# *Articles and Notes*

# Adoption of Soil Conservation Measures in Manilla Shire, New South Wales

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Land in Manilla Shire, New South Wales, is characterised by serious soil erosion and land use is characterised by high rates of adoption of the recommended soil conservation measures. This behaviour is analysed to attempt to determine what factors are promoting soil conservation at each stage in the adoption process. The results suggest that policies to promote farmer perception of erosion problems should be formulated differently from those to promote actual adoption of the recommended measures. Perception of the problem depends mainly on the percentage of farm area that is eroded, but the likelihood of adoption depends mainly on the intensity of the erosion. The farmer's rating as an investor, the size and security of farm income, and the presence of institutional programmes are all significant factors which encourage adoption. While the stewardship motivation and personal factors encourage perception and recognition of a problem, economic factors promote actual adoption.

## 1. Introduction

Land degradation is a serious and persistent problem in Australian agriculture. The widespread interest derives from beliefs that the quality of land has steadily deteriorated, that land quality should be sustained, that new technology masks the true effects of degradation, and that more land should be set aside for parks and other reserves (Chisholm and Dumsday 1987). The state soil conservation agencies have long been involved, while other public servants and politicians are now responding to the problem. The issue for the soil conservation agencies is how to encourage landholders to adopt conservation measures.

Adoption would be promoted by knowledge of which factors influence landholders' decisions, and of ways to influence these factors. A search of the Australian literature revealed little quantitative information of this kind but many qualitative assertions, a conclusion confirmed by Yapp and Connell (1989). Accordingly, a model of the adoption process was developed and applied to landholders in Manilla Shire, New South Wales. Our specific objectives were (a) to determine the relative importance on the adoption process of land condition, personal factors, economic factors and the institutional programmes designed to encourage adoption, and (b) to interpret these results more generally to help formulate policies to promote soil conservation.

Manilla Shire was chosen for study because of it's serious erosion problems and it's substantial programmes of conservation. The Soil Conservation Service (SCS) of New South Wales has maintained an active soil conservation programme there for some time. The Keepit Project, which was started in 1971 to reduce soil erosion in the catchment of Keepit Dam, is located within the Shire.

Farm planning is one of the services provided by the SCS. The Service prepares a farm plan which includes recommendations for soil conservation measures. These measures raise the conservation status of the land to a technical standard set by the Service. Upon approval of a plan, an agreement is prepared which details the required measures and

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the responsibilities of both the SCS and the farmer in carrying it out.

On farms within the Keepit Project, one half of the cost of the required structural works was borne by the SCS, and the landholder was usually eligible for a 15-year loan at 4.5 per cent interest to cover the remainder. This loan was available to all farmers who met the eligibility requirements, wherever their farm was located. (The SCS advances are now generally available at 8 per cent over ten years, and the eligibility criteria have been changed). The farmer's decision to undertake the works should have been influenced by whether or not the property was in the Project, because of the greater need for the works, and because of the cost-sharing programme.

The conservation measures undertaken in the study area include the structural works of banks, grassed waterways, dams and fence re-alignment. They also include the management practices of pasture establishment, changes in crop rotations, and changes from crop to livestock activities. Each farm plan included both structural works and changes to management practices. These measures, and their mix, are appropriate for the area but not necessarily for other areas. The results of the study therefore refer just to this area and to these kinds of conservation measures.

## 2. Literature Review

There appears to be little quantitative information on the adoption of soil conservation measures in Australia. Indeed, after an intensive literature search, Yapp and Connell (1989) concluded that little Australian research had been conducted on factors affecting the adoption of conservation tillage. In contrast, many writers advance descriptive lists of factors that they believe will promote or prevent adoption. For example, Ward (1983) suggests that costs, problems with wheel tracks, and hard-to-kill weeds, all prevent adoption of reduced-tillage techniques in southern Queensland. Direct drilling is a method of conservation tillage that helps to integrate livestock grazing and wheat growing. Scarsbrick (1983) documents the rapid increase in the number of farmers using this method in southern New South Wales. There were two farmers, with 30 hectares, in 1976 and 1800, with 200 000 hectares, in 1982. He then lists the barriers to more rapid adoption and these include lack of equipment, undesirability of burning stubble, and lack of suitable wheat varieties.

In such lists, the relationships between the factors and adoption are rarely justified, and the relative importance of the different factors is rarely established. Nevertheless, these lists can be useful descriptions of the nature and scope of a problem, and they are useful initial steps toward a quantitative analysis.

Adoption is a process of several stages, from the perception of an erosion problem through to the ultimate stage of adoption of appropriate measures. There are few studies of all stages for a given degradation problem and, as far as we can tell, no such studies in Australia. However the stages have sometimes been studied separately. For example, Rickson, Saffigna, Vanclay and McTainsh (1987) study farmer perception of erosion and its consequences on the Darling Downs in Queensland. Farmer perceptions about institutional programmes and soil conservation practices were investigated by Brewin (1980). Thirty farmers in Victoria were asked about their commitment to conservation, their participation in the group conservation programme, and their satisfaction with its progress. Non-adopters perceived they were excluded from close involvement in these programmes. Brewin used this kind of result to suggest how policies and activities could be modified to encourage participation.

