FACTORS AFFECTING SOIL CONSERVATION DECISIONS OF KWAZULU-NATAL COMMERCIAL SUGAR CANE FARMERS

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Technological information is used to assess KwaZulu-Natal commercial sugarcane farmers' intra-plot (panel) soil conservation relative to requirements of the Conservation of Natural Resources Act of 1983. Findings indicate that farmers consider enforcement of the Act to be unlikely and that 28 percent of farmers surveyed do not meet adequate intra-panel soil conservation standards. Multiple regression is used to estimate models representing intra-panel soil conservation adoption and soil conservation effort. Results show that farmers have greater conservation adoption and effort on their relatively steeper panels and implement soil conservation plans on these panels first. Amongst other factors, education and use of extension information sources are positively related to both conservation adoption and effort, and soil conservation decisions are constrained by financial resources, management time and farmers' technical abilities.

FAKTORE WAT GRONDBEWARINGSBESLUITE VAN KOMMERSIËLE SUIKER-BOERE IN KWAZULU-NATAL BEÏNVLOED

Tegnologiese inligting is gebruik om Kwazulu-Natalse kommersiële suikerboere se intra-plot (paneel) grondbewaring te evalueer relatief tot die vereistes in die Wet op Bewaring van Natuurlike Hulpbronne 1983. Bevindings dui daarop dat boere die afdwing van die Wet as onwaarskynlik ag en dat 28 persent van die boere in die opname nie voldoen aan voldoende intra-paneel grondbewaringsstandaarde nie. Veelvoudige regressie is gebruik om modelle wat intra-paneel grondbewaringsaanvaarding en grondbewaringspoging verteenwoordig, te pas. Die resultate toon dat boere groter grondbewaringsaanvaarding en -poging het in hul relatief steiler panele en grondbewaringsplanne eerste op hierdie panele toepas. Opvoeding en die gebruik van voorligtingsdienste is onder andere positief verwant aan beide bewaringsaanvaarding en -poging, terwyl grondbewaringsbesluite beperk word deur finansiële bronne, bestuurstyd en boere se tegniese vaardighede.

1. INTRODUCTION

Estimated annual soil loss in KwaZulu-Natal is in the region of 100 million tons (Maher, 1996). Positive net erosion, that is a rate of soil loss greater than the rate of soil formation, will reduce the long term productivity of cropland resources and has a negative effect on environmental quality. Fuggel & Rabie (1992:191) suggest that erosion is possibly the greatest environmental problem facing South

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Africa. In terms of the Conservation of Natural Resources Act of 1983 *ex ante* soil conservation requirements may be enforced by *ex ante* penalties, i.e. farmers can be prosecuted for carrying out practices that could lead to soil erosion. Conservation committees, drawn from farmers' associations, government officers and other technical representatives, are responsible for applying the 1983 Act, under the guidance of the minister of agriculture (McFarlane & Maher, 1993). However, Maher (1996) quoted by Fitz-Gerald (1996) drew attention to ongoing erosion in KwaZulu-Natal and contends that South African sugarcane farmers are not being held accountable for soil erosion on their farms by either the sugar industry or the Departments of Agriculture or Justice, resulting in too few farmers implementing adequate soil conservation.

This paper reports on research on farmers' soil conservation decisions and actions. Whereas several similar studies have been completed in the United States (e.g. Ervin & Ervin, 1982; Featherstone & Goodwin, 1993; Saliba & Bromley, 1986), only two studies have been completed in South Africa (Barlow & Nieuwoudt, 1995; and Basson, 1962). Although Barlow & Nieuwoudt's (1995) study encompassed KwaZulu-Natal sugarcane growers and is recent, data restrictions in their study necessitated measurement of soil conservation effort essentially in terms of farmer's own assessments, which, by their own admission, does not necessarily reflect conservation effectiveness (Barlow & Nieuwoudt, 1995). No other studies reviewed have analysed intra-farm variations in soil conservation decisions. This is expected to contribute towards an improved understanding of farmers' soil conservation decisions.

