made. Thus, equation system (2) can be viewed as a simultaneous and stochastic decision model. The expected value of *Y* can be written as

$$EY = F(z)EY^* \qquad (3)$$

Where F is the cumulative normal distribution, z is given by $X\beta/\sigma$, Y^* represents the observations above the threshold, and E represents the expectation operator (Greene, 2003). Following McDonald and Moffit (1980), the effect of the k^{th} independent variable can be decomposed as follows:

$$\frac{\partial EY}{\partial X_k} = F(z)\left(\frac{\partial EY^*}{\partial X_k}\right) + EY^*\left(\frac{\partial F(z)}{\partial X_k}\right) \tag{4}$$

By multiplying both sides of Equation (4) by X_k/EY, one can interpret the results as elasticities. The first term on the right-hand side of Equation (4) can be interpreted as the elasticity of the probability of adoption, while the second term can be interpreted as the elasticity of the intensity of soil conservation effort given that adoption occurs.

3.2 Measuring the dependent variables

In order to test the hypothesised relationships outlined in the decision-making process in Figure 2, we construct two variables to measure the three components of the decision-making process. That is, perception of the soil erosion problem, the decision to use a soil conservation practice and soil conservation effort. To measure perception of the soil erosion problem (PERCEP), the respondents were asked to indicate the extent of soil erosion on their land. Possible responses to this question (and their values) are not a problem (0), low (1), moderate (2), and severe (3).

To measure the second and third components, the respondents were presented with a hypothetical scenario in which the government proposes to introduce a program of 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). If the farmer agreed to participate in the program, he/she was then asked to indicate how many vetiver grass strips they would volunteer to plant on their land (EFFORT). 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 which was not feasible to incorporate into the survey, given time and resource constraints.

To check the robustness of the results for soil conservation effort, a third variable - the number of soil conservation measures used (PRAC) - was included. 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 0 (none) to a maximum of 4. The most commonly used soil conservation measure in the study area is trash conservation, followed by contour planting. Others include crop rotation, contour planting, trash conservation, vetiver grass and traditional conservation.

3.3 Measuring the independent variables

The independent variables were chosen to best represent the four categories of factors (personal, economic, physical, and institutional) that are hypothesised to affect the decision to use a soil conservation practice, and soil conservation effort. Each of these variables is briefly discussed below.

(i) Personal factors

The choice of personal characteristics for inclusion in the model is based on innovation diffusion theory and previous empirical studies. The variables considered are perception of the soil erosion problem (PERCEP), age (AGE), farming experience (EXPER), educational level (EDUC), and ethnicity (ETHN). 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) show that perception impacts positively on soil conservation adoption and effort. Thus, the coefficient of PERECEP is expected to have a positive sign in the EFFORT equations.

The empirical evidence on the effect of age on adoption is mixed. Earlier studies (e.g. Bultena and Hoiberg, 1983; Gould et al., 1989; Polson and Spencer, 1991) indicated that age has a positive effect on adoption. However, more recent studies (e.g. Adesina, 1993; Baidoo-Forson, 1999; Bekele et. al, 2003) have shown that age has no statistically significant effect on adoption. Therefore, the effect of age cannot be determined *à priori*. We expect education to have a positive impact on perception of the soil erosion problem and adoption of soil conservation because farmers who are more educated have more access to information on soil conservation measures. The effect of experience on soil conservation behaviour is not clear. On the one hand, farmers with more experience may be more aware of the soil erosion problem. However, it could be the case that older farmers are likely to be relatively less educated, and therefore less knowledgeable about soil conservation technology.

We cannot determine *à 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 labourers 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 that they are likely to be more aware of the erosion problem. But as we show below, the Indo-Fijian farmers tend to be older and less educated than the indigenous Fijian farmers and therefore may not be adequately exposed to extension information. Another confounding factor is that some Indo-Fijian farmers have not had their farming leases renewed and therefore have no security of tenure. As such, it is expected that they would have less incentive to invest in soil conservation measures.