Adoption of measures will vary with social and economic factors, as well as with biophysical characteristics of the land, argue Earle, Rose and Brownlea (1979). Five variables satisfactorily discriminated between farmers who had, and those who had not, adopted soil conservation measures on the Darling Downs. These variables were farm size, perception of the general importance of erosion, pursuit of double-cropping, income and educational level. Increases in each promoted the likelihood of actual adoption.

The final stage of the adoption process, in which the technique is or is not adopted, has been analysed for various agricultural activities. Vere and Muir (1986) analysed the separate influences of livestock prices,

input costs, seasonal conditions and previous pasture improvement activity on the adoption of pasture improvement practices in south-eastern New South Wales. The dependent variable in the regression analyses was area of sown grasses and clovers for individual regions and shires.

## 3. A Conceptual Framework

### 3.1 Nature of adoption decisions

The adoption of innovations has received exhaustive study (see for example Rogers 1983), and research into diffusion of new agricultural practices rests on this body of literature. Conceptual models of adoption vary in their details, but most recognise a multi-stage decision process. Indeed, Kennedy's (1977) general model for agricultural innovations rests on the three stages of (a) recognition of a problem worth resolving and search for innovations, (b) awareness and mental acceptance of a new practice, and (c) adoption or non-adoption of the practice. Despite the difficulties, he concluded that such models were generally relevant but needed refinement for specific studies.

Ervin and Ervin (1982) use a three-stage model to examine the adoption of soil conservation practices in Missouri. Their stages were perception of erosion, decision to adopt, and actual quantity of adoption. A three-stage process was also modelled by Taylor and Miller (1978) for the adoption of measures to control pollution of rivers in Indiana. Their measures included conservation practices of grassed waterways, holding ponds and contour farming, and their stages were knowledge of the innovations, persuasion about them, and the decision to adopt.

To fully explain behaviour, any model of the adoption process must explicitly include motivations. The income and capital gain motives in particular, must be recognised. The stewardship motive, of passing on to the future a fully-productive resource, may also be important to many landholders. As Van Kooten and Furtan (1987) footnote in their