2. CONCEPTUAL MODELS

Following Ervin & Ervin (1982) and Barlow & Nieuwoudt (1995), amongst others, soil conservation may be defined in terms of conservation adoption (NPRAC), relating to the number of soil conservation practices adopted on a panel (farm), or conservation effort (EFFORT), which reflects the effectiveness (and extensiveness) of conservation practices applied on a panel (farm). Variables affecting adoption are also expected to affect effort, although in different ways (Ervin & Ervin, 1982). Linear relationships are postulated for the *i*th farm on the *j*th panel between $NPRAC_{ij}$ and $EFFORT_{ij}$ and a vector of observed farm and farmer characteristics, X_{ij}, and zero mean disturbance terms, e_{ij} and e_{ij}: $NPRAC_{ij} = X_{ij}a + e_{ij}$, and $EFFORT_{ij} = X_{ij}b + e_{ij}$.

3. THE DATA.

The data are based on a stratified random sample consisting of 53 large scale commercial sugarcane farmers in the Eston, Sezela and Mzimkulu sugar mill areas of KwaZulu-Natal, South Africa. The sample was drawn from a list of growers obtained from the South African Cane Growers Association. The survey collected data on attitudes towards and adoption of soil conservation practices as well as on attitudes towards risk. Farmers were visited on their farms during May and June of 1996.

3.1. The dependant variables

Technological information provided in a nomograph designed by Platford (1987) is used to assess panel soil conservation adoption and effort. The nomograph is designed to calculate sugarcane panel widths (vertical intervals) that satisfy requirements of the 1983 Act given the soil type, panel slope and soil conservation practices used on that panel. Within the context of panel soil conservation, soil conservation practices (minimum tillage, stripcropping, terracing and trashing) are integer activities, whilst the vertical interval (VI) is variable. VI's are inversely related to soil conservation effectiveness, *ceteris paribus*. It is apparent that a panel with high (low) conservation adoption may have inadequate (adequate) soil conservation effort if the actual VI between terraces is sufficiently large (small).

It is instructive to weight adoption of a practice by its efficacy in reducing soil loss if policy recommendations are to encourage adoption of appropriate practices. Consequently, NPRAC is a measure of soil conservation through adoption of soil conservation practices and is calculated as the recommended VI considering the practices currently adopted (RECVI) as a proportion of the range of possible recommended VI's for a given panel i.e. $NPRAC_{ij} = (RECVI_{ij} - MINVI_{ij})/(MAXVI_{ij} - MINVI_{ij})$, where $MINVI_{ij}$ and $MAXVI_{ij}$ are the recommended VI's for the *i*th farmer on his *j*th panel if no or all soil conservation practices are adopted respectively. Comparison of the actual VI ($ACTVI_{ij}$) with $RECVI_{ij}$ indicates whether soil on the *j*th panel of the *i*th farmer is being conserved at above, equal to, or below the required standard in terms of the 1983 Act. Hence, $EFFORT_{ij} = (RECVI_{ij} - ACTVI_{ij})/RECVI_{ij}$. Positive (zero, negative) values of EFFORT indicate that soil conservation effort is greater than (equal to, below) the required minimum standards.

Survey respondents provided details of slope gradient, soil type, soil conservation practices used and ACTVI's. Soil erosiveness was classified according to Macvicar (1973). Observations were replicated to encompass measurements for sugarcane panels of both relatively steep and average gradient for each farm (*j* = S (A, B) refers to relatively steep (average, both) slopes). Farmers tend to have greater conservation adoption on their relatively steeper slopes, indicated by mean $NPRAC_{iS}$ and $NPRAC_{iA}$ values of 0.55 and

0.31 respectively. $EFFORT_{iS}$ and $EFFORT_{iA}$ values have a means of 0.18 and 0.02 respectively indicating that on average sugarcane farmers conserve their steeper (average) gradient slopes at greater than (at) the minimum required level. Seventeen (28) percent of farmers were conserving their steeper (average) gradient slopes at below than the minimum required level.

