FACTORS INFLUENCING THE ADOPTION OF SOIL CONSERVATION PRACTICES ON COMMERCIAL FARMS IN KWAZULU-NATAL

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In South Africa, most cultivated soils undergo soil losses of between three and ten tons per hectare per annum, ten times the rate of soil formation (Fuggle and Ralbov, 1992: 193). Thus, erosion is "possibly the greatest environmental problem" facing the country (Topham, 1991). Indeed, this is the view of the author as well, as the losses are substantial and the rate is excessive (Fuggle and Ralbov, 1992: 193). In South Africa, the soil conservation from an economic perspective. In the United States, several studies on this problem have been undertaken (Evins and Evins, 1991; Topham, 1991; Goodwin, 1993; Oudal, Szep and Klemme, 1989; Norris and Bate, 1987). South Africa's current soil conservation policy, farmers must apply to have their farm unit entered into the Soil Conservation Scheme to be eligible for subsidy payments for constructing soil-conserving works. When applications are approved, the extension service compiles a farm conservation plan, which includes plans, specifications, and materials that are to be used in constructing soil conservation works (Government Gazette No. 0338, 1984). In most cases, the capital costs are met, and money appropriated for the scheme are available. Past research suggests conservation adoption is a multi-staged decision process (Evins and Evins, 1982; Sinden and King, 1991), where perceptions of soil erosion is not necessarily followed by action to correct it. Individuals would otherwise be perfectly rational, appropriate corrective action would internalise exclusive benefits (economic or

Duff et al, 1992: 403). Since not all farmers will face both technical and financial constraints, and transaction costs associated with meeting the provisions of Act 43/1983 are likely to be high, levels of soil conservation may be improved if the policy is formulated differently.

Objectives in this study are to identify factors affecting the various stages in the soil conservation adoption-decision process. Based on research undertaken by Evins and Evins (1982) and King (1991), this decision process is assumed to incorporate stages relating to awareness of erosion, conservation adoption-decision perception that it is a problem, resolving, and technical and financial abilities to implement soil conservation measures. If constraints within this adoption-decision process are identified and appropriate assistance targeted at homogenous groups of farmers, improvements in soil conservation may be achieved.

Separate estimation models for each stage in the adoption process are chosen so specific influences of explanatory variables will be useful in developing target strategies (Evins and Evins, 1982: 290). Logistic regression models are used to identify explanatory variables at each stage in the adoption-decision process, using data collected from five different commercial farming areas in Kwazulu-Natal. These models test theoretical relationships between, and establish the relative importance of managerial characteristics, enterprise combinations, erosion/conservation characteristic of farms, relevant institutional controls, farmer perceptions and opinions, and farm financial characteristics, in the soil conservation adoption process. Results provide insights for improving soil conservation policy.

1. Introduction

In South Africa, most cultivated soils undergo soil losses of between three and ten tons per hectare per annum, ten times the rate of soil formation (Fuggle and Ralbov, 1992: 193). Thus, erosion is "possibly the greatest environmental problem" facing the country (Topham, 1991). Indeed, this is the view of the author as well, as the losses are substantial and the rate is excessive (Fuggle and Ralbov, 1992: 193). In South Africa, the soil conservation from an economic perspective. In the United States, several studies on this problem have been undertaken (Evins and Evins, 1991; Topham, 1991; Goodwin, 1993; Oudal, Szep and Klemme, 1989; Norris and Bate, 1987). South Africa's current soil conservation policy, farmers must apply to have their farm unit entered into the Soil Conservation Scheme to be eligible for subsidy payments for constructing soil-conserving works. When applications are approved, the extension service compiles a farm conservation plan, which includes plans, specifications, and materials that are to be used in constructing soil conservation works (Government Gazette No. 0338, 1984). In most cases, the capital costs are met, and money appropriated for the scheme are available. Past research suggests conservation adoption is a multi-staged decision process (Evins and Evins, 1982; Sinden and King, 1991), where perceptions of soil erosion is not necessarily followed by action to correct it. Individuals would otherwise be perfectly rational, appropriate corrective action would internalise exclusive benefits (economic or

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Separate estimation models for each stage in the adoption process are chosen so specific influences of explanatory variables will be useful in developing target strategies (Evins and Evins, 1982: 290). Logistic regression models are used to identify explanatory variables at each stage in the adoption-decision process, using data collected from five different commercial farming areas in Kwazulu-Natal. These models test the theoretical relationships between, and establish the relative importance of managerial characteristics, enterprise combinations, erosion/conservation characteristic of farms, relevant institutional controls, farmer perceptions and opinions, and farm financial characteristics, in the soil conservation adoption process. Results provide insights for improving soil conservation policy.

2. Conceptual models

Conservation adoption-decisions are assumed to encompass the following stages:

2.1 Awareness of erosion occurring

This is presumed a prerequisite in motivating decisions to implement conservation measures, as suggested by Evins and Evins (1982: 290).

2.2 The perception that soil erosion is a problem worthy of action

Farmers aware of erosion are only likely to consider taking corrective action if they perceive it as something worth resolving (Sinden and King, 1990: 182). Given erosion's implications for agricultural productivity, land values, and on-off site effects (Barlow, 1995), it is worth considering corrective action if farmers perceive that injuries to their soil are likely to be severe. Measures may be defined to protect the land in question.

2.3 Ability to effectively implement conservation measures

Feldspat and Lao (1993: 398-399), note that farmers facing technical and financial constraints will be unable to implement effective soil conservation measures. This stage is divided into two components:

(a) Technical ability - reflecting farmers' knowledge of, and ability to maintain and require maintaining conservation measures.

(b) Financial ability - requiring necessary financial resources are available to cover costs of implementing required soil conservation measures.

Attributes representing awareness, perception, and technical and financial ability are used as dependent variables for each stage. Based on research undertaken in the United States, various variables are hypothesised to influence conservation adoption-decisions. These relate to: personal (age, education, farmer perceptions), physical (land quality, enterprise mix), socio-economic (tenure arrangements), financial (financial performance, management, payment receipt) and institutional factors (legislation, agricultural extension programmes) (Fleitken and Goodwin, 1993; Oudal, Szep and Klemme, 1989; Norris and Bate, 1987).

3. Research methodology

This section describes units of measurement used to evaluate variables in the study, defines the dependent variables, and outlines conservation adoption-decision process.

Most variables in this study measure farmer's own ratings or perceptions and are therefore qualitative in nature. Consequently, their units of measurement are based on a Likert-type scale of one to five. One reflects a low rating, negative perception, or less of the characteristic in question (i.e. less erosion), and five reflects a high rating, positive perception, or more of the characteristic in question (i.e. more erosion). Similarly, dummy variables score one to indicate the presence of a particular attribute, and zero otherwise. Variables that are quantitative in nature are measured in percentage units.

Dependent variables

Dependent variables for each stage in the adoption process are explicitly defined and coded to have a value of one if farmers have a particular attribute, or zero otherwise. If more than one measure were used to define an attribute, a simple change was made so that the occurrence of the attribute was measured (Steel and Torrie, 1981: 281). This variable was measured using a specific model in the data, and can therefore be combined.

Farmers that either indicated erosion in at least a moderate problem on the land they own considering climate and soil type, or agreed that bad soil conservation practices can be defined as being aware and scoring one for this variable. These measures guarantee farmers' increased on-farm erosion awareness.

Respondents score one for the perception dependent variable if they agree that bed conservation practices lead to losses in productivity, and that these are reflected in lower land values. Farmers that either indicated erosion in at least a moderate problem on the land they are considering climate and soil type, or agreed that bad soil conservation practices can be defined as being aware and scoring one for this variable. These measures guarantee farmers' increased on-farm erosion awareness.

Accordingly, these variables score one for this dependent variable. Farmers believing they have the financial resources to construct and maintain soil conservation practices required for their farms score one for this dependent variable. This measure may not distinguish between
A multi-stage adoption-decision process is modelled to isolate factors influencing commercial farmers’ decisions to implement soil conservation measures. The models are estimated using logistic regression analysis, and represent farmers’ awareness of erosion occurring, perceptions that it is a problem worth resolving, and technical and financial abilities to implement appropriate soil conservation practices. Data were collected from five different commercial farming regions in KwaZulu-Natal. Results show visible erosion impacts, formal agricultural education, and perceptions reflecting the seriousness of erosion’s impacts on the environment, positively influence awareness. Farmers investing their own capital when implementing soil conservation measures, and those doing this with no outside technical assistance are more likely to implement conservation measures regularly attend soil conservation courses, and help others implement conservation practices. Inadequate technical skills to implement soil conservation measures appears to be a major constraining factor within the adoption process. Financial ability is influenced by farmers’ willingness to invest their own capital in conservation measures, larger proportions of farm area under crops, and perceptions reflecting on-farm financial and managerial benefits from soil conservation. Government expenditure is also thought to be a factor influencing farmers’ abilities to implement soil conservation practices, and at education and research that emphasizes individual benefits of soil conservation.