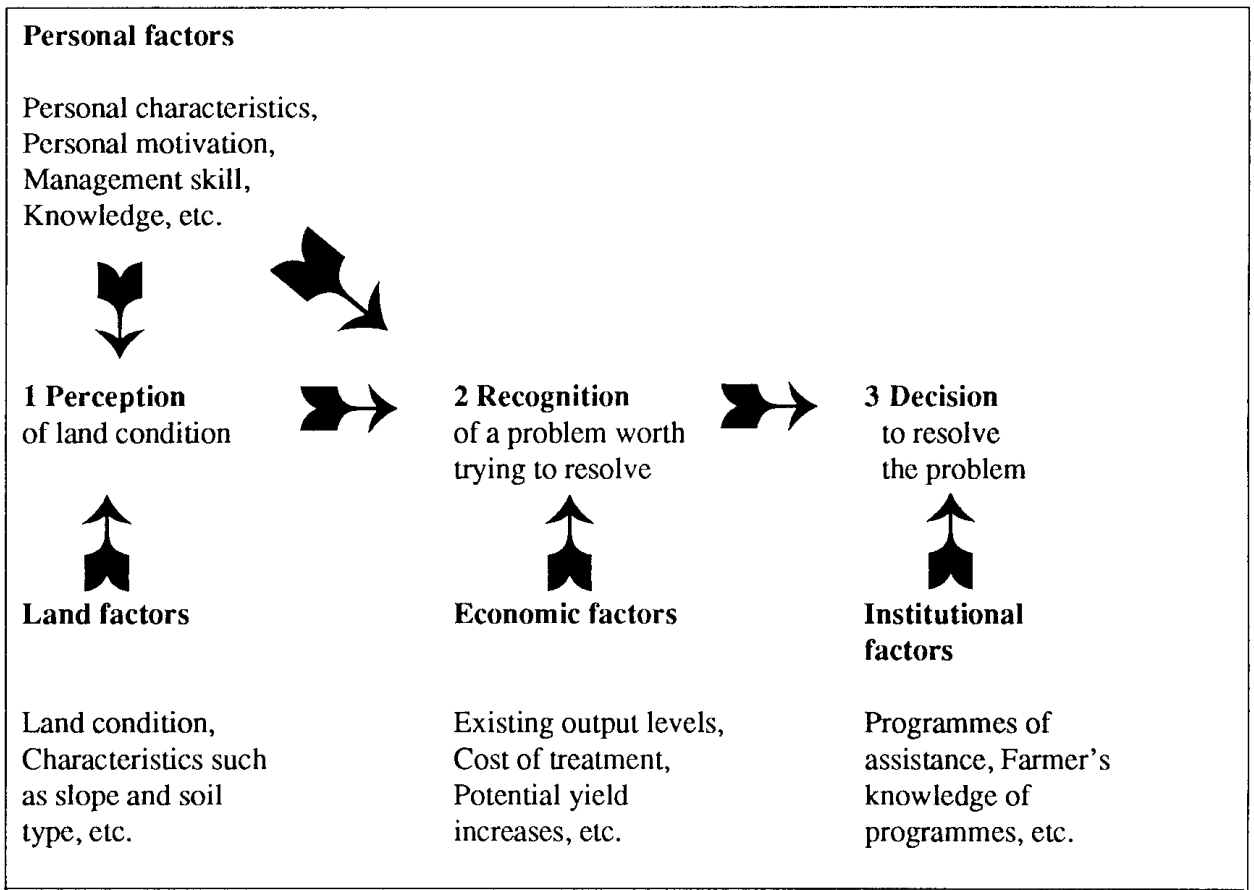


**Figure 1: Three stages in the process of adoption of soil conservation measures**

review of soil deterioration in Canada, stewardship is almost always reported as a reason for adopting conservation practices and economics is reported as a reason for rejecting them. Explanatory variables will of course vary with location and practice, but motivation should always be an important factor.

### 3.2 A model of the adoption process

The conceptual model in Figure 1 embraces the multi-stage adoption process and includes all the relevant influences through four groups of factors. The model is based on Ervin and Ervin (1982), but their last stage, quantity of adoption, is redefined as the decision on whether or not to resolve the erosion problem and a new stage is added. As Saliba (1985) argues, such models help to emphasise the separate importance of the different factors, as well as the relationships among them. For simplicity, the model omits the feedback loops that Saliba and Bromley (1986) use to characterise changes over time. But it expands their decision process to include a problem recognition stage between perception and decision.

Perception of land condition (PERCEP) concerns the farmer's awareness of the erosion status of the land, and depends on both the exogenous factors of the land and the personal attributes of the farmer. Recognition (RECOG), that a problem is worth trying to resolve, rests on these initial perceptions, on economic factors, and on the farmer's motivation to address the problem. The decision whether to undertake conservation measures (FIXIT) rests on both the perception and recognition stages, but also depends on the institutional factors. This behaviour could be modelled by the following system of structural equations:

(1) PERCEP = f(Land factors, personal factors)
(2) RECOG = f(PERCEP, other personal factors such as motivation, economic factors)
(3) FIXIT = f(RECOG, institutional factors)

Equations (1) and (2) recognise the possibility that some personal factors may influence PERCEP rather than RECOG — and vice versa. Equations (2) and (3) presume that both recognition and decision stages depend on economic forces and that the same economic forces influence both.

If all three stages are resolved simultaneously, the system should be estimated simultaneously. If the three are resolved sequentially in the same decision process, the system should be estimated sequentially. In other circumstances, separate estimation of each of the three models is appropriate. These circumstances include cases where (a) the final decision stage may occur one or two years after the recognition stage — as in the present research, (b) where the separate effects of the factors at each stage may be of interest — as apparently they were to Taylor and Miller (1978) and Ervin and Ervin (1982), or (c) where perhaps just one stage in the process is to be analysed. For separate estimation, the stages may be specified as follows:

(4) PERCEP = f(Land factors, personal factors)
(5) RECOG = f(Land factors, personal factors, economic factors)
(6) FIXIT = f(Land factors, personal factors, economic factors, institutional factors)

These individual models of the stages in the adoption process are estimated for the sample of farms in Manilla Shire. They are estimated separately because the final decision to adopt (the "FIXIT" stage) occurred after the first two stages.

The model of Figure 1 extended the framework provided by Ervin and Ervin (1982). The explanatory power of the models for each of their three stages was reflected in their coefficients of determination of 0.31, 0.26 and 0.25. Many studies of adoption of conservation measures, including Taylor and Miller (1978), show coefficients of a similar magnitude indicating the limitations of using cross-sectional data to analyse this kind of problem. Further limitations arise because the decision process is usually continuous and is always dynamic, so the separation into three stages is a simplification. Such characteristics as landholder motivation are hard to conceptualise and hard to measure. Indeed, some characteristics can only be measured on a yes/no scale which fails to reflect their continuous nature. Due to such limitations, the results of any

adoption study need to be interpreted carefully, particularly if the explanatory power of the results is low.

The model of Figure 1 is particularly suited to examination of the stages in the adoption process, and to identification of the important factors at each stage. Other models and approaches are suited to other variations of the problem. For example, Lindner, Pardey and Jarrett (1982) applied regression analysis to investigate influences on the timing of adoption and the lags between information and adoption. The role of information was incorporated through variables of distance (kms) to nearest adopter or the nearest innovation source. Gibbs, Lindner and Fischer (1987) then investigated the timing of discovery and time lags of discovery by groups of discoverers.

## 4. Method

The variables PERCEP, RECOG and FIXIT are all conveniently and logically defined as binary variables. The farmer either does or does not perceive that the land is in an eroded condition (PERCEP = 1 and 0 respectively), does or does not recognise that erosion is a problem worth resolving (RECOG = 1 and 0 respectively), and does or does not adopt measures to fix up the problem (FIXIT = 1 and 0 respectively). The farmers appeared to differentiate very clearly between these three variables. Land perceived as eroded (PERCEP = 1) was not inevitably land on which erosion was recognised as a problem worth resolving (so RECOG = 0 here). Recognition of a problem (RECOG = 1) did not inevitably lead to its resolution by adoption (so FIXIT = 0 here).

