AN ECONOMIC ANALYSIS OF SOIL CONSERVATION POLICY FOR SELECTED COMMERCIAL FARMS IN KWAZULU-NATAL

BY

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I hereby certify that, unless specifically indicated to the contrary in the text, this thesis is the result of my own original work.

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ABSTRACT

Inherent in the erosion process is a high level of uncertainty. This is associated with the inability to accurately quantify and predict the consequences of prolonged erosion for agricultural production, or estimate the time period over which induced innovations will be able to compensate for it. Therefore, there are incentives to formulate strategies that will achieve tangible reductions in erosion.

Data were collected through a postal survey conducted in October 1993, from the following five commercial farming regions: Dalton/Wartburg, Camperdown/Eston, Dundee, Estcourt, and Winterton. Soil conservation incentives are expected to differ according to enterprise types and site-specific circumstances, and stratifying according to these regions incorporates a diverse spectrum of agricultural systems. There were 480 potential survey respondents, and 159 (35 percent) usable questionnaires were returned. The response rate is relatively good for a postal survey, although results may be slightly biased in favour of farmers that are concerned or interested in soil conservation.

Adoption of soil conservation measures is modelled as a multi-stage decision process, representing the following phases: awareness of the erosion problem, the perception that erosion is worth trying to resolve, farmers' technical and financial abilities to implement soil conservation measures required for their farms, and finally the actual adoption of conservation practices. A logistic regression analysis shows visible erosion impacts, knowledge of erosion's adverse implications for agricultural productivity, farmers' willingness to invest their own capital in conservation activities, predominantly crop farms,

and sufficient financial resources, have significant positive impacts on adoption. The mean predicted probability score for the Technical Ability model is 0.54, illustrating farmers' lack of technical soil conservation skills to implement appropriate conservation measures is a major constraining factor within the adoption process.

Variables influencing conservation effort, reflecting the extensiveness and effectiveness of soil conservation measures, are expected to differ from those affecting adoption, and effort is modelled separately using linear regression. Results support prior expectations indicating conservation effort depends mainly on the following financial characteristics: farmers' willingness to invest their own capital in conservation activities, debt financing, and on-farm financial and managerial benefits from implementing soil conservation activities.

Farmers' perceptions regarding the monitoring and enforcement of soil conservation legislation are also analyzed using frequency tables. Although 65 percent of respondents believe that violations of Act 43/1983 will be discovered, only 20 percent perceive that transgressions will be both detected and subsequently prosecuted. This suggests the transactions costs related to enforcing prosecutions are high, and the possibility of being prosecuted is unlikely to encourage farmers to implement soil conservation activities.

Agents (eg. Soil Conservation Committees and extension officers), and media (eg. extension service reports) play an invaluable role in promoting soil conservation. High transactions costs associated with enforcing legislation indicate it may be appropriate for the government to play an active part in research, and in providing information about erosion and soil conservation, to facilitate a better functioning land market. This is distinct from having a clear advantage over market forces in the use of this information. Cross-compliance programs, should perhaps be considered as short to medium-term strategies, to encourage farmers to implement soil conservation activities.

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INTRODUCTION

In South Africa, soil erosion occurs at rates between three and 10 tons per hectare per annum on most cultivated soils, 10 times the rate of soil formation (Fuggle and Rabie, 1992: 191). In a country where there is "no room for further lateral agricultural expansion" (McKenzie and Tapson, 1993: 3), this has serious implications for sustainable agricultural and economic development, and erosion is possibly South Africa's greatest environmental problem (Fuggle and Rabie, 1992: 191).

According to Pasour (1990: 211-212), increasing productivity of cropland over time in the United States suggests that the severity of erosion is exaggerated, and moreover, freely functioning land markets will eliminate the erosion problem. However, the underlying crux of the soil erosion problem is perhaps its insidious nature. Agricultural technologies, while complementing a soil's productive potential, concurrently conceal erosion's long-term detrimental impacts. Consequently, these effects and associated costs may not be fully captured by market forces, and reflected in lower agricultural land values. This makes observing the benefits of soil conservation equally difficult. Nevertheless, increases in agricultural production cannot be sustained indefinitely while basic soil quality deteriorates, and furthermore, erosion's impacts are not confined to effects on agricultural productivity.