FAKTORE WAT DIE AANVAARDING VAN GRONDBEWARINGSPrAKTEKE VAN KOMMERSIELSE PLASE IN KWAZULU-NATAL BEINFLUÊR

Kreftigheid van aanhanger-borstel-proces word as model om faktore om te isoel wat kommersiële boere as besluite betref om grondbewarringsmaatreëls toe te pas. Die model is gemaak deur gebruik van logistiese regressieanalyse en verteenwoordig boere se besluite om eroseer plaas te verseker, perspekte deur dat ‘n probleem is wat benodig om on te pas is, en te besluit om grondbewarringsmaatreëls toe te pas. Data is ingesamel oor verskillende kommunale landbouwgebiede in KwaZulu-Natal. Resultate toon dat die betrokkeเทก-impakte, forme landbouwimpakte, en perspekte deur wat die eroseer se impak op die omgewing weerspieël, bewustheid positief betrokke. Boere wat hul kapitaal investeer om grondbewarringsmaatreëls toe te pas, en wat dit soond meer goedgehou is as die boere wat hul kapitaal investeer om grondbewarningsmaatreëls toe te pas, wat deur die verskillende boere as besluite om grondbewarringsmaatreëls toe te pas. Dit is belangrik om bewust te wees van die waarde van grondbewarringsmaatreëls toe te pas.

1. Introduction

In South Africa, most cultivated soils undergo soil losses of between three and ten tons per hectare annually, ten times the rate of soil formation (Juggie and Rades, 1992: 193). Thus, erosion is “possibly the greatest environmental problem” (Juggie and Rades, 1992: 193). Impacts of this, and as far as the author is aware, Bannister’s study (1962) is the only one in South Africa to analyze farmers’ soil conservation policies from an economic perspective. In the United States, several studies on this problem have been conducted (Evins and Ervin, 1993; Goodwin, 1993; Goodwin and Klemme, 1989; Norris and Bier, 1987; and Sinden and King, 1991).

Under South Africa’s current soil conservation policy, farmers must apply to have their farm unit entered into the Soil Conservation Scheme to be eligible for subsidy payments for constructing soil conservation works. When applications are approved, the extension service compiles a farm conservation plan, which includes plans, specifications, and materials that are to be used in constructing soil conservation works (Government Gazette No. 4038, 1984: 1991). Subsidies are paid to farmers provided provisions of Act 46 of 1993 are met, and money appropriated for the scheme is available.

Past research suggests conservation adoption is a multi-stage decision process (Ervin and Ervin, 1982; Sinden and King, 1991), where perception of a soil problem is not necessarily followed by action to correct it. Individuals would otherwise be perfectly rational, appropriate corrective action would internalize exclusive benefits (economic or financial) by implementing required soil conservation measures.

Factors influencing soil conservation practices on commercial farms in KwaZulu-Natal

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Duff et al, 1992: 403) Since not all farmers will face both technical and financial constraints, and transaction costs associated with meeting the provisions of Act 43/1983 are likely to be high, levels of soil conservation may be improved if the model is formulated differently. In the study, this decision process is assumed to incorporate stages relating to awareness of erosion, and farmer perceptions. If it is a problem worth resolving, and technical and financial abilities to implement soil conservation measures. If constraints within this adoption-decision process are identified and appropriate assistance targeted at homogenous groups of farmers, improvements in measures and technology may be achieved.

Separate estimation of models for each stage in the adoption process is pertinent as specific influences of explanatory variables will be useful in developing target strategies (Evins and Ervin, 1982: 290). Logistic regression models are used to identify explanatory variables at each stage in the adoption-decision process, using data collected from five different commercial farming areas in KwaZulu-Natal.

These models test theoretical relationships, and establish the relative importance of managerial characteristics; enterprise combinations, erosion/consequence characteristics of farms, relevant institutional controls, farmer perceptions and opinions, and farm financial characteristics, in the soil conservation adoption process. Results provide insights for improving soil conservation policy.

2. Conceptual models

Conservation adoption-decisions are summed to encompass the following stages:

2.1 Awareness of erosion occurring

This is a prerequisite in motivating decisions to implement conservation measures, as suggested by Evins and Ervin (1982: 290). Farmers aware of erosion are only likely to consider taking corrective action if they perceive it as something worth resolving (Sinden and King, 1991: 182). Given erosion’s implications for agricultural productivity, land values, and on-off effects (Barlow, 1995), it is worth considering corrective action when farmers’ perception of the problem is high. Although costs of appropriate measures may exceed the benefits.

2.2 Ability to effectively implement conservation measures

Feldt and Lincoln, (1993: 398-399), note that farmers facing technical and financial constraints will be unable to implement effective soil conservation measures. This stage is divided into two components;

i) Technical ability - reflecting farmers’ knowledge obtained from relevant institutions and maintaining required conservation measures.

ii) Financial ability - representing whether necessary financial resources are available to cover costs of implementing required soil conservation measures.

Attributes representing awareness, perception, and technical and financial abilities are used as the dependent variables for each stage. Based on research undertaken in the United States, a variables are hypothesized to influence conservation adoption-decisions. These relate to personal (age, education, farmer perceptions), physical (farm size, enterprise mix, socio-economic circumstances), financial (farm size, off-farm income, payment receipts) and institutional factors (legislation, agricultural assistance programs) (Fernlethorne and Goodwin, 1993; Goodwin, 1989; Sinden and Klemme, 1989; and Norris and Bier, 1987).

3. Research methodology

This section describes units of measurement used to evaluate variables in the study, defines the dependent variables, and outlines conservation planning process.

Most variables in this study measure farmers’ own ratings or perceptions and are therefore qualitative in nature. Consequently, their units of measurement are based on a Likert-type scale of one to five. One reflecting a low rating, negative perception, or less of the characteristic in question (i.e. less erosion). Five represents a high rating, positive perception, or more of the characteristic in question (i.e. more erosion). Similarly, dummy variables score one to indicate the presence of a particular attribute, and zero otherwise. Variables that are quantitative in nature are measured in percentage units.

3.1 Dependent variables

Dependent variables for each stage in the adoption process are explicitly defined and coded to have a value of one if farmers have a particular attribute, or zero otherwise. If more than one measure were used to define an attribute, a simple-charge index was used to transform the dummy variables into percentage variables (Steel and Torrie, 1981:281). These variables are measured in particular dimensions in the data, and can therefore be combined.

Farmers that either indicated erosion is at least a moderate problem on the land they own are classified as aware. Those who agreed that their farms are categorized as unknowable of factors that affect their farm are, as defined above and scored one for this variable. These two measures guarantee farmers without on-farm erosion are unaware.

Responders score one for the perception dependent variable if they agree that bed conservation practices lead to losses in productivity, and agree that these are reflected in lower land values.

Those believing they have the technical knowledge to construct and maintain soil conservation practices required for the farm in question and financial constraints will be unable to implement effective soil conservation measures. This stage is divided into two components;

i) Technical ability - reflecting farmers’ knowledge obtained from relevant institutions and maintaining required conservation measures.

ii) Financial ability - representing whether necessary financial resources are available to cover costs of implementing required soil conservation measures.

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having the financial ability and "being willing" to invest money in soil conservation measures, and this should be considered when evaluating the model.

An anonymous reviewer indicated that respondents with poorer abilities often awarded themselves higher scores than those who are actually better, and a perception variable must be included in the model.