(ii) Economic factors

A number of economic factors are considered in this study. These are net farm income, farming status, and land ownership. It is hypothesised that the level of net farm income (INC) will have a positive effect on the decision to undertake soil conservation and soil conservation effort because farmers with higher net income are less likely to be financially constrained to adopt soil conservation measures. Farming status (FSTAT) is expected to have a differential impact on perception of soil erosion and conservation adoption. Full-time farmers are expected to be more aware of the soil erosion problem than part-time farmers because they spend longer periods on the farm. However, full-time farmers do not have a diversified income and therefore may perceive a greater risk of investing in soil conservation.

Farmers who own their land are expected to be 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) which came into effect 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 expiry of the 30-year lease or 20-year extension, there is no automatic right of renewal.[2]

(iii) Physical factors

The variables chosen to represent physical factors are area farmed (AREA) and class of land (CLASS). It is hypothesised that the area cultivated will 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 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 that they are more likely to perceive the problem and take conservation action.

The Ministry of Agriculture, Sugar and Land Resettlement recognises four land types: 1st Class to 4th Class. 1st Class land is fairly flat and suitable for the farming of many

[2] 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 et al., 2001).

different types of crops and generally requires no improvement. 2nd Class land has a flat to gentle slope, 3rd Class land is quite steep and suited to only certain types of crops, while 4th 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, it is hypothesised that farmers are more likely to perceive the soil erosion and undertake soil conservation measures effort the steeper is the slope of their land. This implies that the coefficient of CLASS is expected to be negative.

(iv) Institutional factors

Participation in an extension program (EXTN) is used to represent institutional factors. Based on innovation-diffusion theory, it is hypothesised that farmers who have participated in extension programs would be more knowledgeable about the effects of soil erosion and would therefore be more likely to perceive the erosion problem and adopt soil conservation (e.g. see Kebede, 1986; Baidu-Forson, 1999). EXTN is measured as a dummy variable where “1” indicates attendance of an extension program on soil conservation and “0” indicates non-attendance.

Table 1 summarises the definitions and measurements of the variables used to estimate the empirical model described in Equations (2) to (7).

[Table 1]

3.5 Data

The data for this study were obtained from a survey carried out in 2005 in the Nadi catchment located in the western part of Viti Levu (Figure 1). The sample comprised 610 farmers randomly selected from the records of the Fiji Sugar Corporation (FSC) and stratified according to ethnicity. The FSC records were also used to obtain information on the area of sugarcane cultivated. Each respondent was asked, in a face-to-face interview, questions about his/her 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 44% of the sample farmers were indigenous Fijians, while 76% were Indo-Fijians. Indigenous Fijians are relatively new to sugarcane farming, and the average years 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 and relatively more educated than their Indo-Fijian counterparts. The average age of the former is 49.9 years compared to 52.2 years for the latter, and the level of education is 8.5 years for the former compared to 8.3 years for the latter. 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$1899 versus F$1296). The majority of the sample farmers (84%) are full-time farmers. However, a higher proportion of indigenous Fijian farmers (89%) have off-farm employment. 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%).

[Table 2]

4. Results and discussion

Table 3 presents a correlation matrix for pairs of independent variables. It can be seen that age has a fairly high positive correlation (r = 0.60) with experience and a high negative correlation (r = -0.50) with education. Scatter plots of the data confirm that the younger farmers tend to be relatively more educated and have less experience than the older ones. Area farmed is moderately correlated with net farm income (r = 0.35), as can be expected. In the remaining cases, the correlation coefficients are low, with the absolute values of most falling below 0.1. The education and experience variables were omitted from the regression owing to their high correlation with age.

[Table 3]

Table 4 presents results for the three models of soil conservation behaviour – perception of the soil erosion problem (PERCEP) and adoption of soil conservation practices (EFFORT and PRAC). The coefficient estimates were obtained using SHAZAM Profession Edition v9.0 (White, 2000). We begin the analysis by examining the results for the PERCEP model (columns 1 and 2). The significant variables affecting perception of the soil erosion problem are age, ethnicity, and extension education. The coefficient of age is positive and highly significant. This implies that when we control for key variables such as ethnicity and land ownership, age (and experience, by proxy) is important in the farmer's ability to perceive the effects of erosion. In this case, the older the farmer, the more likely they are to perceive the erosion problem.