To accomplish substantial reductions in erosion, it is imperative the causes of the problem are addressed, rather than its symptoms. If the significance of economic parameters within the erosion process can be determined, policy makers may be able to improve incentive structures that motivate soil conservation activities. As far as the author is aware, Basson's study (1962) is the only one in South Africa to analyze implications of soil conservation from an economic perspective. Accordingly, the primary objective of this study is to identify factors that influence commercial farmers'[1] decisions to implement soil conservation measures. This analysis may isolate short-comings in South Africa's current soil conservation policy, provide information for recommending improvements, and identify areas requiring further research.

A framework within which implications of the physical erosion process can be understood, is outlined in Chapter one. This highlights the importance of the soil's characteristics for agricultural production, and emphasizes that natural factors influencing erosion are unique for site-specific circumstances. Subsequently, transactions costs associated with collecting information about soil erosion and conservation are relatively high, and market forces may not take full account of these. In an attempt to verify the significance of the erosion problem, Chapter two examines the on-site and off-site consequences of soil erosion in this country, and considers their physical and economic implications.

In Chapter three, South Africa's past and current soil conservation policies are discussed, and constraints inherent in their strategies are highlighted. The current policy, entrenched in the Conservation of Agricultural Resources Act 43/1983, suggests providing both technical and financial assistance to farmers, and penalties for violations, will ensure soil conservation measures are adopted (Government Gazette No.92338, 1984). However, its effectiveness is questionable if all farmers do not face both technical and financial constraints, if

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1 Structural differences between the commercial and developing (subsistence) agricultural sectors suggests these may require different approaches to the soil erosion problem. This study concentrates on the commercial agricultural sector.

transactions costs associated with meeting its provisions are high, or if legislation is not enforced. Ways in which agricultural policy objectives may contradict those of soil conservation policy are also briefly examined, highlighting the need for an integrated approach to policy formulation by policy makers.

Chapter four summarizes the variety of interacting factors that influence soil erosion. The importance of information pertaining to the land's natural capabilities for shaping farmers' perceptions about appropriate land use, and subsequently facilitating a better functioning land market, is emphasized. Soil conservation studies completed in the United States are also reviewed. Although these do not employ a standard theoretical model of soil conservation adoption and use, they provide valuable insights for identifying factors that influence farmers' soil conservation decisions. They show farmers' personal characteristics, and physical, socio-economic, financial, and institutional factors, influence soil conservation adoption (Featherstone and Goodwin, 1993; Sinden and King, 1990; Gould, Saupe and Klemme, 1989; Norris and Batie, 1987; and Ervin and Ervin, 1982).

Further developments suggest conservation adoption is a multi-stage decision process (Ervin and Ervin, 1982; Sinden and King, 1990), where realization of a soil erosion problem is not necessarily followed by action to correct it. Individuals would otherwise be perfectly rational, the appropriate corrective action would internalize exclusive benefits (economic or otherwise), and decision-makers would not face constraints (Duff *et al*, 1992: 403). Finally, Ervin and Ervin (1982: 291), distinguish between adoption of soil conservation of practices and soil conservation effort. This has important implications for policy formulation, since if the objective is to minimize erosion, it is imperative to consider factors affecting both the degree of soil conservation and the extent to which it is applied.

In Chapter five, the government's role in formulating soil conservation policy to effectively account for the multitude of interacting factors influencing erosion, is discussed.

Conceptual soil conservation models representing a multi-stage adoption-decision process, soil conservation effort, and farmers' perceptions regarding enforcement of Act 43/1983, are explained in Chapter six, and statistical techniques and model estimation procedures used in the empirical analysis are outlined in Chapter seven. These involve logistic and linear regression, and principal component analysis techniques.