In each case, the farmer is choosing between two situations. The logit and probit methods can be applied to model this kind of binary choice when the equation to be estimated is linear in its parameters and when individual observations are to be analysed. In these methods, choice is modelled by the following linear probability model:

$$(7) \qquad I_i = a + bX_i + e_i$$

where $I_i$ is the binary choice variable measured as 1 or 0, $X_i$ is a vector of attributes (or independent variables), and $e_i$ is the random disturbance.

The probit method is used to estimate the equation when the underlying probability distribution, to relate $I_i$ to $X_i$, is normal. The logit method is used when this distribution is not normal. The models for each stage in the adoption process invite the use of dummy variables and qualitative ratings so a normal distribution could not be justified. The logit method was therefore used to estimate the models.

Parameters a and b are generally estimated through maximum likelihood procedures. When the sets of observations are statistically independent, and when the sample is large, the maximum likelihood estimates are distributed normally and hypotheses about the parameters can be tested with the t-statistic.

Logit analysis has been widely used to investigate participation in agricultural and land-use activities and to assess the impact of extension programmes (see for example Brown and Kodras 1987; Ferguson 1989; Garcia, Hudson and Waller 1988; Hughes, Robertson and Savin 1987; and Lisansky, Andrews and Lopez 1988). In the present study, logit analysis is used to estimate equations (4), (5) and (6).

## 5. Data Collection

### 5.1 The study area

The study was undertaken in Manilla Shire, New South Wales. Data were collected simultaneously for the present research and for research into the relationships between soil conservation and land values (King and Sinden 1988). Sales of all properties larger than 40 hectares were identified for the period between December 1979 and October 1985. During this period 154 properties changed hands. Farms purchased by government agencies, properties not used for agriculture, properties solely suited to grazing, and within-family transactions were excluded. The grazing properties were omitted because they were on higher, steeper land, were much larger, and required a different package of conservation measures. Seventy eligible farms remained and the survey included the first 50 farmers with whom appointments could be made. A set of 50 farms, or 71 per cent of the population, seemed to approximate a census and so avoid sample bias.

The farmers who bought the properties may be

relatively random in the sense that they came from widespread locations and backgrounds. However they may not distribute themselves so randomly between the Keepit Project and the rest of the study area. Accordingly, the available socio-economic characteristics of the buyers were compared. Thirty-eight per cent of all purchasers bought additions to existing properties, with the same proportion in and outside the Project. Sixty eight per cent of all purchasers had a child who could take on the property, 62 per cent in, and 70 per cent outside, the Project. The 50 farmers had spent, an average of 19.8 years in farming while those who bought land in the Project had spent 24.3 and those outside 18.3 years. There was no significant difference between these groups for their years in farming.

The sellers all sold their farms in a common time period and so they may have certain common characteristics. Data were collected from new owners and SCS officers on whether the sellers sold all their farm, on whether the seller had a child to pass the property to, on whether the sale was pressured, and on the sellers new occupation. Seventy-three per cent of the 50 sellers sold their whole farm, 77 per cent in the Project and 72 per cent outside. Only 47 per cent of sellers had a child who could take on the property, with no difference in or out of the Project. Forty-nine per cent had been pressured to sell because of tax demands or mortgage repayments, 42 per cent in and 51 per cent outside the Project. Forty-six per cent of sellers remained in farming, 38 per cent from inside and 49 per cent outside the Project.

The buyers suggested that 12 per cent, on average, of a farm needed treatment at the time of purchase whereas the officers of the SCS suggested that 66 per cent of each of the 50 farms needed treatment at this time. The officers suggested that this 66 per cent was representative for this kind of property in the shire as a whole. The figure was 62 per cent in the Project and 68 per cent on farms outside. This lower value for project farms is a measure of the technical success of the Project.

The representative farm is a family-owned and operated mixed farm, 354 hectares in size, of which 64 per cent is suitable for cropping. Soil fertility varies predominantly with soil type, and all 50 farms are on the red-brown earth type.

## 5.2 The variables

### 5.2.1 The adoption process

One dependent variable was defined for each of the three stages of the adoption process. The landholder's perception of the condition of the land at the time of purchase (PERCEP) was defined as 1 = very degraded, degraded or about average, and 0 = conserved or well conserved. Data were obtained through a 5-point rating question: when you bought the land, did you think it was very degraded, degraded, about average, conserved or well conserved? Twenty-seven of the fifty felt their land was average, degraded or very degraded, while 23 rated their land as conserved or better.

Data on recognition were obtained from the question: did the potential loss of agricultural productivity due to erosion detract seriously from the value of the land at the time of purchase? The variable RECOG was scored at 1 if yes (10 responses) and 0 if no (40 responses).

Officers of the SCS provided data on (a) which landholders had contracted and started the recommended works as of December 1985 (17), and (b) which landholders were about to sign the contracts and about to start (12). By December 1986, all these 12 had completed their contracts and started the works. FIXIT, for the decision to undertake the conservation measures, was coded as 1 = had started or were about to start (29 in all), and 0 = otherwise (21).

Landholders could conserve their soil incrementally, rather than in the all-or-nothing manner of the FIXIT variable. This incremental approach did not appear to be typical in the study area, where 29 of the farmers had contracted for the whole set of measures in the farm plan. The reasons for this all-or-nothing behaviour are clarified in the analysis.