3.2. The independent variables

The information indices ($INFO_i$, i = 1,.., 3) are derived from a principal components analysis of information sources that farmers both use and consider important for soil conservation. $INFO_1$ is positively related to use of non extension information sources. $INFO_2$ is positively related to use of media information (radio, television, magazines, newspapers) relative to other sources of information. $INFO_3$ is positively related to use of extension information. Risk preference indices ($RISK_i$ i = 1,.., 3) are derived from a principal component analysis of "adjusted Arrow-Pratt absolute risk aversion coefficients" elicited for each respondent over five different hypothetical lotteries considered separately (see Ferrer *et al*, 1997). $RISK_1$ is positively related to the farmer's absolute level of risk aversion, $RISK_2$ is negatively related with safety constraints in decision making, and $RISK_3$ is positively related to the rate of increasing absolute risk aversion with gamble size. SKIL is the farmer's own assessments of his technical skills in implementing soil conservation, measured on a lykert-type scale where 1 is poor and 5 is excellent.

Other variables include the farmers age (AGE); education (EDU), measured as years of formal education; whether he is a farm manager (MNGR = 1, otherwise zero); the proportion of land rented (PRENT); the farm debt-asset ratio (DBASR), the proportion of time spent in off farm employment (OFRT); whether the farmer has significant income from dividends or rent (UID = 1, otherwise zero); hectares of sugarcane farmed (CANE); the proportion of land operated that is not under sugarcane (DIVERS); the percentage slope of the panel (SLOPE); whether the soil is highly erodible (ERSV = 1, otherwise zero); for how many years the farm has held a land use plan (LUPYR); whether the farm is below an altitude of 500 meters (COAST = 1, otherwise zero); whether the farmer is still active in implementing his soil conservation plans (ACTV = 1, otherwise zero); and AVG which equals 1 if j = A, otherwise zero. Farm income per hectare was excluded from the analysis due to several missing or unreliable values.

Legislated soil conservation requirements are only likely to be effective where farmers expect them to be enforced. Farmers were asked to rate the probabilities of "excessive" erosion being discovered by the authorities on their farm or a farm in their area (DISC), and if this was not abated, the probability that the farmer would be prosecuted (PRSC). Whilst over sixty percent of farmers considered discovery to be likely, only 21 percent of farmers considered prosecution to be likely. Both DISC and PRSC are significantly negatively correlated with EFFORT, contrary to *a priori* expectations. Consequently, these variables were excluded from the analysis.

4. RESULTS AND DISCUSSION

OLS regression techniques were used to estimate the hypothesised models. Eight cases containing missing values were excluded from the analysis. Variables were generally dropped from the estimated models if estimated coefficients were not statistically significant at the 20 percent level of confidence. SLOPE is significantly correlated with COAST and was excluded from the NPRAC models to reduce collinearity. Results are presented in Table 1. Although achieved goodness of fit statistics are good compared to many previous studies on soil conservation decisions, they generally indicate poor explanatory power of farmer's decisions. R^2 statistics are higher in the conservation adoption and j = S models relative to conservation effort and j = A models respectively.

Table 1: Results of the regression analyses

	Soil Conservation Adoption			Soil Conservation Effort		
VARIABLE	$NPRAC_{iB}$	$NPRAC_{iS}$	$NPRAC_{iA}$	$EFFORT_{iB}$	$EFFORT_{iS}$	$EFFORT_{iA}$
AVG	-0.21592***			-0.12344**		
AGE				-0.00761**		-0.01340**
EDU	0.04120***	0.03091**	0.03843***	0.03894***	0.0412***	0.05183*
$RISK_3$	-0.05769**	-0.11675***				
SKIL	0.13973***	0.11932***	0.13040***	0.07950*	0.09398**	
$INFO_2$				-0.05676*	-0.06883**	-0.08242*
$INFO_3$	0.08037***	0.10862***	0.07511**	0.04940*	0.06332**	
LUPYR				0.01403***	0.00912*	0.02184**
ACTV	-0.15223***	-0.04474*	-0.22030***	-0.17115***		-0.35879***
DIVERS	-0.20911*	-0.15044**		-0.30605**	-0.10935**	
UID				0.22480**		0.31249*
OFRT	-0.29171**	-0.38559**				
MNGR	-0.04487	-0.34130***				
CANE	0.00017	-0.00018**				
ERSV	0.12361**	0.20191***				
COAST	0.16587***	0.17392***	0.18892**			
CONSTANT	-0.35597	-0.13914	-0.64792***	-0.20046	-0.6858***	-0.02273
Adjusted R^2	0.5887	0.6988	0.4182	0.4270	0.4638	0.3226
F	11.6141***	9.6993***	9.0880***	7.6319***	7.4885***	4.5717***
df	77	33	39	79	38	38

Note: ***, **, and * indicate significant at the 1%, 5% and 10% levels respectively.