The variable for ethnicity is also statistically significant. Bearing in mind that this a dummy variable with "0" representing indigenous Fijian farmers, the negative coefficient implies that, *ceteris paribus,* indigenous Fijian farmers tend to perceive the soil erosion problem more than Indo-Fijian farmers. This result is surprising given that the former have less farming experience than the latter. However, the difference could be explained by the fact that the indigenous Fijian farmers are relatively more educated and have more exposure to extension education.

As expected, extension education has a highly significant positive effect on perception of the soil erosion problem. Contrary to expectations, economic factors such as net farm income, farming status, and land ownership, as well as physical factors (area and class of land) do not exert any significant influences on perception of the soil erosion problem.

[Table 4]

Columns 3 and 4 of Table 4 present results for soil conservation effort once the adoption decision has been made. It can be seen that all the coefficients have the expected signs stated in the prior hypotheses. However, only three variables are statistically significant. These are perception of the soil erosion problem, ethnicity, and extension education. Perception of the soil erosion problem has a strong positive influence on conservation effort. The coefficient of ethnicity is negative and highly significant, implying that indigenous Fijian farmers make more soil conservation effort compared to their Indo-Fijian counterparts, *ceteris paribus*. This difference can be explained by the security of tenure granted to the former group under the revisions to ALTA.

The other significant variable is extension education which has a positive effect on soil conservation effort, as expected. The variables which are not statistically significant are equally noteworthy. According to theory and past empirical studies, economic factors are expected to be influential in the perception of the soil erosion problem and conservation adoption. However, this is not the case in this study.

Nevertheless, our results do not necessarily imply that economic factors are not important in adoption of soil conservation technology. Rather, they suggest that the types of soil conservation measures being used in the area are not capital intensive. Such low cost and low-input technologies are more appropriate and may have a better chance of wide scale adoption than more expensive ones.

The last set of results is for the PRAC model which utilises the number of soil conservation practices already in use on farms as a proxy for conservation effort. This model provides a consistency check on the key explanatory variables affecting adoption of soil conservation measures. The results indicate that six out of nine coefficients in the PRAC model have the same signs as in the EFFORT model. Perception of the soil erosion problem, age, and extension education have positive signs in both models and are all highly significant, except age which is significant here but not in the EFFORT model. Thus, in general, the results of the EFFORT model can be said to be fairly robust. Comparing the results across the three models, it can be concluded that generally speaking, the factors that influence perception of the soil erosion problem are the same ones that affect adoption of soil conservation.

Table 5 presents elasticities computed at the means of the significant variables in the EFFORT equation in Table 4. The elasticities are calculated for the probability of adoption, intensity of soil conservation effort given that adoption occurs, and total elasticity. Using the PERECEP variable as an example for interpretation, a ten percent increase in perception of the soil erosion problem would lead to an increase of one percent in the probability of adoption. Farmers who have already adopted conservation measures would be expected to increase their effort by 0.2 percent, and total effort would increase by 1.4 percent. The elasticity estimates generally indicate inelastic responses to changes in the socioeconomic and other characteristics, with the marginal changes in the characteristics increasing the probability of adoption more than it increases the intensity of soil conservation effort. Ethnicity has the largest impact on the probability of adoption and intensity of effort, suggesting that it is a key issue to be addressed in any future extension programs.

[Table 5]

In general, the study's findings provide support for the conceptual framework used to characterise the decision-making process outlined in Figure 2. In particular, the results support the key hypothesis that perception of the soil erosion problem is a crucial factor affecting soil conservation adoption. The significance of the personal and institutional variables indicates that soil conservation programs need to account for these factors in order to enhance the chances of success.