### 5.2.2 Land factors

A direct, readily perceivable, measure of land condition is the percentage of the property that needed treatment. Each farmer was therefore asked what percentage was thought to need treatment (PCTREAT) at the time of purchase. The farmers often suggested that land characteristics other than

PCTREAT were intuitively closer to PERCEP, the perception that land is in an eroded condition. Deep gullies, buried fences, and scoured fords are all more obvious in the area than sheet erosion across paddocks. Nevertheless PCTREAT was retained as an important measure of land condition because it applied to all properties and could be derived in a systematic way.

A more detailed, readily-observable concept of land condition was developed with the help of SCS officers. Six indicators of condition were defined including silting of fence lines and state of the water flow lines. The property was scored on a scale of 1 (very good condition) to 5 (very poor condition) on each indicator. A total score of 30 on this visual rating (VISRAT) indicated a property in very poorly conserved condition on all six indicators. The average was 11.8 and the range was from 7 to 20.

A field-by-field measure of the cost of the conservation works was available through the farm plans. The total cost of all the recommended works was calculated (and expressed as CCOST in $ per hectare over all hectares of the purchase). Properties with low erosion potential, a technical condition and standard implicit in the recommended works, have low values for CCOST and vice versa.

Landholders have this CCOST information in the final FIXIT stage and they could interpret it in three ways. First, it is the total cost of the recommended conservation works and the actual cost for those outside the Keepit Project. Those within the Project have half their costs paid by the State. If more expensive works are less likely to be adopted, a negative sign would be expected. Secondly, CCOST is a measure of land condition and a direct reflection of the seriousness of the landholder's degradation problem. Soil Conservation Service officers stress this kind of interpretation to the landholder. Land with higher CCOST is in worse condition and *ceteris paribus* should be treated first — hence a positive sign would be expected. Third, CCOST indicates the likely yield increase, with land in worse condition likely to give the highest increase in yield _ hence a positive sign would be expected for this reason also. On balance, we would expect a positive sign on CCOST.

The potential increase in yield with CCOST, and the increase in urgency of treatment with increasing CCOST, seem unlikely to be linear. The increase in yield and in urgency would seem likely to exhibit diminishing marginal increments with increments in CCOST, so CCOST is transformed logarithmically.

Farmer perceptions on three more aspects of land condition at the time of purchase were collected . ACCESS was the standard of roads to homestead, fields, buildings and on the property generally. It was coded 1 if they required substantial and carefully-defined repairs every 1 year, 2 if every 2 years, etc. SILTRO was coded similarly for the frequency of maintenance to adjacent shire roads due to silting and gullying from the property. The farmers estimated the cost of on-farm conservation works necessary to stop erosion into off-farm water courses (WATERC in $ per ha).

5.2.3 Personal factors

An important factor in the adoption decision is the management skill of the farmer, a concept that is inherently difficult to measure. Years in farming (BYRSF) was used as one measure. Another was a rating on a 1 to 10 scale of landholder ability to invest capital to obtain a high yet safe return (BINV). The purchase price of each property, and estimates of present farm incomes were available to help the SCS officers and the researchers estimate this rating. Through their preparation of farm plans, the officers had detailed knowledge of the landholders ability to keep records and what records were kept, and of the frequency with which landholders sought advice and the kinds of advice sought. Through their relatively long periods in the district and their close involvement in extension work and applications for loans, the SCS officers had considerable knowledge of the economic viability of the landholders.

The intensity of the landholder's search for a purchase reflects the care in his decision to buy the property, even though this choice might also reflect market conditions. This care may carry through to other decisions, so BSCH was included and defined as the number of properties the landholder said were seriously considered in the search for land.

The importance of stewardship and the conserva-

tion ethic was assessed. Landholders were given a list of 14 potential benefits from soil conservation and asked to select the five that they thought generally gave the greatest satisfaction to them. One benefit was, "pass on to the future a fully productive resource". The variable BSTEW was coded as 1 if this benefit was selected and 0 otherwise, and relationships between it and two other personal characteristics were tested. There were no visual trends in the data of BSTEW and the existence of children to pass the property to, or of BSTEW and those who bought to expand an existing property. The correlation coefficients between BSTEW and these two other variables were less than 0.12.

The quantity of information available to the farmers, and the farmers' active pursuit of this information, should influence perception, recognition and the decision to adopt. CCOST measures the cost of necessary works, and hence indicates the condition of land. But CCOST data were only available at the final stage. Thus we asked farmers how many sources of information on soil erosion and conservation they had seriously consulted at the time of purchase. BQINFO was coded as this number, and the sources were typically SCS, Department of Agriculture, stock and station agents, and farmers' own knowledge (particularly for purchase by a neighbour). On average farmers reported that they had seriously consulted 3.6 such sources.