As dependent variables for models representing stages in the adoption-decision process are defined as binary variables, it is appropriate to use logistic regression analysis to attempt to identify, in this stage of the model, a binary dependent variable the probability of having an attribute (P) given X, to the probability of not having the attribute (1-P). This is linear in parameters βj (Jolliet, 1988:483). The intercept β0 is estimated using the maximum-likelihood method (Norusis, 1990a: 54). This generates coefficients making observed results "likely".

\[ L = \ln \left( \frac{P}{1-P} \right) = \beta_0 + \sum \beta_j X_j \]

(1)

Interpretations of logit coefficients differ from linear regression coefficients, representing the change in the log odds of an event occurring in comparison to an independent variable. Re-arranging equation (1), the probability of having an attribute given X can be written as:

\[ P = \frac{1}{1+e^{-\left( \beta_0 + \sum \beta_j X_j \right)}} \]

(2)

Regression coefficients for PCs are difficult to interpret because they are measured in standardised units. For unit changes in the PCs, although the value of the coefficient indicates the relative magnitude of the predicted changes in the dependent variable (i.e. largest effect lead to total increase), the absolute value of this change cannot be interpreted. Nevertheless, due to the qualitative nature of most of the variables used in this study, and the associated subjectivity, the absolute magnitude of their units of measurement is not as critical as in a more precise, objective variable. Consequently, utilising principal components is not considered to impose additional limitations.

Once each of the models in the analysis had been identified, dummy variables for factors that influence the models' dependent variables. If these dummy variables are significant, this implies there are regional differences, other than those explained by variations in the models' explanatory variables, that significantly influence the dependent variables. The significance of these dummy variables has implications for interpreting the models correctly.

4. Data source and respondent's characteristics

A postal survey was conducted during September and October 1993 to collect data. From five different areas in KwaZulu-Natal namely Dalton/Wartburg, Camperdown/Eaton, Escombe, Wartburg, and Dundee were interviewed. Forty-one farmers (62 farmers) indicate detection of erosion on their farm. As "very likely", while 24 percent (37 farmers) replied "likely". As few as 11 percent (16 farmers) indicated "unlikely" and 16 percent (24 farmers) "very likely", that they would be prosecuted in such circumstance.

5. Results

Results for models representing the various stages in the adoption-decision process are presented below. Two tables are used to explain each logit model. The first describes principal coefficients that are significant in each model, and the second table presents equations representing the models.

480. Duplicate and incorrect addresses reduced the sample to in each region were provided by extension agents in KwaZulu-Natal, as reported by Woodburn (1993). In the second stage of the model estimation procedures, 12 individual six PCs were identified as significantly affecting farmers. In the final stage, the forward-stepwise method for selecting explanatory variables produced a single multivariate model. Only PC coefficients significant at the 10 percent level (or lower), based on the F-test for linear regression, and these are presented in Table 1. The Wartburg district reflects a predominantly cropping farming area with dairy, dairy, and sheep operations dominate Dundee and Escombe regions, and these are labelled as livestock farming areas. Finally, the Wartburg and Escombe farmers are viewed as having a different set of mixed farms within the sample, where maize and beef to a lesser extent, dairy, are primary enterprises.

Table 1: Cropped land as a percentage of farm area, for farms surveyed in KwaZulu-Natal (October 1993)

<table>
<thead>
<tr>
<th>Farming area</th>
<th>Cropped land (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dalton/Wartburg</td>
<td>48.4</td>
</tr>
<tr>
<td>Camperdown/Eaton</td>
<td>57.8</td>
</tr>
<tr>
<td>Dundee</td>
<td>52.2</td>
</tr>
<tr>
<td>Emmarenti</td>
<td>2.9</td>
</tr>
<tr>
<td>Wartburg</td>
<td>119.2</td>
</tr>
</tbody>
</table>

Significance levels of statistics indicating how well predicted models fit the data are provided on the right side of the second table. A statistically non-significant -2LL (within two log of the likelihood, indicates the model is not significantly different from the perfect model. The goodness of fit statistics compare observed values to the predictions by the model. There should be no statistically significant difference between observed and predicted values, i.e. the predicted values must confirm the goodness of fit statistic.

The chi-square statistic is comparable to the overall F-test for linear regression, testing the null hypothesis that coefficients for all variables in the model, except the constant, are zero. The improvement statistic tests the null hypothesis that the explanatory variables added at the last step are zero (Norusis, 1990a: 54).

5.1 Awareness model

Thirty-five explanatory variables (21 of which had less than 10 missing values) were expected to influence awareness. These relate to personal factors, enterprise types, physical farm characteristics, conservation attitudes, the value of agents and media providing information on soil erosion and conservation. The model estimation procedure, 12 individual six PCs were identified as significantly affecting farmers. This implies there are regional differences, other than those explained by variations in the models' explanatory variables, that significantly influence the dependent variables. The significance of these dummy variables has implications for interpreting the models correctly.

Therefore (2L) indicate detection of excessive erosion on farms as "very likely", while 24 percent (37 farmers) replied "likely". As few as 11 percent (16 farmers) indicated "unlikely" and 16 percent (24 farmers) "very likely", that they would be prosecuted in such circumstance.

5. Results

Results for models representing the various stages in the adoption-decision process are presented below. Two tables are used to explain each logit model. The first describes principal coefficients that are significant in each model, and the second table presents equations representing the models.

<table>
<thead>
<tr>
<th>Component</th>
<th>Variable with component loadings greater than 0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWR1</td>
<td>-0.83<em>Spatial + 0.76</em>Site</td>
</tr>
<tr>
<td>AWR2</td>
<td>-0.91<em>Erosion + 0.76</em>Site</td>
</tr>
<tr>
<td>AWR3</td>
<td>-0.70<em>Yrmed + 0.75</em>Erosion</td>
</tr>
</tbody>
</table>

Units of measurement for variables are based on a Likert-type scale of one (low) to five (high), unless percentages or dummy variables are specified. Level definitions are as follows:

- Spatial = individual ratings reflecting values associated with minimizing water pollution, as a potential benefit of soil conservation.
- Site = individual ratings reflecting values associated with maintaining storage capacity, as potential benefits from soil conservation.
- Erosion = extent of erosion on the farm (Barlow, 1990: 63).
- Yrmed = years of formal agricultural education.
- Erosion = extent of erosion on the farm when the farmer began managing it.
"having the financial ability" and "being willing" to invest money in soil conservation measures, and this should be considered when selecting this model.

An anonymous reviewer indicated that respondents with poorer abilities often award themselves higher scores than those who are actually better, and a perception variable must be incorporated as an explanatory variable.

As dependent variables for models representing stages in the adoption-decision process are defined as binary variables, it is appropriate to use logistic regression analysis to estimate the awareness, perception, and ability models. This approach, a binary dependent variable indicates the presence or absence of a particular attribute, for example, adoption of conservation measures as opposed to non-adoption.

The logit (L) equation, (1), represents the log of the odds ratio in favor of having an attribute, i.e. the log of the probability of having an attribute (P) given X, to the probability of not having the attribute (P). L is linear in parameters (A) and can be interpreted as a weighted sum of observations (X).

\[ L = \ln \left( \frac{P}{1-P} \right) = A_1 X_1 + A_2 X_2 + \ldots + A_p X_p \]  

Interpretations of logit coefficients differ from linear regression coefficients, representing the change in the log odds of having an attribute for a one unit change in explanatory variables (X). Rearranging equation (1), the probability of having an attribute given X can be written as:

\[ P = \frac{1}{1+e^{-L}} \]

Equation (2) represents the logistic function which converts the predicted probabilities (P) into values between zero and one in a way very similar to X. Equation (2) is in a binary linear since the log in L is in \( \ln \) (Equation 1998: 483).

In SPSS, dependent variables in logistic regression may only have two values, zero or one, and this package is used to estimate the awareness, perception, and ability models.

3.2 Model estimation procedures

A three stage procedure was followed when estimating models in the adoption-decision process. To include the variables with the maximum number of valid cases, the numerous hypothetical explanatory variables for each model were reduced to two. The first group contained variables with less than 10 missing values in the data set, and the second with 10 or more missing values. There is a high degree of correlation (at least at the five percent level of significance) between several variables in each group and only one of these. Therefore, each group was divided and a principal component analysis (PCA) was conducted in each group.