5. Conclusions and policy implications

The main aim of this paper was to examine the factors which affect Fijian cane farmers' adoption of soil conservation measures. This was done 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 estimated to explain the factors explaining perception of the soil erosion problem. Next, two models were used examine to soil conservation effort, which included perception of soil erosion and other relevant factors as independent variables. The study results indicate that the significant factors affecting perception of the soil erosion problem are age, ethnicity, and extension education, while the significant variables affecting soil conservation effort are perception of the erosion problem, age, ethnicity and extension education. Contrary to theoretical expectations, economic and physical factors do not significantly affect soil conservation behaviour in this sample of farmers.

The study's findings that perception of erosion problems and extension education significantly affect adoption behaviour, while economic factors play a lesser role have important implications for the design of soil conservation programs in Fiji. They suggest that, for example, merely increasing farmers' ability to invest in soil conservation (e.g. with financial incentives) will not guarantee that such investments would be made. Rather, what is required is increased awareness of the problem which can be achieved through information dissemination and education programs on aspects of soil conservation. The lack of significance of economic factors may suggest that even resource-poor farmers can and do invest in soil conservation activities, given an adequate institutional response to the problem of land degradation. In particular, there is the 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.

There is the need to increase the resources for soil conservation in order to assist extension officers to increase their on-farm visits. Proper training of agricultural extension personnel is also 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 individualised program rather than a 'one size fits all' approach is required 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. Given that a reduction in soil erosion could generate significant public, as well as private benefits, there is the need for the government to explore avenues, perhaps with donor assistance, to devote more resources to addressing the problem. There is also an urgent need for education and extension programs that target land users and the general public to inform them about the need for conservation and ways of improving soil productivity. This program should also target the school system and provide quality teaching materials on the sustainable use of land and soil resources.

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

References

Adesina, A.A. and Zinnah, M. 1993, 'Technology characteristics, farmers' perceptions and adoption decisions: a Tobit model application in Sierra Leone', *Agricultural Economics*, vol. 9, pp.297-311.

Anim, F.D.K 1999, 'A note on the adoption of soil conservation measures in the Northern Province of South Africa', *Journal of Agricultural Economics*, vol. 50, pp. 336-345.

Baidu-Forson, J. 1999, 'Factors influencing adoption of land-enhancing technology in the Sahel: Lessons from a case study of Niger', *Agricultural Economics*, vol. 20, pp.231-239.

Bekele, W. and Drake, L. 2003, 'Soil and water conservation behaviour of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area', Ecological Economics, vol. 46, pp.437-451.

Blase, M.G. 1960, 'Soil erosion control in Western Iowa: progress and problems', Unpublished PhD dissertation, Iowa State University, Ames.

Bultena, G.L. and Hoiberg, E.O. 1983, 'Adoption of agricultural innovations in developing countries', *Journal of Soil and Water Conservation*, vol. 38, pp.281-284.

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

Dorfman, J.H. 1996, 'Modeling multiple adoption decisions in joint framework', *American Journal of Agricultural Economics*, vol. 78, pp.547-557.

Earle, T.R., Rose, C.W., and Brownlea, A.A. 1979, 'Socioeconomic predictors of intention towards soil conservation and their implications in environmental management', *Journal of Environmental Management*, vol. 9, pp.225-236.

Ervin, C.A. and Ervin, D.E. 1982, 'Factors affecting the use of soil conservation practices: hypotheses, evidence and policy implications', *Land Economics*, vol. 58, pp. 277-292.

Feder, G. and Slade, R. 1984, 'The acquisition of information and the adoption of technology', *American Journal of Agricultural Economics*, vol. 66, pp. 312-320.

Gould, B.W., Saupe, W.E., and Klemme, R.M. 1989, 'Conservation tillage: the role of farm and operator characteristics and the perception of erosion', Land Economics, vol. 65, pp. 167-182.

Greene, W.H. 2003, *Econometric Analysis*, 5th edition, Prentice Hall, New Jersey.