Chapter eight outlines the method used to collect data for the study, and summarizes respondents' characteristics and soil conservation orientations. To account for different enterprise types and site-specific circumstances, data were collected from the following five farming areas in KwaZulu-Natal, namely Dalton/Wartburg, Camperdown/Eston, Estcourt, Winterton, and Dundee. A total of 159 cases were used in the analysis.

Results of the empirical analysis are presented in Chapter nine, and to conclude, policy implications of the study's findings are discussed.

CHAPTER 1

THE SOIL EROSION PROCESS: INCORPORATING AN ECONOMIC PERSPECTIVE

In 1936 General Smuts declared soil erosion to be the biggest problem confronting this country (Beinhart, 1984: 68). Fifty-six years later, Fuggle and Rabie (1992: 191) reiterate this, describing erosion as "possibly the greatest environmental problem facing South Africa". These parallel statements immediately evoke questions regarding the seriousness of this widely acclaimed "soil erosion problem". Could it have been so serious considering the increases in agricultural production? Is it still a problem, and if so, what are the causes and can these be resolved?

Soil - the most basic of natural resources - can be considered a form of natural capital (Barbier, 1993: 2). As an economic asset its value is determined by the present value of its capitalized income or welfare potential. It is reasonable to assume that returns to the soil *per se* and therefore its value, are highly correlated with returns to, and the value of agricultural land. These must be greater than, or at least equal to, alternative rates of return for land to be an effective form of wealth. Returns to agricultural land compare favourably with stock market dividends (Nieuwoudt, 1980: 393), yet real current earnings are low relative to land values (Barry *et al*, 1988: 270). This may create the misconception that overall returns are low relative to alternative income-yielding assets. However, real growth in expected returns are capitalized into the land value and realised when the land is sold.

Provided rights to land are transferable there is a strong incentive to implement conservation measures as these preserve future income streams (Pasour, 1990: 200). If farmers know the soil base determines productivity and subsequently farm resale values, they should conserve it (McConnell, 1983: 86). Why then is soil allowed to erode at rates greater than it can be replaced? A reasonable explanation is that the true value of conservation investments are not reflected in land values, suggesting market forces do not incorporate information about erosion's detrimental impacts for agricultural productivity. This implies costs, associated with collecting and providing this information (transactions costs), exceed the benefits of doing so. In such circumstances the market ignores these transactions costs and operates effectively within resulting constraints (Ervin and Mill, 1985: 940).

Consequently, farmers attempting to earn comparable current rates of return may be inclined to maximize current output at least cost, irrespective of long-term consequences for the soil base. Soil conservation investments are unlikely as they impose additional constraints on restricted liquidity capacities, and the opportunity costs of resources used to install them are relatively high. Secondly, if conservation investments are not reflected in land values, they will be perceived to have relatively long pay-back periods compared with agricultural production cycles. These perceptions are conducive to excessive rates of erosion, frequently preceding subsequent soil degradation processes, with detrimental consequences for agriculture and society. Integrating physical aspects of soil erosion with economic theory facilitates a better cognizance of inherent problems within the process. This requires a sound understanding of the physical interactions involved and accordingly these are addressed in ensuing paragraphs. Within this holistic framework, explanations for excessive erosion rates may be more easily understood.

1.1 The erosion process

Broadly defined, (Lozet and Mathiea, 1991: 93), erosion represents the "action of climatic or natural agents (wind, rain, rivers), often enhanced by human action (deforestation, overgrazing), which results in the removal of the surface layer of soils ..." . Lal (1993: 1) describes erosion as "the process causing a decline in a soil's inherent capacity to produce economic goods and perform ecological functions". This economic perspective places emphasis on the soil's capacity to fulfil present human needs and future requirements. Fuggle and Rabie, (1992: 191) stress that soil loss is a natural process and soil erosion occurs when the rate of soil loss exceeds the rate of soil formation at a given location. Stocking (1972: 1) enforces this, distinguishing between soil erosion and geological erosion, the former being a "man-induced process" that essentially compresses the time scale of erosive actions. Thus, time considerations are inherently important within the erosion framework.