In PCA, variables are standardized in order to avoid one variable being weighted twice as much as the other in the principal components (PCs), and the analysis is carried out on the correlation matrix (Marcel, 1990: 109). Principal components are uncorrelated indices measuring different dimensions in the data (Osacy, 1990: 95). Only PCs with eigenvalues greater than one were retained (Norusis, 1990: 191), such as approximately measuring the effects of variables having component loadings greater than 0.3. Finally, these PCs from these two groups were used in the second stage, where all PCs from the first group and those from the second group were regressed in a logit model on the dependent variable. In an attempt to identify the best models, PCs were estimated using forward-stepwise, backward-stepwise, and enter methods of variable inclusion (Norusis, 1990: 191) in the model (SPSS Incorporate, 1990: 317). Each method used to enter independent variables was then used to make a set of PCs significantly related to the dependent variable.

Thirdly, variables with component loadings greater than 0.3 from the set of significant PCs were isolated. A PCA was conducted on this set of isolated variables, and new PCs derived regressed in the logit model. All components, including those with loadings less than 0.3, are used to calculate principal component scores. Therefore PCs coefficients in each of the predicted models indicate the relative contribution of each principal component score. Each of the three methods for entering independent variables into the model were used, producing six models. Goodness of fit statistics, which are discussed in the results section, are used to select the best models.

Regression coefficients for PCs are difficult to interpret because they are measured in standardised units. For unit changes in the PCs, the estimated change in the probability of having an attribute (P) depends on both the component scores (X) and the coefficient of the component (A).

Once each of the models in the analysis had been identified, dummy variables for farm type were introduced as explanatory variables to the models’ dependent variables. If these dummy variables are significant, this implies there are regional differences, other than those explained by variables in the respective model’s explanatory variables, that significantly influence the dependent variables. The significance of these dummy variables has implications for interpreting the models correctly.

4. Data source and respondents’ characteristics

A postal survey was conducted during September and October 1993 to estimate awareness, perception and ability models. Nine different areas in KwaZulu-Natal namely Dalton/Wartburg, Camperdown/Estaton, Estcourt, Winterton, and Dundee were identified in consultation with extension specialists at the Cedara Agricultural Development Institute. This stratification attempted to accommodate a diverse spectrum of agricultural systems as conservation incentives are expected to differ according to enterprise types and site-specific circumstances. Addresses for 498 possible respondents belonging to respective Farmers’ Associations in each region were randomly selected and duplicate and incorrect addresses replaced the sample to 480.

Members of Soil Conservation Committees in each area participated in a pilot survey to ensure questions were

Significance levels of statistics indicating how well predicted models fit the data are provided on the right side of the second table. A statistically non-significant -2LL (not in the annulus of the likelihood), indicates the model is not significantly different from the perfect model. The goodness of fit statistics compare observed probabilities with those predicted by the model. There should be no statistically significant difference between observed and predicted probabilities for a well fitted model (Norusis, 1990: 52). Cases correctly classified by the predicted model: indicates the percentage of the sample used to test the goodness of fit statistic. Cases used for classification are also used to predict the model, therefore cases correctly classified, may be slightly biased upwards (Norusis, 1990: 50).

The model chi-square statistic is comparable to the overall F-test for linear regression, testing the null hypothesis that coefficients for all variables in the model, except the constant, are zero. The improvement statistic tests the null hypothesis that the coefficients for all variables in the added at the last step are zero (Norusis, 1990: 54).

5.1 Awareness model

Thirty-five explanatory variables (21 of which had less than 10 missing values) are expected to influence awareness. These relate to personal factors, enterprise types, physical farm characteristics, conservation attitudes, the value of agents and media providing information on soil erosion and conservation decisions in influencing farmers’ awareness. Table 1 lists the six explanatory variables included. Only PC coefficients significant at the 10 percent level (or higher), based on the overall model fit statistics, were retained (Norusis, 1990: 48). The model shows three PCs are significantly related to awareness of the erosion problem, and these are used in the model.

Table 2: Details of principal components that are significant in the awareness model

<table>
<thead>
<tr>
<th>Principal component label</th>
<th>Variables with component loadings greater than 0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWR1</td>
<td>0.82<em>Spoilt + 0.76</em>Silt</td>
</tr>
<tr>
<td>AWR2</td>
<td>0.98*.addHandler + 0.66<em>Area+ 0.76</em>Fairv</td>
</tr>
<tr>
<td>AWR3</td>
<td>0.76<em>Spoilt + 0.75</em>Envir</td>
</tr>
</tbody>
</table>

Units of measurement for variables are based on a Likert-type scale of one (low) to five (high), unless percentages or dummy variables are specified. Label definitions are as follows:

Spoilt = individual ratings reflecting values attached to minimizing water pollution, as a potential benefit of farming.
Silt = individual ratings reflecting values attached to maintaining storage capacity, as potential benefits from soil conservation.
Envir = extent of erosion on the farm the farmer believes. A variable used to explain each logit model. The first describes principal components that are significant in each model, and the second table presents equations representing the models.

<table>
<thead>
<tr>
<th>Farming area</th>
<th>Cropped land (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dalton/Wartburg</td>
<td>60.4</td>
</tr>
<tr>
<td>Camperdown/Estaton</td>
<td>57.8</td>
</tr>
<tr>
<td>Dundee</td>
<td>52</td>
</tr>
<tr>
<td>Estcourt</td>
<td>59</td>
</tr>
<tr>
<td>Winterton</td>
<td>31.9</td>
</tr>
</tbody>
</table>
Principal component AWR1 represents the value of on-farm or individual benefits from soil conservation, derived from reducing off-site erosion impacts. AWR2 reflects visible erosion impacts, and AWR3 portrays years of agricultural education. AWR4 represents years of education regarding erosion's implications for the broader environment.

The awareness model is presented in Table 3, where variable labels and their coefficient estimates (β) are indicated for the first and second columns respectively. Exponential(β), or Exp(β), presented in the third column, is the factor by which the odds, or probability in favour of having attribute changes, when the corresponding explanatory variable increases by one unit (Norum, 1990a: 45). Coefficients of Exp(β) can be interpreted, rather than its absolute value, because PCs are measured in standardized units. If β is negative, Exp(β) is less than one and the factors represented by the corresponding PC decrease the odds. Conversely, if β is positive, Exp(β) is greater than one and the odds are increased. Therefore, Exp(β) indicates the direction of the change in the odds associated with respective PCs.

The model correctly classifies 78.8 percent of cases in the sample, and coefficient signs for variables in AWR2 and AWR3 are positive as expected, while that for AWR1 was uncertain. The Exp(β) value for AWR1 implies the odds of being aware when the reduction of off-site erosion impacts, minimizing water pollution and preventing silting up of reservoirs to maintain storage capacities, are perceived as important or on-farm benefits from soil conservation. It is highly probable that on-farm benefits from soil conservation are not internalized on the farm, explaining the negative relationship between AWR1 and awareness. A PC representing respondents' capital gains motives is positively correlated (at the five percent level of significance) to AWR1, suggesting farmers with relatively high capital gains motives are less aware. This raises questions as to whether soil conservation investments are reflected in farm land prices.

As expected, past and current visible erosion impacts on individual's farms (AWR2) increase the odds of being aware. It should be emphasized that erosion can have adverse impacts on the productive potential and considerable soil loss can occur without visible impacts. AWR2 is positively correlated (at the five percent level of significance), to a PC representing agents (Soil Investment Committees, field days/conferences, extension officers, consultants, and farmers' own knowledge, and other farmers in the area), and media (extension service reports), providing information on soil erosion and conservation decisions.

Table 3: Logit model; factors affecting farmers' awareness of the erosion problem, on farms sampled in KwaZulu-Natal (October 1993)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient estimate (β)</th>
<th>EXP (β)</th>
<th>Significance levels for goodness of fit statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWR1</td>
<td>-0.55**</td>
<td>0.56</td>
<td>0.00</td>
</tr>
<tr>
<td>AWR2</td>
<td>1.00**</td>
<td>2.73</td>
<td>0.00</td>
</tr>
<tr>
<td>AWR3</td>
<td>0.88**</td>
<td>2.43</td>
<td>0.00</td>
</tr>
<tr>
<td>Constant</td>
<td>0.70**</td>
<td>2.05</td>
<td>0.00</td>
</tr>
</tbody>
</table>

** Significant at 1% level based on likelihood ratio

Number of cases included in this analysis 118

Overall classification 78.8%

The perception model is presented in Table 5. PCP3 is only significant at the 20 percent level, however, if eliminated, the A2LL statistic becomes statistically significant indicating a significant lack of fit in the model (Norum, 1990a: 48). A WRI is the appropriate government for establishing soil loss limits based on recommendations from Research Institutes (dummy variable: yes = 1, no = 0).