International Union for Conservation of Nature (IUCN) 1992, *Environment: Fiji, The State of the Environment Report*, report prepared for the Government of Fiji by IUCN as part of technical assistance provided by the Asian Development Bank.

Jamison, D. and Moock, P.R. 1984, 'Farmer education and farm efficiency in Nepal: the role of schooling, extension services, and cognitive skills', *World Development*, vol. 12, pp. 67-86.

Kebede, Y., Gunjal, K., and Coffin, G. 1990, 'Adoption of new technologies in Ethiopian agriculture: the case of Tegulet-Bulga District, Shoa Province', *Agricultural Economics*, vol. 4, pp. 27-43.

Kumar, S. and Prasad, B. 2002, 'Fiji's economic woes: a nation in search of development progress', *Pacific Economic Bulletin*, vol. 17, no. 1, pp.1-23.

Lal, P., Lim-Applegate, H., and Reddy, M. 2001, 'The land tenure dilemma in Fiji: can Fijian landowners and Indo-Fijian tenants have their cake and eat it too?', *Pacific Economic Bulletin*, vol. 16, no. 2, pp. 106-19.

Lapar, M., Lucila, A., Pandey, S. 1999, 'Adoption of soil conservation: the case of the Philippine uplands', *Agricultural Economics*, vol. 21, pp.241-256.

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

Lynne, G.D., Shonkwiler, J.S., and Rola, L.R. 1988, 'Attitudes and farmer conservation behaviour', *American Journal of Agricultural Economics*, vol. 70, pp. 12-19.

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

McDonald, J.F. and Moffit, R.A. 1980, 'The uses of Tobit analysis', *Review of Economic Statistics*, vol. 62, pp. 318-321.

Norris, P.E. and Batie, S.S. 1987, 'Virginia farmers' soil conservation decisions: an application of Tobit analysis', *Southern Journal of Agricultural Economics*, vol. 19, pp.79-80.

Nowak, P.J. and Korsching, P.F. 1983, 'Social and institutional factors affecting the adoption and maintenance of agricultural BMPs', in F. Schaller and G. Bailey (eds.). *Agricultural Management and Water Quality*, Iowa State University Press, Ames, Iowa.

Rahm, W. and Huffman, W. 1984, 'The adoption of reduced tillage: the role of human capital and other variables', *American Journal of Agricultural Economics*, vol. 66, pp. 405-413.

Sinden, J.A. and King, D.A. 1990, ‘Adoption of soil conservation measures in Manilla Shire, New South Wales’, *Review of Marketing and Agricultural Economics*, vol. 58, pp.179-192.

Swami, S. 2004, ‘Watershed management in Fiji’, paper presented at a workshop on Trade Liberalisation, Agriculture and Land Degradation in Fiji: Implications for Sustainable Development Policies, Suva, 15-16 April.

Tobin, J. 1958, ‘Estimation of relationships for limited dependent variables’, *Econometrics*, vol. 26, pp. 24-36.

White, K.J. 2000. *Shazam for Windows – Professional Edition v9.0,* University of British Columbia, B.C., Canada.