A soil profile comprises A, B, and C horizons. Typically, an A horizon has the greatest accumulation of organic matter and maximum available plant nutrients. (More than 50 percent of yields are obtained on account of native reserves in the soil (Rauta, 1992: 1-4.2)). It is important for water retention and availability, and facilitates plant rooting depth. These characteristics are crucial for plant growth and the A horizon is the most favourable for realising optimum plant productivity. Weathering is generally less intense in the B horizon and conditions for plant growth less favourable. Inhibiting characteristics frequently include: higher clay content, a reduction in organic matter and nutrients, low pH, salt accumulation, high aluminium saturation, and restricted water permeability. Material that is relatively unaffected by soil-forming processes is found in the C horizon. If soil erodes to this level, plant growth is entirely restricted by the absence of rooting depth (Larson, Pierce and Dowdy, 1987: 18-21; Lal and Stewart, 1992b: 435).

Although important, technological innovations in agriculture can restrain efforts to control soil erosion. Technology essentially complements the soil's productivity in crop systems. Potentially higher incomes per hectare raise the opportunity cost of idle land and farmers are encouraged to crop land more intensively. In the short to medium-term productivity increases and erosion's impacts are not realised. In intensive livestock farming, technological innovations (feedlots and improved feed formulations), tend to substitute for the soil's productive potential. Improvements in productivity are not directly related to soil quality, and there is less incentive for soil conservation. This demonstrates that enterprise types have different implications for conservation policy incentives.

Figure 1. (adapted from Gardner and Barrows, 1985: 944) hypothesizes a general relationship between soil depth and potential productivity levels when erosion's effects are realised over time. Two basic possible scenarios are illustrated. The first, (ABCD), represents a soil-agricultural productivity relationship with no yield enhancing agricultural technologies (eg. fertilizer, hybrids, irrigation), and maximum attainable yield is Y. The second, (A'B'C'D'), illustrates how agricultural technologies mask erosion's impacts on productivity. Maximum yield potentials vary between Y_1' and Y_2' depending on the extent of erosion. It is noteworthy that with soil conservation, technological improvements would not be nullified by erosion and yields exceeding Y_2' would be possible.