5.2.4 Economic factors

Relevant economic factors include existing agricultural yields, because these will affect the farmer's overall ability to pay for works. Two yield variables, as proxies for gross farm income, were therefore included. WHEAT was the total wheat yield per hectare expected in the next year, as estimated by the farmer. It was recorded as total yield in tonnes divided by the total area of the property. This basic measure of agricultural production was supplemented by STOCK, the total livestock carrying capacity expected in the next year in livestock-month equivalents per hectare. STOCK obviously recognises grazing potential of the land, and partially recognises the potential of arable land to provide fodder crops. The cost of conservation works (CCOST) is expressed per hectare over all hectares of the purchase, so WHEAT and STOCK are expressed per hectare over all hectares of the purchase.

The landholder's economic motives for purchasing and managing the land will influence the recognition of the problem and the decision to adopt. Each farmer was asked whether it was thought that the potential agricultural income and potential capital gain from the property were especially important reasons for purchase (INCMOT and CAPGMOT respectively). These two variables were both coded 1 if so, 0 otherwise. Fifty per cent listed the income motive as especially important, and 42 per cent listed capital gain as especially important. These two motives, along with availability of water, were the most-frequently cited reasons for the particular purchase.

5.2.5 Institutional factors

The town of Manilla is central to the area, and is the headquarters of the local Soil Conservation District and the Keepit Project. Over the years, properties closer to Manilla have had greater access to the SCS extension programme and the SCS plant and machinery, so perhaps less conservation work remains to be done on these properties. Again, more extension advice is currently focussed on the more distant properties, so distance from Manilla (DMAN in kilometres) should partly explain the influence of the extension programme.

Farmers within the Keepit Project were eligible for a 50 per cent subsidy on the cost of the recommended conservation works, as well as the standard 4.5 per cent loan for the remainder of the cost. This cost-sharing programme is an incentive provided by the SCS to the farmer to complete recommended works. Accordingly, INK was defined as 1 when the property is within the Project, and 0 otherwise.

Farmers who have had previous soil conservation loans, and particularly those who have had previous agreements with the SCS for land within the Project, can better assess what the agreements entail. PRAG was therefore defined as 1 = the landholder has had a previous agreement concerning land within the Project, 0 = otherwise.

## 6. Results

The logit models for each of three stages of the

adoption process are presented in Tables 1 and 2. The likelihood ratios show that the set of coefficients as a whole is significantly different from zero at the five per cent level or better in each model. The null hypothesis, that there is no relationship between the dependent variable and its set of explanatory variables, is clearly rejected in each case.

The correlations between the independent variables in each of the models were calculated and observed. The highest was 0.426 between INK and PRAG in the model for fixing up the problem, and none of the others exceeded 0.380. These low correlations suggest that the variables are measuring different characteristics, and their measurements and inclusion do not lead to multicollinearity.

We now consider the models for each stage in the process.

### 6.1 Perception of land condition

The signs on the significant variables of the full equation (8) in Table 1 indicate that the likelihood that a property is perceived as degraded increases with increases in the percentage of its land needing

**Table 1: Perception Functions Derived by Logit Analysis[a]**

| Explanatory Variables | | Equation 8 | Equation 9 |
|---|---|---|---|
| **Land Factors** | | | |
| PCTREAT | % farm to be treated | 0.119<br>(2.4)*** | 0.058<br>(2.2)** |
| ACCESS | Property access | 0.003<br>(0.1) | |
| SILTRO | Shire road silting | -0.006<br>(0.6) | |
| WATERC | "Off-farm" conservation costs | -0.076<br>(2.1)** | |
| VISRAT | Visual rating | -0.051<br>(0.4) | |
| **Personal Factors** | | | |
| BINV | Investment rating | 0.670<br>(1.4)* | 0.360<br>(0.9) |
| BSCH | Search intensity | 0.013<br>(0.3) | 0.013<br>(0.3) |
| BYRSF | Years in farming | -0.055<br>(1.9)** | -0.043<br>(1.7)* |
| BQINFO | Information quantity | -0.149<br>(0.5) | -0.058<br>(0.2) |
| Constant | | -0.056 | -0.591 |
| Likelihood ratio | | 17.789 | 11.504 |
| Level of significance | | 0.05 | 0.05 |

[a]The numbers in parentheses are t-statistics, with significance at ( ) *** for 1 per cent or better, ( )** for 5 per cent, and ( )* for 10 per cent. The data capture human behaviour in the presence of biological and climatic variations. Any relationship significant at the 10 per cent or better is therefore of interest, as well as any at the usual levels of 5 and 1 per cent.