The Perception model is presented in Table 5. PCP3 is only significant at the 20 percent level, however, if eliminated, the A2LL statistic becomes statistically significant indicating a significant lack of fit in the model (Norum, 1990a: 48).

Table 5: Logit model; factors affecting farmers' perceptions of erosion as worth trying to resolve, on farms sampled in KwaZulu-Natal (October 1993)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient estimate (β)</th>
<th>EXP (β)</th>
<th>Significance levels for goodness of fit statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP1</td>
<td>0.41**</td>
<td>1.50</td>
<td>0.01</td>
</tr>
<tr>
<td>PCP2</td>
<td>0.25</td>
<td>1.29</td>
<td>0.00</td>
</tr>
<tr>
<td>PCP3</td>
<td>0.84**</td>
<td>2.32</td>
<td>0.00</td>
</tr>
<tr>
<td>Constant</td>
<td>0.85**</td>
<td>2.34</td>
<td>0.17</td>
</tr>
</tbody>
</table>

** Significant at 1% level based on Wald statistic

Number of cases included in this analysis 131

Overall classification 76.9%

The PC representing the importance of on-site benefits derived from reducing off-site erosion impacts is negatively correlated with off-site benefits, which have similar effects on perceptions and awareness, enforcing the earlier implication that off-site benefits from soil conservation cannot be internalized at the farm-level.

Information variables representing Soil Conservation Committees, field days/conferences, extension officers, consultants, farmers' own knowledge, other farmers in the area, and extension service reports, make important contributions in these first two stages of the adoption–decision process framework. The X variables are significant; however, these factors are complementary, an effective means of disseminating information relating to soil conservation, and are therefore useful for improving perception and awareness levels.

Implications as to whether soil conservation investments are reflected in farm land prices, as presented in the awareness and perception model, are inconsistent. The relevant correlation coefficient indicates respondents with higher capital gains motives, (who are apparently less aware of erosion and its impacts), are also part-time farmers. However, provided erosion or soil conservation activities are reflected in land values, landowners have an incentive to ensure their farms are adequately conserved. Therefore, the only reasonable explanation for this anomaly is that full-time farmers, part-timers, or part-time farmers, as investigated here, realize the true value of soil conservation investments, even

Table 4: Details of principal components that are significant in the perception model

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient estimate (β)</th>
<th>EXP (β)</th>
<th>Significance levels for goodness of fit statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP1</td>
<td>0.41**</td>
<td>1.50</td>
<td>0.01</td>
</tr>
<tr>
<td>PCP2</td>
<td>0.25</td>
<td>1.29</td>
<td>0.00</td>
</tr>
<tr>
<td>PCP3</td>
<td>0.84**</td>
<td>2.32</td>
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</tr>
<tr>
<td>Constant</td>
<td>0.85**</td>
<td>2.34</td>
<td>0.17</td>
</tr>
</tbody>
</table>

** Significant at 1% level based on Wald statistic

Number of cases included in this analysis 131

Overall classification 76.9%

Individual experiences where observable impacts on agricultural production, as a direct result of erosion (PCP1), have the largest positive influence on perceptions that erosion is worth trying to resolve. The value of extension officers is important in these circumstances, presumably in an advisory capacity. PCP2 is positively correlated (at the one percent and five percent level of significance respectively) to two indices. The first represents agents and media providing information on soil erosion and conservation decisions, and the second represents the importance of passing a fully productive soil resource on to future generations, improving the land's market value. This implies soil conservation investments do affect land values.
Table 4: Details of principal component that significant in the perception model

<table>
<thead>
<tr>
<th>Principal component label</th>
<th>Variables with component loadings greater than 0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCF1</td>
<td>0.83* RvRt + 0.70* RvZr</td>
</tr>
<tr>
<td>PCF2</td>
<td>0.83* RvRt + 0.77* Logist</td>
</tr>
<tr>
<td>PCF3</td>
<td>0.87* Exp(s) + 0.44* Aged</td>
</tr>
</tbody>
</table>

Table 5: Logit model; factors affecting farmers’ perceptions that erosion is worth trying to resolve, on farms sampled in KwaZulu-Natal (October 1993)

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Probability in favour of farmers regarding erosion as something worth trying to resolve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Coefficient estimate (β)</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>PCF1</td>
<td>0.41**</td>
</tr>
<tr>
<td>PCF2</td>
<td>0.25</td>
</tr>
<tr>
<td>PCF4</td>
<td>2.32</td>
</tr>
<tr>
<td>Constant</td>
<td>0.85**</td>
</tr>
</tbody>
</table>

** = Significant at 1% level based on Wald statistic

Table 3: Logit model; factors affecting farmers’ awareness of the erosion problem, on farms sampled in KwaZulu-Natal (October 1993)

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Probability for farmers aware of the erosion problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Coefficient estimate (β)</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>AWR1</td>
<td>-0.65**</td>
</tr>
<tr>
<td>AWR2</td>
<td>1.00**</td>
</tr>
<tr>
<td>Constant</td>
<td>2.84</td>
</tr>
</tbody>
</table>

** = Significant at 1% level based on likelihood ratio

Table 2: Exponential(B,), or Exp(B,), is the coefficient of the independent variable, changes the odd ratio of the dependent variable, when the independent variable is increased by one unit, and the dependent variable is a constant. The value of Exp(B,) is significant at: 1% level based on likelihood ratio.

The model correctly classifies 78.8% of the cases in the sample, and coefficient signs for variables in AWR2 and AWR3 are positive as expected, while that for AWR1 was unexpected. The EXP(B,) value for AWR1 implies the odds of being aware when the reduction of off-site erosion impacts, minimizing water pollution and preventing settling up of reservoirs to maintain storage capacities, are perceived as important individual or on-farm benefits from soil conservation. It is highly probable that off-site benefits from soil conservation are not internalized on the farm, explaining the negative relationship between AWR1 and awareness. A PC representing respondents' capital gains motives is positively correlated (at the five percent level of significance) to AWR1, suggesting farmers with relatively high capital gains motives are less aware. This raises questions as to whether soil conservation investments are reflected in farm land prices.

As expected, past and current visible erosion impacts on individual’s farms (AWR2) increase the odds of being aware. It should be emphasized that erosion can have adverse impacts on the productive potential and considerable soil loss can occur without visible impacts. AWR2 is positively correlated (at the five percent level of significance), to a PC representing agents (Soil Investment Committees, field days/conferences, extension officers, consultants, farmer’s own knowledge, other farmers in the area), and media (extension service reports), providing information on soil erosion and conservation decisions. The perception model is presented in Table 5. PCP3 is only significant at the 20 percent level, however, if eliminated the -2LL statistic becomes statistically significant indicating a significant lack of fit in the model (Noru§is, 1990a: 48). The perception model portrays years from the recognition of the seriousness of erosion as important individual or on-farm benefits (AWR3), is not likely to derive individual or on-farm benefits from reducing these off-site impacts (AWR1).

The model correctly classifies 78.8% of the cases in the sample, and coefficient signs for variables in AWR2 and AWR3 are positive as expected, while that for AWR1 was unexpected. The EXP(B,) value for AWR1 implies the odds of being aware when the reduction of off-site erosion impacts, minimizing water pollution and preventing settling up of reservoirs to maintain storage capacities, are perceived as important individual or on-farm benefits from soil conservation. It is highly probable that off-site benefits from soil conservation are not internalized on the farm, explaining the negative relationship between AWR1 and awareness. A PC representing respondents' capital gains motives is positively correlated (at the five percent level of significance) to AWR1, suggesting farmers with relatively high capital gains motives are less aware. This raises questions as to whether soil conservation investments are reflected in farm land prices.

As expected, past and current visible erosion impacts on individual’s farms (AWR2) increase the odds of being aware. It should be emphasized that erosion can have adverse impacts on the productive potential and considerable soil loss can occur without visible impacts. AWR2 is positively correlated (at the five percent level of significance), to a PC representing agents (Soil Investment Committees, field days/conferences, extension officers, consultants, farmer’s own knowledge, other farmers in the area), and media (extension service reports), providing information on soil erosion and conservation decisions. The perception model is presented in Table 5. PCP3 is only significant at the 20 percent level, however, if eliminated the -2LL statistic becomes statistically significant indicating a significant lack of fit in the model (Noru§is, 1990a: 48).