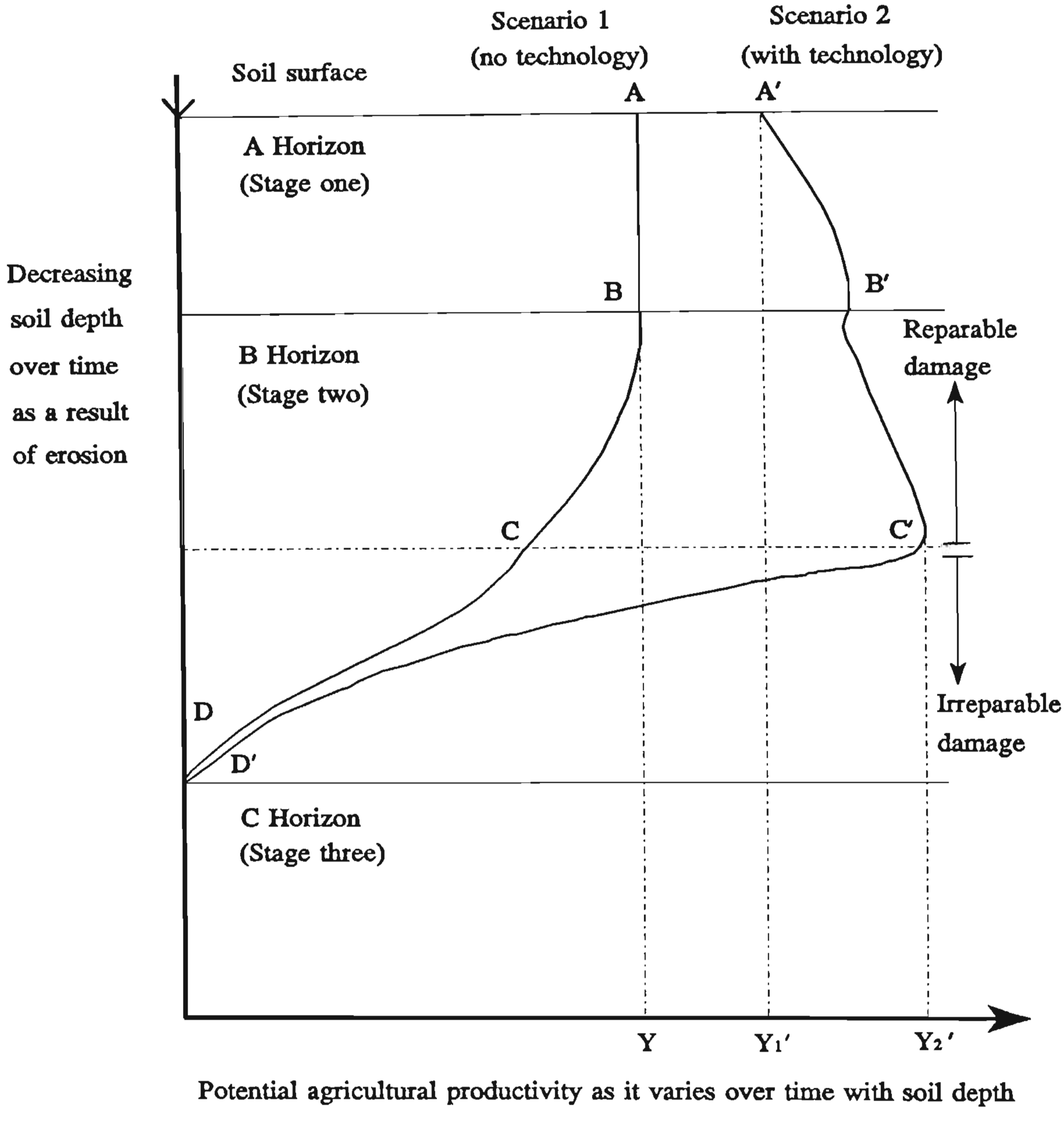

Figure 1: A general soil-agricultural productivity relationship depicting the effects of erosion on potential yields over time (Adapted from Gardner and Barrows, 1985: 944).

The relationship depicted assumes no conservation measures have been implemented, consequently becoming less conducive to firstly increasing productivity levels and then to maintaining productive potential. Stages one, two, and three relate to erosion in the A, B, and C horizons respectively. Parameters defining the relationship are difficult to measure and influenced by a wide variety of highly site-specific factors associated with soil type, climate, topography, land use, and management. The relative depths of soil horizons and magnitudes of interactions vary accordingly. An important implication of these variations is that erosion is not a prerequisite to significant yield differences (Schertz *et al*, 1985).

1.1.1 Stage one (A Horizon)

Agricultural activities (crop or pastoral) disturb the balance of natural vegetation making soils susceptible to erosive agents. As interpreted by McConnell (1983: 84), "output expansion per farm in a given time period requires more soil loss". Lal and Stewart, (1992a: 1,9), argue that this need not necessarily apply since farming systems can and must be soil-restorative[2]. They concede however, that adoption of these restorative measures are "subject to socio-political and economic pressures". Degrative effects of tillage operations on soils include: a decline in soil organic matter content and soil biodiversity; deterioration in structure; and disruptions in water, carbon, and nutrient cycles (Lal, 1993: 4). Overgrazing in livestock operations exposes the soil to natural elements resulting in similar degrative effects.

Young *et al* (1985: 139), claim the complementary relationship between A horizon soils and technology reinforces the economic justification for soil conservation. Yet, provided the A

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2 Such restorative technology is documented in various technical papers (Lal and Stewart, 1992a).

horizon can support a plant's minimum effective rooting depth (ie. until just before BB'), conservation incentives do not relate to productivity. Costs incurred will not be compensated with productivity improvement benefits even in the long-term. On relatively deep soils, losses of four to five tons per hectare per annum (between A and B) may occur without productivity impacts (Harlin and Berardi, 1987: 3). Progressive developments in agricultural technology over time (A' to B'), conceal many of erosion's adverse effects, further delaying farmers' decisions to implement conservation measures. Subsequently, substantial off-site impacts (externalities) occur before soil conservation becomes economically rational. This represents a divergence between social and private costs.