**Table 2: Recognition and Fixit Functions, Derived by Logit Analysis[a]**

| Explanatory Variables | | RECOG (Equation 10) | FIXIT (Equation 11) |
|---|---|---|---|
| **Land factors** | | | |
| PCTREAT | % farm to be treated | 0.029 | -0.001 |
| | | (0.1) | (0.1) |
| CCOST | Cost of required conservation works | | 1.766 |
| | | | (2.3)** |
| **Personal factors** | | | |
| BINV | Investment rating | 1.973 | 1.121 |
| | | (2.2)** | (1.7)* |
| BSCH | Search intensity | 0.105 | 0.065 |
| | | (1.6)* | (0.8) |
| BYRSF | Years in farming | -0.096 | -0.005 |
| | | (2.2)** | (0.1) |
| BQINFO | Information quantity | -0.508 | |
| | | (1.1) | |
| BSTEW | Stewardship ethic | 3.258 | -1.030 |
| | | (1.7)* | (0.6) |
| **Economic factors** | | | |
| INCMOT | Income motive | -0.211 | 0.810 |
| | | (0.2) | (0.7) |
| CAPGMOT | Capital gain motive | 1.614 | 1.053 |
| | | (1.5)* | (1.0) |
| WHEAT | Wheat yield | 0.623 | 1.061 |
| | | (0.8) | (1.4)* |
| STOCK | Livestock carrying capacity | -0.113 | 0.225 |
| | | (0.8) | (2.1)** |
| **Institutional factors** | | | |
| DMAN | Distance to Manilla | | 0.198 |
| | | | (1.9)** |
| INK | In Keepit Project | | 2.221 |
| | | | (1.3)* |
| PRAG | Previous agreement | | -4.056 |
| | | | (1.4)* |
| Constant | | -9.278 | -16.352 |
| Likelihood ratio | | 19.436 | 34.310 |
| Level of significance | | 0.05 | 0.01 |

[a]The numbers in parentheses are t-statistics, with significance at ( ) *** for 1 per cent or better, ( ) ** for 5 per cent and ( )* for 10 per cent.

treatment (PCTREAT), and with increases in the investment rating of the landholders (BINV). These variables are significant, with positive signs. The likelihood decreases with increases in the costs of treatment to stop off-farm erosion (WATERC) and with increases in the landholder's years in farming (BYRSF). These variables are significant with negative signs. Increases in off-farm watercourse erosion (as captured in WATERC) are associated with decreases in the perception that the farm itself is degraded (PERCEP), and the relationship is stronger for those with more years in farming (BYRSF). This association may reflect an attitude that the causes and responsiblity for off-farm erosion are different to those for on-farm erosion, an attitude which may reflect economic rationality.

Three factors of land condition have no significant influence on perception of the land as degraded or conserved. One is the off-farm factor of silting of shire roads (SILTRO), while the other two are the on-farm factors of access to property roads and tracks (ACCESS) and the visual characteristics of degradation (VISRAT). The visual characteristics are highly observable but perhaps the VISRAT variable did not capture them effectively.

The recognition and FIXIT models refer to farmer behaviour and on-farm agricultural output. Variables ACCESS, SILTRO and WATERC do not refer to agricultural output as such, and VISRAT refers to more than just agricultural output. Thus for compatibility with the recognition and FIXIT models, another perception model (equation 9) was estimated with PCTREAT as the only factor of land condition. As Table 1 shows, PCTREAT and BYRSF are the two most significant variables, a result comparable to equation 8.

### 6.2 Recognition of a problem

The signs on the significant variables in the recognition model of equation (10) indicate that farmers who were likely to recognise erosion as a serious problem were those who were classified as better investors (BINV), who had considered larger numbers of properties for purchase (BSCH), who had spent less years in farming (BYRSF), and who adhered to the conservation ethic (BSTEW). Motivation to provide capital gain also enhanced the likelihood of recognition. But the other three economic factors were not significant, suggesting that recognition depends more on personal factors than on land or economic factors. The land factor PCTREAT was significant only at between 10 and 15 per cent.

### 6.3 Fixing up the problem

The decisions to adopt the recommended measures were taken up to four years after purchase of the land. The available information at this time differed from that at the time of purchase, so variable BQINFO (information available at the time of purchase) was omitted and CCOST was included in the FIXIT model. The BQINFO variable was also omitted because the landholders felt that CCOST provided more objective, more precise, more relevant and more embracing information. The institutional variables (DMAN, INK, and PRAG) were of course included, and PCTREAT was retained on the assumption that little change had occurred since purchase date in the percentage of the property to be treated.

The results of equation (11) show that conservation works are more likely to be adopted on properties where intensity of degradation is high (CCOST), where landholders could be classed as better investors (BINV), and where current wheat production (WHEAT) and livestock carrying capacity (STOCK) are higher.

Works are more likely to be undertaken when properties are in the Keepit Project (INK) and when they are subject to more intensive extension efforts (DMAN). However, buyers who had previous agreements are less likely to fix up their land condition and conversely buyers who have not had previous agreements (PRAG) are more likely to undertake the works. We return to this point in the discussion.

The derivatives of the FIXIT probability function were calculated with respect to the significant explanatory variables. They were calculated at the variable means and can be used to show the change in probability of actual adoption for a given change in the independent variable. A ten per cent change was used and the results were as follows:

| | | | |
|---|---|---|---|
| CCOST | 0.698 | WHEAT | 0.114 |
| BINV | 0.381 | INK | 0.058 |
| DMAN | 0.289 | PRAG | -0.024 |
| STOCK | 0.184 | | |

These derivatives show that the land condition (CCOST) is the most influential variable affecting adoption and is about twice as influential as the next most important one (BINV).

Models for the three stages were also estimated sequentially but they provided no new or different information. The FIXIT model was run with the logarithm of actual cost of conservation works to reflect the 50 per cent contribution to costs of those inside the Keepit Project. This model provided no new or different information from equation (11).

No attempt has been made to assess or include attitudes to risk, or the riskiness of conservation measures. The extra time to collect data for these would have been prohibitive.