The perception model is presented in Table 5. PCP3 is only significant at the 20 percent level, however, if eliminated the -2LL statistic becomes statistically significant indicating a significant lack of fit in the model (Noru§is, 1990a: 48).
though these may not be fully reflected in the land market. This is an issue requiring further research.

5.3 Technical ability model

Educational characteristics, enterprise types, and the value of land and the proportion of area covered by soil erosion and conservation activities are the main explanatory variables modelled. These factors are represented by 31 variables. Ten variables approximated by four PCs were significantly related to technical ability. As in 5.2, the final estimation procedures produced the best Technical Ability model using the enter method. The three PCs retained in the model are specified in Table 6.

Table 6 Details of principal components that are significant in the technical ability model

<table>
<thead>
<tr>
<th>Principal component label</th>
<th>Variables with component loadings greater than 0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABL1</td>
<td>= 0.82* Boro + 0.72* Rhee + 0.61* Sipot</td>
</tr>
<tr>
<td>TABL2</td>
<td>= 0.71* Owned + 0.64* Yræd</td>
</tr>
<tr>
<td>TABL3</td>
<td>= 0.74* Temp + 0.68* Logis</td>
</tr>
</tbody>
</table>

Units of measurement for variables are based on a Likert-type scale of one (low) to five (high), unless percentages or dummy variables are specified. Label definitions are as follows:

Boro = frequency with which farmers attend soil conservation courses
Rhee = frequency with which farmers help others implement soil conservation practices (yes = 1 - no = 0)
Owned = area owned relative to that operated (percentage)
Yræd = years of formal agricultural education
Temp = area operated currently under timber (percentage)
Logis = knowledge of soil conservation (dummy variables: ven =1, vo = 0)

Principal component TABL1 reflects the frequency with which farmers attend soil conservation courses and help others implement or maintain soil conservation measures. The proportion of area owned relative to that operated, and educational achievements are represented by TABL2. TABL3 indicates the proportion of farm area currently under timber and knowledge of soil conservation legislation. Table 7 shows the technical ability model, which fits the data better if TABL4 is retained, despite its coefficient being statistically insignificant.

This model correctly classifies 71.2 percent of cases in the sample. As anticipated, the odds of having the necessary technical ability are higher for farmers regularly attending soil conservation courses, and frequently helping others implement or maintain soil conservation practices (TABL1). TABL1 is positively correlated (at the one and five percent level of significance respectively) to two PCs. The first principle component aggregates and provides information on soil erosion and conservation, and the second reflects educational programs as a policy tool to promote soil conservation. Farmers with higher off-farm incomes appear to be less financially able to implement conservation measures. Larger off-farm incomes are expected to improve a firm's model. Implications are, farmers investing their own capital in conservation activities are more likely to implement soil conservation activities. TABL2 is negatively correlated with TABL3. TABL3 reflects the expected relationship between livestock enterprises and financial ability during the large capital expenditure on fencing, required to establish rotational cattle systems. Farmers with larger off-farm incomes, appear to be less financially able to implement conservation measures. Larger off-farm incomes are expected to improve a firm's model. Implications are, farmers investing their own capital in conservation activities are more likely to implement soil conservation activities.

There are hence problems in farming business running, in which case expenditures on soil conservation receive a low priority. If conservation activities are not fully reflected in land values, then it is rational not to invest in conservation measures, as returns to these investments are not realised. The greater perceived on-farm benefits from soil conservation (TABL2), the more likely necessary financial resources will be available. Together with inferences from TABL1, these results imply farmers with the financial ability to implement required conservation measures are more likely to implement and possibly allocate financial resources for conservation activities. This result supports the expected negative relationship between livestock enterprises and financial ability, due to large capital expenditure on fencing, required to establish rotational cattle systems. Farmers with larger off-farm incomes, appear to be less financially able to implement conservation measures. Larger off-farm incomes are expected to improve a firm's model. Implications are, farmers investing their own capital in conservation activities are more likely to implement soil conservation activities. TABL3 reflects the expected relationship between livestock enterprises and financial ability during the large capital expenditure on fencing, required to establish rotational cattle systems. Farmers with larger off-farm incomes, appear to be less financially able to implement conservation measures.

5.4 Financial ability model

Financial characteristics, farmer opinions and enterprise types are the main hypothesised explanatory variables for the financial ability model. These are represented by 26 variables, 17 of which had less than 10 missing values. In the second stage of the model estimation procedure, six individual variables were represented by three PCs. As in the previous two models, this best model for financial ability was obtained using the enter method. The two PCs retained are illustrated in Table 8.

Principal component FABL1 approximately reflects the frequency with which farmers invest their own capital in conservation activities, family income from off-farm sources, and the proportion of arable land on the farm. Large levels of off-farm income will cause FABL1 to be negative. FABL2 is negatively correlated with TABL3. FABL2 represents an index reflecting the perceptions of on-farm financial and managerial benefits from implementing soil conservation measures. The financial ability model is presented in Table 9.

As with the technical ability model, 71.2 percent of cases in the sample are correctly classified by this model. Implications are, farmers who invest their own capital in conservation activities are more likely to implement conservation measures (FABL1). This result supports the expected relationship between livestock enterprises and financial ability, due to large capital expenditure on fencing, required to establish rotational cattle systems. Farmers with larger off-farm incomes, appear to be less financially able to implement conservation measures. Larger off-farm incomes are expected to improve a firm's model. Implications are, farmers investing their own capital in conservation activities are more likely to implement soil conservation activities.
though these may not be fully reflected in the land market. This is an issue requiring further research. 

5.3 Technical ability model

Educational characteristics, enterprise types, and the value of financial and non-financial benefits of soil erosion and conservation decisions, are the main explanatory variables modelled. These factors are represented by 31 variables. Ten variables approximated by four PCs were significantly related to technical ability. As in 5.1, the final estimation procedure produced the best Technical Ability model using the enter method. The three PCs retained in the model are specified in Table 6.

Table 6: Details of principal components that are significant in the technical ability model

<table>
<thead>
<tr>
<th>Principal component label</th>
<th>Variables with component loadings greater than 0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABL1</td>
<td>0.82* Timpor + 0.72*Rhelp</td>
</tr>
<tr>
<td>TABL2</td>
<td>0.71<em>Yread + 0.64</em>Yosed</td>
</tr>
<tr>
<td>TABL3</td>
<td>0.74<em>Timpor - 0.68</em>Logis</td>
</tr>
</tbody>
</table>

Units of measurement for variables are based on a Likert-type scale of one (low) to five (high), unless percentages or dummy variables are specified. Label definitions are as follows:

- *Rhelp = frequency with which farmers help others implement soil conservation practices.
- Yread = years of formal agricultural education.
- Timpor = proportion of farm area currently under timber.
- Logis = knowledge of soil conservation (dummy variable: yes = 1, no = 0).

Principal component TABL1 reflects the frequency with which farmers attend soil conservation courses and help others implement or maintain soil conservation measures. The proportion of area owned relative to that operated (percentage) and the financial ability model. These are represented by 26 variables, 17 of which had less than 10 missing values. In the second stage of the model estimation procedure, six individual variables were represented by three PCs. As in the previous two tables, the best legal model for financial ability was obtained using the enter method. The two PCs retained are illustrated in Table 8.

Principal component TABL1 approximately reflects the frequency with which farmers invest their own capital in soil conservation activities, family income from off-farm sources, and the proportion of arable land on the farm. Large levels of off-farm income will cause TABL1 to be negative. TABL2 approximately represents an index reflecting farmers perceptions about on-farm financial and managerial benefits from implementing soil conservation measures. The financial ability model is presented in Table 9.

As with the technical ability model, 71.2 percent of cases in the sample are correctly classified by this model. Implications are, farmers investing their own capital in soil conservation activities are more financially able to implement conservation measures (TABL1). This result supports the expected negative relationship between livestock enterprises and financial ability, due to large capital expenditure on feeding. Farmers with larger off-farm incomes are less likely to invest in conservation measures, or that these are keeping the farm business running, in which case expenditures on soil conservation receive a low priority. If conservation activities are not fully reflected in land values, then it is rational for farmers to allocate financial resources for conservation activities as an investment decision. TABL2 is positively correlated with the five percent level of significance, to a PC capturing risk perceptions, and farm expenditure on conservation and maintenance of soil conservation works as a percentage of farm turnover. As expected, this implies financially able farmers are less likely to be risk averse. However, this issue needs more detailed research.