As expected, farmers still active in implementing soil conservation plans have lower conservation adoption and lower conservation effort. This effect is more marked on average slopes implying that farmers adopt conservation practices on their steepest slopes first. The estimated AVG variable coefficient of -0.216 and - 0.123 in the $NPRAC_{iB}$ and $EFFORT_{iB}$ models indicates that other factors considered only partially explain observed greater conservation adoption and effort on relatively steeper gradient panels.

Results support the hypothesis that education is positively related to conservation adoption and conservation effort. Farmers who use information from extension sources have greater conservation adoption and conservation effort, in particular on steeper slopes. Farmers who use more media information sources relative to other information sources apply significantly lower conservation effort on all panels. Land use plans (LUP's) encourage greater conservation effort, but are not significant in explaining conservation adoption which may reflect autonomy provided in LUP's (McFarlane & Maher, 1993). It is speculated that information sources that focus on dramatic and visible soil erosion fail to draw farmers' attentions to the generally discernible nature of most soil erosion and erosion on flatter slopes.

Farmer's age is negatively related to soil conservation effort, reflecting that older farmers have shorter planning horizons. This suggests that soil loss and soil conservation are incompletely capitalised into land values (Ervin & Mill, 1985). Constraints on management time, indicated by OFRT, DIVERS and CANE decrease both conservation adoption and effort. The negative relationship between MNGR and adoption may indicate that farm managers are less prepared to devote management time to soil conservation since if assessment is based on current financial performance. Financial constraints reduce soil conservation effort but not conservation adoption, reflecting the capital intensive nature of developing and restructuring soil conservation structures. The non significance of OFRT in explaining conservation effort may reflect the opposing effects of off farm employment on management time and financial constraints. Farmers' technical abilities constrain conservation adoption more than conservation effort, suggesting that farmers are more concerned with their abilities to implement conservation practices relative to conservation structures.

Conservation adoption is positively related to COAST and ERSV. These variables reflect, firstly, that trashing is a less viable option inland due to lower temperatures (McFarlane & Maher, 1993) and, secondly, that conservation adoption is greater on more erodible panels. This latter result may reflect greater conservation adoption requirements on more erosive land in terms of the 1983 Act (Platford, 1987). Physical panel characteristics were not significant in explaining conservation effort, possibly because farmers have economic incentives to have wider (narrower) panel widths on steeper (flatter) slopes (Platford, 1987), thus negating the effect on conservation adoption.

5. CONCLUSIONS AND POLICY IMPLICATIONS

Analysis of intra-panel soil conservation effort reveals that 17 (28) percent of farmers surveyed do not meet required standards on their steeper (average) gradient panels. In terms of the 1983 Act, farmers can be prosecuted for not meeting these minimum requirements. However, the survey revealed that sugarcane farmers generally consider enforcement of required standards to be unlikely. Research on factors impeding enforcement is necessary if the efficacy of existing policies is to be improved. It is speculated that soil conservation committee members are reluctant to create antagonism within their own communities. Responsibility for enforcing the 1983 Act should, perhaps, lie with individuals external to the farming communities.

Results of regression analysis reveal the long term nature of implementing soil conservation decisions on sugarcane farms and further indicate that farmers tend to adopt more practices and have greater soil conservation on their steeper slopes. Further, farmers also tend to implement their soil conservation decisions on their steeper slopes first. Farmers must be made aware of soil loss on all slopes. This is perhaps best achieved through education and extension. Farmers should also be encouraged to adopt land use plans. It is imperative that information focuses more on the importance of barely discernible soil loss if farmers are to be made aware of soil loss on their own farms and especially their flatter slopes. Farmers' soil conservation decisions are constrained by both income and management time. Policies that subsidise soil conservation investments are likely to promote soil conservation effort amongst sugarcane farmers. Farmers could be encouraged to entrust labour with more responsibility for implementing time intensive practices to release management time.

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