As the profile level approaches BB', A and B horizons integrate and soil properties change accordingly. Consequent structural variations initiate significant changes in yields (Schertz *et al*, 1985). Because of its insidious nature, farmers may not detect the extent of erosion until productivity begins to decline at BB'. Frequently erosion is not uniformly distributed over the farm or even within fields, specifically impeding effective input applications in crop management (Nowak *et al*, 1985: 122).

1.1.2 Stage two (B Horizon)

Below BB' it becomes more difficult and increasingly expensive to optimize agricultural production. The most serious constraints are decreased rooting depth, and a reduction in plant-available water resulting from inadequate intake rate or storage capacity (Meyer *et al*: 1985: 268). Yields may decline slightly when the above constraints are realised, and before appropriate technology to restore productive potential is adopted. Inputs still negate any contraction of the production possibilities frontier resulting from soil degeneration (McKenzie and Tapson, 1993: 8), and farmers are apathetic toward soil loss.

In the short-term, relative net benefits of avoiding erosion-induced productivity losses do not compare with those from using inputs. Provided additional costs are less than the market value of increased yields, farmers will substitute inputs for soil depth. Williams *et al* (1993: 129), report that risk-averse farmers are not prepared to make soil conservation expenditures when annual erosion rates are 20 tons per hectare or less and the planning horizon is less than 20 years. (These results are specific to their study).

Until CC', erosion damage may be regarded as "reparable". Soil attributes can be restored with the addition of agricultural inputs at the expense of increased production costs, although these and off-site costs to society rise exponentially. Concurrently soil conservation investments become less affordable. Beyond this threshold level, soil structure has deteriorated to the extent that damage is "irreparable" (Frye, 1987: 154). Determining when this threshold level will be reached is particularly difficult. Under crop production, effects of erosion are masked by any inputs used, and in livestock systems, loss of soil by wind and sheet erosion is usually not recognised until advanced stages when gullies become conspicuous. Hereafter, agricultural technologies need to be soil substitutes rather than soil complements. The soil has lost its resilience and encroachment of undesirable plant species (weeds and unproductive vegetation) follows (Beinhart, 1984: 57), precluding the use of land for economical agricultural production.

1.1.3 Stage three (C Horizon)

At DD' the "soil base" has no favourable properties to facilitate agricultural production. Soil is no longer an input in the production process and both the availability and feasibility of appropriate substitutes will determine future production. It is important to note that before reaching this extreme, other constraints may have inhibited production. For example, erosion may raise costs of applying inputs until this becomes prohibitive. Similarly, internalising off-site costs associated with erosion will increase costs of erosive actions and create incentives for conservation.

1.2 Discussion and summary

The underlying crux of the soil erosion problem is its insidious nature. McKenzie and Tapson (1993: 13), report a loss of six tons per hectare at a density ratio of 1.3 tons per cubic metre would represent a loss of 0.46mm of soil off the soil surface. Pimentel (1987: 221), describes comparable figures for an American situation. Removal of 15 tons of soil per hectare, possible during a single storm, would reduce soil depth by one millimetre. At an average erosion rate of 18 t/ha/annum, only 1.3 centimetres of soil will be lost over a 10 year period. It would take between 100 and 400 years to replace this (*ibid*). This makes observing the benefits of soil conservation equally difficult. In South Africa most cultivated soils undergo soil losses of between three and 10 tons per hectare per year, ten times the rate of soil formation (Fuggle and Rabie, 1992: 191).

In summary, the preceding synopsis suggests soil erosion causes progressive declines in productive potential and subsequently in returns to agricultural land. Agricultural technology masks erosion's impacts in the short to medium-term and in addition, transactions costs associated with collecting information about these impacts are relatively high. Consequently, the land market may not fully account for them, and it is rational for farmers to postpone implementation of conservation measures. Short-term financial constraints due to unrealised capital gains, coupled with random variability in incomes (inherent in agricultural production activities), place severe stress on farm cash flows. This, it is argued (Lok, 1983: 33), makes it difficult for farmers to adopt a planning horizon beyond a single crop year, and soil conservation is difficult to justify and implement.