Table 7: Logit model; factors influencing farmers’ technical ability to implement and maintain soil conservation measures, on farms sampled in KwaZulu - Natal, (October 1993)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient estimate (β)</th>
<th>Exp (β)</th>
<th>Significance levels for goodness of fit statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABL1</td>
<td>1.13**</td>
<td>3.09</td>
<td>2-Log likelihood</td>
</tr>
<tr>
<td>TABL2</td>
<td>-0.64**</td>
<td>0.53</td>
<td>Model Chi-square</td>
</tr>
<tr>
<td>Constant</td>
<td>0.24</td>
<td>1.27</td>
<td>Improvement</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Goodness of fit</td>
</tr>
</tbody>
</table>

** Significant at 1% level based on Wald statistic

Table 8: Details of principal components that are significant in the financial ability model

<table>
<thead>
<tr>
<th>Principal component label</th>
<th>Variables with component loadings greater than 0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABL1</td>
<td>0.73<em>Rhelp + 0.69</em>Offin</td>
</tr>
<tr>
<td>TABL2</td>
<td>0.90*Crop</td>
</tr>
</tbody>
</table>

Units of measurement for variables are based on a Likert-type scale of one (low) to five (high), unless percentages or dummy variables are specified. Label definitions are as follows:

- *Rhelp = frequency with which farmers invest their own capital in soil conservation measures.
- Offin = current proportion of family income from off-farm sources (percentage).
- Crop = proportion of farm area currently cropped (percentage).

Principal component TABL1 approximately reflects the financial ability to implement and maintain soil conservation measures. The financial ability model is presented in Table 9.

Table 9: Logit model; factors influencing farmers’ financial ability to implement and maintain soil conservation measures, on farms sampled in KwaZulu - Natal, (October 1993)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient estimate (β)</th>
<th>Exp (β)</th>
<th>Significance levels for goodness of fit statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABL1</td>
<td>0.85**</td>
<td>2.34</td>
<td>2-Log likelihood</td>
</tr>
<tr>
<td>TABL2</td>
<td>0.60**</td>
<td>1.82</td>
<td>Model Chi-square</td>
</tr>
<tr>
<td>Constant</td>
<td>0.55**</td>
<td>1.75</td>
<td>Improvement</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Goodness of fit</td>
</tr>
</tbody>
</table>

** Significant at 1% level based on Wald statistic

Number of cases included in this analysis 111

Overall classification 71.2%

Table 10: Predicted probabilities for each model

| Predicted probability score | Model for each region in every region and for the whole sample. These are calculated by substituting standardized variable values or PC scores for each case into the predicted model. An analysis of variance was conducted on log scores, and the F-statistic should be used for the relative importance of the models for each region (Steel and Torrie, 1981: 96). Since dummy variables for farm region are not significant, for models where the -statistic is significant, differences between regions can be attributed to variations in explanatory variables within each model. Predicted probabilities for each model

Table 11: Predicted probabilities for each model

| Model for each region in every region and for the whole sample. These are calculated by substituting standardized variable values or PC scores for each case into the predicted model. An analysis of variance was conducted on log scores, and the F-statistic should be used for the relative importance of the models for each region (Steel and Torrie, 1981: 96). Since dummy variables for farm region are not significant, for models where the -statistic is significant, differences between regions can be attributed to variations in explanatory variables within each model.
The mean prediction score in favour of farmers being aware of the erosion problem (P(WARE)) is 0.62, and there are no statistically significant differences in P(WARE) between regions in the sample. Predicted probabilities in favour of farmers perceiving erosion as something worth trying to resolve (P(PERC)), and in favour of farmers having the technical ability and confidence to maintain soil conservation practices (P(TABLTY)), are 0.67 and 0.54 respectively, and have the highest and lowest average scores. The mean predicted probability in favour of farmers having the financial ability to implement and maintain soil conservation practices (P(FABLI)) is relatively low at 0.61.

Based on the F-statistic, there are significant differences between regions, at the 10 percent level, in P(PERC) scores. The F-statistic (P(TABLTY) and P(FABLI)) indicate there are statistically significant differences in these scores, between regions, at the one percent level. Probability scores for the Dalton/Warbuck and Estcourt regions show the biggest differences, and therefore variations in explanatory variables for these two regions, in each model, are examined below. It is noteworthy that Dalton/Warbuck has predominantly crop farming area, and Estcourt, a predominantly livestock farming area.

Differences in P(PERC) can be attributed to the frequency with which farmers invest their own capital when implementing soil conservation measures (Rivest), and past and current experience of circumstances where significant soil loss has had impacts on yields, yields, or income (Impact). These variables are expressed in principal components (PCF1 and PCF2 respectively, and their mean scores are higher for respondents from the Dalwnt/Warbuck region. This implies erosion’s impacts are more noticeable, and hence farmers’ constraints relatively less, on predominantly crop farms.

P(TABLTY) shows the lowest overall predicted scores highlighting an important constraint within the soil conservation adoption process. The mean score indicating the frequency with which farmers attend soil erosion courses (Score), reflected by principal component TABL1, is relatively higher for the Dalton/Warbuck district. This explains the higher P(TABLTY) score in this region. The fact that respondents from this area score well for P(PERC) suggests there may be a greater demand for soil conservation courses in this farming community, and soil conservation courses may be held more frequently.

For P(FABLI) scores, differences are associated with the frequency with which farmers invest their own capital when implementing soil conservation measures (Rivest), the proportion of arable land on a farm (Cropor), and family income from off-farm sources (Offfarms), expressed in principal component FABLI. In Dalwnt/Warbuck, the mean contribution to family income from off-farm sources is 12.4 percent, and in Estcourt this is 28.9 percent. As indicated in Table 2, the proportion of arable land on farms in Dalwnt/Warbuck averages 60.4 percent, and in Estcourt, this average is 2.7 percent. Those farmers, who obtain most of their family income from the farm, and who frequently invest their own capital when implementing soil conservation activities, are more likely to have financial resources to implement all the farm’s necessary soil conservation measures.

Although a relatively high percentage of cases in the sample are correctly classified by the models, it is unlikely that these represent all explanatory variables influencing conservation adoption-decisions. Limitations in this type of analysis include: simplifying the continuous and dynamic nature of the decision process into separate stages, using cross-sectional data to analyse this dynamic problem, and difficulties in measuring many of the variables accurately (Hinlin and King, 1990: 142). This stems from the fact that answers to some questions are subjective, and farmers generally tend to understate the severity of erosion on their farms and overstate the adequacy of their conservation practices (Nielan et al., 1989: 12).

Despite these drawbacks, results explain the underlying hypothesis relatively well, and although specific to the study area, several useful conclusions for soil conservation policy formulation can be derived.

6. Conclusions

Data from 159 commercial farms in KwaZulu-Natal were used to determine factors influencing conservation adoption-decisions. Four stages: awareness of soil erosion, the perception that it is a problem, worth solving, using technical and financial abilities to implement required conservation measures, are assumed to represent this decision process. Separate logit models are estimated to identify variables associated with each stage. Results generally support this multi-stage decision theory, illustrating different policies may be appropriate for farming areas with different enterprise combinations.

Principal components reflecting visible erosion impacts, agricultural education, and knowledge about erosion’s off-site consequences are shown to have positive influence on awareness levels. Similarly, the most influential principal component in the perception model reflects circumstances where farmers had experience of reduced agricultural productivity due to erosion. These measures are less likely to be implemented before erosion's effects become conspicuous. Therefore, research, education and extension emphasizing both benefits derived from preventing erosion before it becomes evident is imperative, and this should accelerate the individual or unit demand benefits of soil conservation activities. Other principal components significantly related to perception reflect the ability to implement soil conservation decisions, and other government conservation expenditure may be better spent on education to improve farmers’ technical abilities to implement and maintain conservation measures.

Results from the financial ability model imply that predominantly livestock operations, which also have relatively large off-farm income sources, are less financially able to implement required conservation practices. Finally, it should be noted that although soil conservation, subsidies should possibly be restricted to conservation measures appropriate for livestock enterprises (i.e. fencing), while other government conservation expenditures may be better spent on education to improve farmers’ abilities to implement conservation practices. It is important to be aware that these factors should probably be allocated to the most influential principal components for targeting soil conservation policy.