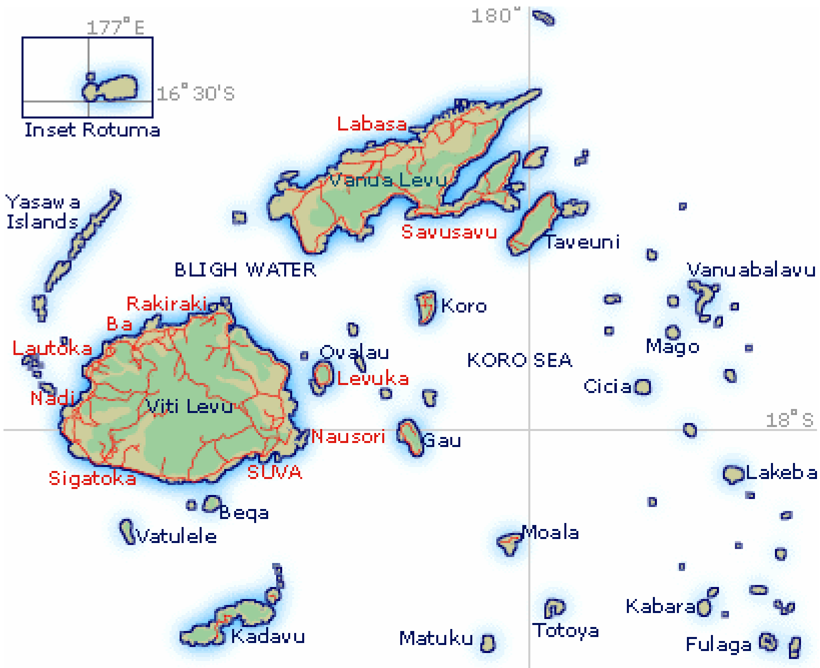

Figure 1 Map of Fiji

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

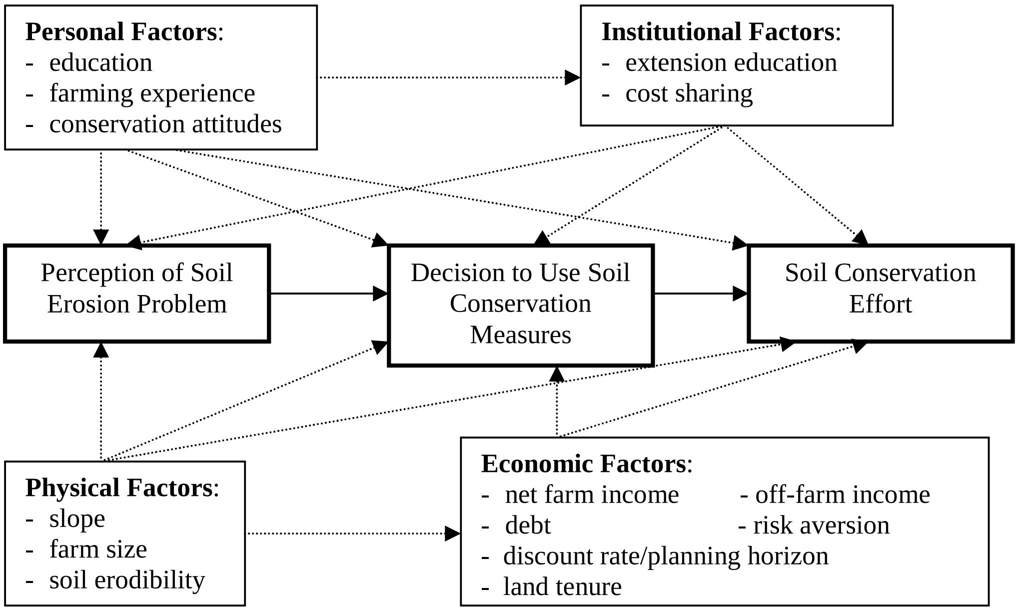

Figure 2 The decision to use soil conservation

Source: adapted from Ervin and Ervin (1982)

Table 1 Definitions of the variables in the empirical model

Variable	Definition	Measurement
Dependent variables:		
PERCEP	Perception of soil erosion	0= not a problem, 1=low, 2=moderate, 3=severe
EFFORT	Number of grass strips to be planted on farm	Numbers
PRAC	Number of conservation practices used on farm	Numbers
Independent variables:		
AGE	Age of farmer	Years
EXPER	Farming experience	Years
EDUC	Education	Years
ETHN	Farmer's ethnicity	0= indigenous Fijian, 1=Indo-Fijian
INC	Net farm income	Fiji dollars
FSTAT	Farming status	1=full-time, 2=part-time
OWN	Owns farm land	0 = no, 1 = yes
AREA	Area of farm	Acres
CLASS	Class of land	1=flat, 2=gentle, 3=quite steep, 4=marginal (steep)
EXTN	Attended extension program	0 = no, 1 = yes