Erosion therefore remains a serious problem despite increases in agricultural production. The extent to which its impacts are recognized by farmers, and therefore reflected in the land market, are expected to be influenced by the availability of relevant information. Unless fully informed of erosion's long-term consequences, farmers are unlikely to perceive conservation investments as profitable. Nevertheless, precise site-specific measurements of erosion rates and the consequences of their impacts for individual farmers and society are difficult to quantify, and the lack of appropriate information about erosion's impacts may be a major constraining factor revealing why extensive erosion continues. This issue is pursued in the analytical section of the thesis. In the ensuing chapter prevalent estimates of the significant consequences of erosion are discussed.

CHAPTER 2

CONSEQUENCES OF SOIL EROSION AND THEIR SIGNIFICANCE

It is argued that erosion damage is overemphasized as technological innovations maintain and even increase agricultural production levels. However major breakthroughs in agricultural technology are becoming less frequent. Crop production has slowed considerably and yields are beginning to plateau as a result (Heady, 1984: 11). Technological inputs cannot sustain increased agricultural production indefinitely while basic soil quality deteriorates. Furthermore, erosion damage is not confined to effects on agricultural productivity.

Reviewing the implications of erosion's on-site impacts and their associated externalities, to establish their detrimental consequences for: sustainable agricultural productivity and the costs of production, external costs imposed on society, and the quality of the environment, are the primary objectives in this chapter. There must be consensus between "those involved" that the problem exists if there is to be progress toward solving it, thereby overcoming the first obstacle in formulating policies to combat erosion (Trudgill, 1990: 105).

2.1 Consequences

Predominately, on-site erosion damage impacts on productivity. Soils become sensitive to changing climatic conditions, inputs become less effective, and yield variability increases risk and uncertainty. Off-site impacts comprise air pollution from wind erosion, pollution of downstream water resources, consequences associated with flooding, and damage to water storage facilities (Follet and Stewart, 1985; and Ribaudo *et al*, 1989). These on and off-site damages are relatively unquantified and poorly researched in South Africa. Available monetary cost estimates are presented in the following paragraphs.

2.1.1 On-site effects

Tillage and use of inputs influence soil quality and enhance erosion. This reduces maximum yield potentials and increases technological inputs required to maintain yields. Erosion also affects grazing capacities through changing the composition of plant cover in pastures (Lok, 1983: 30; and Adler, 1985: 2). In 1963, Ross calculated that erosion had destroyed 25 percent of the original soil fertility reserves in South Africa (Rabie, 1976: 16)[3].

Sampson (1981), proposed the concept of "hectare-equivalents" in an attempt to quantify erosion impacts. The average weight of a well managed agricultural soil, roughly 15 centimetres deep over one hectare, is 1950 tons. Even if the sum of many small losses, this is equivalent to losing one hectare of productive land. Yield differences between eroded and uneroded soil, *ceteris paribus*, would reflect productivity and economic losses attributable to erosion (Frye, 1987: 154). In South Africa, over three million hectares has been rendered unproductive and over 60 percent of the country's surface area is in a poor condition as a result of soil erosion (Fuggle and Rabie, 1992: 191).

In 1985, Du Plessis (1987) estimated the annual cost of nutrient losses attributable to erosion to be R365 million (R976 million at 1992 prices (AAS, 1994: 94)). This does not include off-site costs of pollution associated with nutrient waste or pesticides. Increases in fertilizer

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[3] It was not possible to trace the original reference and establish how this was calculated, or the time period involved.

application rates because of erosion are increasingly expensive, particularly since less than 50 percent of nitrogenous fertilizers are recovered by crops (Lal and Stewart, 1992a: 6).