## 7. Discussion

The results of any case study are hard to generalise. In the present study area, there was serious soil erosion, an active SCS programme to combat it and the Keepit Project to stimulate the programme even further. Manilla Shire is therefore unlikely to be representative of any other shire, even though the sample of farms may represent their kind in the shire. The farmers themselves were diverse, including new entrants and neighbours buying adjacent land. (The models were rerun with a dummy variable to distinguish between new entrants and neighbours. Inclusion of this variable failed to change the signs or the levels of significance of other variables). Nevertheless, the scarcity of quantitative studies of adoption of soil conservation and the scarcity of statistically-significant results within those studies, justifies such a study in this shire.

### 7.1 The assessment of land condition

The condition of the land proved to be a major influence in explaining both perception and the ultimate adoption of the recommended measures. But different variables, reflecting different concepts of land condition, were important at these different stages. The percentage of land needing treatment (PCTREAT) was significant in the perception stage, but not in the ultimate FIXIT stage where CCOST was significant. Policy advice and extension usually emphasises poor land condition, so it now appears to be important to emphasise this condition in terms of the right concept at the right stage in the adoption process.

In a sense, any concept of land condition that contributes to a landholder's perception, recognition or adoption, is a useful measure. Officers of the SCS assessed the percentage of each property that they felt needed treatment at the time of purchase (PCTREATS). They felt that, on average, 66 per cent of each farm needed treatment whereas landholders reported that only 12 per cent needed treatment, on average. In a paired-sample t-test, the set of values of PCTREAT (landholder' assessments) proved significantly different from the set of values of PCTREATS (SCS assessments) at better than one per cent. Apparently, landholder assessment of land condition on this variable differs from expert assessment. Landholders may, of course, have under-reported to us the percentage of their land requiring treatment. Even though landholder assessment may be inaccurate, increases in it significantly promote increases in perception so perhaps this kind of assessment can still be accepted and promoted to enhance the perception that erosion is a problem.

### 7.2 The role of economic factors

The major determinant in the final decision to adopt was CCOST, the economic measure of land condition. Two other significant variables were the key economic factors of annual wheat yield (WHEAT) and livestock carrying capacity (STOCK). The significance of STOCK suggests that adoption depends on the security of income derived from the diversity of farm enterprises, as well as the actual size of the farm income. The only significant personal factor is the buyer's investment rating (BINV). Overall the significance of these economic variables helped to maintain our faith that the economic paradigm still provides a useful model of farmer behaviour.

Nevertheless non-economic factors are important too. In the final FIXIT stage, all three institutional

variables are significant. *Ceteris paribus*, farmers with previous experience of agreements (PRAG) are less likely to adopt and these may also be the older farmers. Personal factors as a group are important in the recognition stage even though the economic variables as a group are important in the FIXIT stage. The recognition model, with the significant stewardship variable (BSTEW), explains the intention to behave in a certain way. The intention is changed into action after economic and institutional factors are fully incorporated. The Van Kooten/Furtan hypothesis might therefore be reversed — stewardship is an important reason in recognising a problem but economics is the reason for resolving it.

The role of information in the several stages of adoption is indicated by the variables BQINFO and CCOST. The number of sources of information used by the landholders at the time of purchase (BQINFO) had no significant influence on perception or recognition. However, in the final stage landholders had the estimates of CCOST and this was a significant variable. The positive sign on CCOST indicates that the likelihood of adoption increases as land condition worsens. Thus, general information on the problems of soil erosion seems to have little significant effect on perception or recognition. But the specific kind of farm-by-farm information embodied in CCOST seems to be significant in determining actual adoption.

The significance of the institutional factors helps to explain the high adoption rate in the study area and within the Keepit Project. The results show that this Project has a positive effect on adoption, because location of a farm within it (INK = 1) significantly increases the likelihood of adoption. The direct extension effort (as measured by DMAN) also significantly increases the likelihood of adoption. This kind of project, and the kind of extension maintained in the area, are both useful policy instruments to promote soil conservation.

## 8. Conclusions

The adoption of soil conservation measures in the study area does appear to vary with several distinct factors, and the factors differ between the perception, recognition and decision stages of adoption. These factors include land, personal, economic and institutional characteristics. The most significant variables in the final decision to adopt were the cost of the required works (CCOST), livestock carrying capacity (STOCK), and distance to Manilla (DMAN) which is a proxy for extension effort. Government agencies cannot influence CCOST or STOCK, but they can directly influence the quantity of extension effort and this would appear to influence the likelihood of actual adoption. Further, the existence of the Keepit Project is significant in this stage, and the SCS directly influences this variable through creation of such projects. The negative influence of PRAG suggests that the process and legalities of reaching agreements, and the agreements themselves, could be simplified.

The three most influential variables in the FIXIT stage, according to the derivatives were CCOST, BINV and DMAN. The importance of the landholders rating as an investor (BINV) suggests that encouragement of investment training, and demonstration of the economic potential of conservation, may well influence adoption.

The potential for the Soil Conservation Service to promote adoption seems considerable because all three institutional factors are significant. The degree to which that potential is realised depends on a set of economic variables (CCOST, BINV, WHEAT and STOCK), because these are the other significant variables in the FIXIT stage.

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