Notes:

1) Explanations for hypothesised explanatory variables in each model are outlined by Barlow (1995).
2) Farmers rated the statement “Provides benefit of soil conservation measures with no technical assistance, use of farmer’s own capital in doing so, and knowledge of erosion off-site impacts.”

Regular attendance at soil conservation courses has a significant positive effect on the estimated odds in favour of having the necessary technical ability. However, this model has relatively low predicted probabilities (mean P(TABLTY) = 0.54). This implies a critical need to provide and encourage attendance at soil conservation courses to improve farmers’ soil conservation skills. It is possible that those who attend courses have better technical ability and the results must be interpreted in the light that there is a tendency that those with soil conservation course experience also have better technical abilities. Variables representing agents and media providing information on soil erosion and conservation decisions are important in the first three stages of the adoption-decision process. These information sources should possibly be restricted on improving farmers’ technical abilities to implement and maintain conservation measures.

References


Table 1: Mean predicted probabilities for each stage in the conservation-adoption decision process, for each area sampled in KwaZulu-Natal (October 1995)

<table>
<thead>
<tr>
<th>Forming area</th>
<th>P(Class)</th>
<th>P(Per?)</th>
<th>P(Tabl?)</th>
<th>P(Fab?)</th>
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<tr>
<td>Entire sample</td>
<td>0.62</td>
<td>0.67</td>
<td>0.68</td>
<td>0.78</td>
</tr>
<tr>
<td>Dalton/Warbuck</td>
<td>0.63</td>
<td>0.73</td>
<td>0.68</td>
<td>0.78</td>
</tr>
<tr>
<td>Camperdown/Eaton</td>
<td>0.58</td>
<td>0.67</td>
<td>0.55</td>
<td>0.73</td>
</tr>
<tr>
<td>Dunker</td>
<td>0.66</td>
<td>0.67</td>
<td>0.49</td>
<td>0.48</td>
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<tr>
<td>Estcourt</td>
<td>0.59</td>
<td>0.60</td>
<td>0.46</td>
<td>0.45</td>
</tr>
<tr>
<td>Winterton</td>
<td>0.65</td>
<td>0.66</td>
<td>0.55</td>
<td>0.62</td>
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<tr>
<td>F-statistic</td>
<td>0.79</td>
<td>2.33</td>
<td>0.97</td>
<td>1.33</td>
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<tr>
<td>Significance level</td>
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</table>
P(ERCEP) suggests there may be a significant positive effect on the estimated odds in favour of having the necessary technical ability. However, this model has relatively low predicted probabilities (mean P(TABLTY) = 0.54). This implies a critical need to provide and encourage attendance at soil conservation courses to improve farmers' soil conservation skills. It is possible that those who attend courses have better technical ability and the results must be interpreted in the light that there is a tendency that those with soil conservation course experience also have better technical abilities. Variables representing agents and media providing information on soil erosion and soil conservation decisions are important in the first three stages of the adoption—decision process. These information sources should function primarily on improving farmers' technical abilities to implement and maintain conservation measures.

Based on the F-statistic, there are significant differences between regions, at the 0.10 percent level, in soil conservation measures (F棠LTY). The F(TABLTY) and P(TABLTY) indicate there are statistically significant differences in these scores, between the regions, at the 0.10 percent level. Probability scores for the Dalton/Wartburg and Estcourt regions show the biggest differences, and therefore variables in explanatory variables for these two regions, in each model, are examined below. It is noteworthy that Dalton/Wartburg, a predominantly crop farming area, and Estcourt, a predominantly livestock farming area.

Differences in P(TABLTY) can be attributed to the frequency with which farmers invest their own capital when implementing soil conservation measures (F棠LTY). Farming experience and extension emphasis on soil conservation impacts significantly affect the estimated odds in favour of adopting soil conservation measures. Extension emphasis on soil conservation impacts significantly affect the estimated odds in favour of adopting soil conservation measures. One possible reason for this is that farmers in the KwaZulu-Natal region have relatively low P(TABLTY) scores. This implies that there is a relatively low probability of farmers investing in soil conservation measures in this region.

For P(TABLTY) scores, differences are associated with the frequency with which farmers invest their own capital when implementing soil conservation measures (F棠LTY). The proportion of arable land on a farm (Crop), and family income from off-farm sources (Offfarm), are also significant explanatory variables influencing conservation adoption decisions. These variables indicate the frequency with which farmers attend soil conservation courses (F棠LTY), and past and current experience of circumstances where significant soil loss has led impacts on yields, or income (Imp). These variables are expressed in principal components (PCP) and PCP棠 respectively, and their mean scores are higher for respondents from the KwaZulu-Natal region. These imply erosion's impacts are more noticeable, and cash flow constraints relatively less, on predominantly crop farms.

P(TABLTY) shows the lowest overall predicted scores highlighting an important constraint within the soil conservation adoption process. The mean score indicating the frequency with which farmers attend soil conservation courses (F棠LTY) is significantly lower for farmers in the KwaZulu-Natal region. This implies erosion's impacts are more noticeable, and cash flow constraints relatively less, on predominantly crop farms.

P(TABLTY) shows the highest overall predicted scores highlighting an important constraint within the soil conservation adoption process. The mean score indicating the frequency with which farmers attend soil conservation courses (F棠LTY) is significantly higher for farmers in the KwaZulu-Natal region. This implies erosion's impacts are more noticeable, and cash flow constraints relatively less, on predominantly crop farms.

Principal components reflecting visible erosion impacts, agricultural education, and knowledge of the extent of observed effects on crop yields are shown to have positive influence on awareness levels. Similarly, the most influential principal component in the perception model reflects circumstances where farmers had experience of reduced agricultural productivity due to erosion. This implies conservation measures are less likely to be implemented before erosion's effects become conspicuous. Therefore, education, research and extension emphasis on soil erosion derived from preventing erosion before it becomes evident is imperative, and this should accentuate the individual or small-farm benefits of soil conservation activities. Other principal components significantly related to perception reflect the ability to implement soil conservation measures, attitude (P(ERCEP)), and determines adoption-decision. Variables representing agents and media providing information on soil conservation impacts are important in the first three stages of the adoption—decision process. These information sources should function primarily on improving farmers' technical abilities to implement and maintain conservation measures.

Regular attendance at soil conservation courses has a significant positive effect on the estimated odds in favour of having the necessary technical ability. However, this model has relatively low predicted probabilities (mean P(TABLTY) = 0.54). This implies a critical need to provide and encourage attendance at soil conservation courses to improve farmers' soil conservation skills. It is possible that those who attend courses have better technical ability and the results must be interpreted in the light that there is a tendency that those with soil conservation course experience also have better technical abilities. Variables representing agents and media providing information on soil erosion and soil conservation decisions are important in the first three stages of the adoption-decision process. These information sources should function primarily on improving farmers' technical abilities to implement and maintain conservation measures.

Results from the financial ability model imply that predominantly livestock operations, which also have relatively large off-farm income sources, are less financially able to implement required conservation practices. Finally, it is notable that farmers' adoption of soil conservation measures is relatively low at 61.1”. This stems from the fact that answers to some questions are subjective, and farmers generally tend to underestimate the severity of erosion on their farms and overstate the adequacy of their conservation measures (Nielan et al, 1989: 12).

Despite these drawbacks, results explain the underlying hypothesis relatively well, and although specific to the study area, several useful conclusions for soil conservation policy formulation can be derived. 6. Conclusions

Data from 159 commercial farms in KwaZulu-Natal are used to determine factors influencing conservation adoption—decision. Four stages: awareness of soil erosion, the perception that it is a problem worth resolving, social and technical and financial abilities to implement required conservation measures, and are assumed to represent this decision process. Separate logit models are estimated to identify variables associated with each stage. Results generally support this multi-dimensional decision theory. Illustrating different policies may be appropriate for farming areas with different enterprise combinations.

Principal components reflecting visible erosion impacts, agricultural education, and knowledge of the extent of observed effects on crop yields are shown to have positive influence on awareness levels. Similarly, the most influential principal component in the perception model reflects circumstances where farmers had experience of reduced agricultural productivity due to erosion. This implies conservation measures are less likely to be implemented before erosion's

Barlow, Nieuwoudt and Levin

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