Table 2 Descriptive statistics on the variables used in the empirical models

Variable	Indigenous Fijian mean	Indo-Fijian mean	Total sample mean	Standard deviation
Dependent variables:				
PERCEP	0.62	0.42	0.46	0.71
PRAC	0.72	0.97	0.91	0.69
EFFORT	4.10	2.55	2.91	5.53
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	-	-	0.76	0.44
INC	1295.64	1898.73	1759.17	1752.79
FSTAT	0.89	0.82	0.84	0.37
OWN	0.53	0.21	2.42	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
Sample size	146	464	610	

Table 3 Correlation matrix of the independent variables

	AGE	EXPER	EDUC	ETHN	INC	FSTAT	OWN	AREA	CLASS	EXTN	PERCEP
AGE	1										
EXPER	0.602	1									
EDUC	-0.538	-0.322	1								
ETHN	0.105	0.408	-0.052	1							
INC	0.020	0.100	0.011	0.149	1						
FSTAT	0.154	0.077	-0.204	-0.135	-0.007	1					
OWN	-0.007	-0.062	-0.032	-0.313	-0.079	0.065	1				
AREA	0.045	0.114	-0.049	0.144	0.341	0.093	-0.054	1			
CLASS	-0.025	-0.013	0.075	0.107	0.040	-0.062	-0.044	-0.053	1		
EXTN	-0.058	-0.196	0.001	-0.292	-0.040	0.069	0.017	0.062	-0.036	1	
PERCEP	-0.052	-0.016	-0.021	-0.131	-0.070	0.138	0.087	0.082	0.153	0.139	1

Table 4 Regression results for perception of soil erosion and adoption of soil conservation[a]

Independent variables	PERCEP[a]		EFFORT[b]		PRAC[c]	
	Normalised coefficient	Asymptotic *t*-ratio	Normalised coefficient	Asymptotic *t*-ratio	Normalised coefficient	Asymptotic *t*-ratio
Personal:						
PERCEP	-	-	0.20×10^{-4}	4.44***	0.25×10^{-4}	5.62***
AGE	0.80×10^{-4}	7.17***	0.12×10^{-4}	1.04	0.61×10^{-4}	5.34***
ETHN	-0.20	-2.09**	-0.31	-3.05***	0.12	1.09
Economic:						
INC	-0.39×10^{-5}	-1.32	0.11×10^{-5}	0.40	0.11×10^{-5}	0.41
FSTAT	0.43×10^{-5}	1.28	-0.46×10^{-5}	-1.25	0.11×10^{-5}	0.31
OWN	0.51×10^{-7}	0.61×10^{-7}	0.68×10^{-5}	0.81	0.21×10^{-5}	0.28
Physical:						
AREA	-0.34×10^{-2}	-0.53	0.61×10^{-2}	0.91	-0.60×10^{-5}	-0.86
CLASS	-0.42×10^{-5}	-0.51	-0.31×10^{-5}	-0.37	-0.34×10^{-5}	-0.42
Institutional:						
EXTN	0.21×10^{-4}	5.79***	0.70×10^{-5}	1.70*	0.15×10^{-4}	3.63***
Constant	0.15	1.62	0.07	0.71	-0.23	-2.21
Log L	-5735.0		-4818.0		-4908.9	

Notes:
a. The dependent variable is PERCEP – perception of the soil erosion problem.
b. The dependent variable is EFFORT – soil conservation effort.
c. The dependent variable is PRAC – number of soil conservation practices used.
* denotes significance at the 10% level.
** denotes significance at the 5% level.
*** denotes significance at the 1% level.

Table 5 Elasticities at sample means of the significant variables in the EFFORT model

Independent variable	Elasticity of		Total elasticity
	Adoption probability	Expected intensity of conservation effort	
PERCEP	0.1074	0.0294	0.1368
AGE	0.0121	0.0033	0.0154
ETHN	-1.1236	-0.3081	-1.4317
FSTAT	-0.0398	-0.0109	-0.0507
EXTN	0.0438	0.0120	0.0558