Irrigation may become essential to offset reduced water holding capacities of eroded soils. Apart from capital outlays to install the system, irrigation water containing sediment and other erosion-related contaminants can lead to increased costs. Fine silt develops an impermeable soil crust reducing infiltration and inhibiting seed germination, and dissolved salts can affect crop yields (Clark II, 1985: 22). Other on-farm costs incurred relate to: maintenance of conservation works, cleaning out drainage structures, soil compaction, and inconvenience when ploughing severely eroded fields (Scotney, 1978).

Arguably, no single cost can be that large, however the cumulative expenses increase exponentially and can be significant. Furthermore, reduced property values and lower land rental rates, reflecting the extent of damages to productivity through smaller capitalized expected future returns, will occur in the long-term.

2.1.2 Off-site effects

The effects of soil erosion extend beyond the farm resulting in significant and costly impacts to society[4]. In-stream impacts incorporate biological, recreational, and preservation effects, while those off-stream consist mainly of flood damage, water conveyance and storage problems. Domestic and industrial water requirements, including electric power generation, also have implications for water treatment. In the USA, non-point source pollution from

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[4] Although these effects cannot be attributed solely to commercial agriculture, or even to the agricultural sector, they illustrate the consequences of erosion's off-site impacts.

agriculture contributes as much as 99 percent of suspended solids in US waterways (Clark II, 1985). Air pollution caused by wind erosion is also believed to affect solar radiation and chemical processes in the atmosphere (Wild, 1993: 235).

Table 1 shows estimates of mean annual off-site sediment damage for South Africa. The infra-structural damage estimate excludes costs for harbours, roads, bridges, culverts and water distribution networks. Neither are these data reflective of environmental damage, and their inclusion is expected to raise the total cost to over R100 million (R172 million at 1992 prices (AAS, 1994: 94)). Furthermore, these estimates illustrate direct costs incurred and do not represent economic damage assessments.

Table 1: Mean annual off-site sediment damage for South Africa, in millions of Rands (1988 figures) (Braune and Looser, 1989: 138).

Deposition of sediment in rivers	R53 million
Sedimentation component of flood damage (agriculture)	R30 million
Sedimentation component of flood damage (infra-structural)	R3 million
Additional water treatment costs	R8 million
Total estimated off-site costs	R94 million

Sediment damage relates to overwash of infertile material, associated flood plain scour and bank erosion, damage to agricultural land and crops, and variable seasonal flow of rivers causing flooding due to increased surface run-off. Sediment load and deposition make the biggest contribution to flood damage in the drier regions of South Africa. A conservative approximation representing 20 percent of total flood damage is R30 million annually at 1988 costs, (R52 million at 1992 prices (AAS, 1994: 94)), (Braune and Looser, 1989: 135). Up to forty five million tons of sediment yield a year for the Caledon, Orange, and Little Caledon Rivers (originating in Lesotho) have been estimated (Darkoh, 1987: 27).

Water is a relatively scarce factor of production in South Africa, and erosion poses a serious threat to this country's water resource infrastructure. In 1952, silt suspension in annual run-off of South Africa's rivers was estimated at 400 million tons. Detailed silt sampling in the catchment area above the Hendrik Verwoerd dam in 1976 indicated that this area alone was losing 400 million tons annually (Rabie, 1976: 16). In its first three years, the Welgedacht Dam on the Claredon River lost 32 percent of its capacity (Scotney and McPhee, 1991: 8). The Camperdown dam was three quarters silted within 22 years, and 30 million cubic metres of silt were deposited within a six year period at the estuary of St. Lucia Bay (Adler, 1985: 9). The contribution to annual water purification costs due to silt is estimated at R530 million (McKenzie and Tapson, 1993: 14).

Average storage capacity lost in major dams throughout the country is approximately 10 percent per decade (Scotney and McPhee, 1991: 8). In 1988, mean annual reservoir storage loss rates were 0.35 percent, and construction and dredging costs averaged R0.50 and R1.40 per cubic metre storage volume respectively. Resulting losses were equivalent to R53 million, (R91 million at 1992 prices (AAS, 1994: 94)), (Braune and Looser, 1989: 135). South Africa's climate results in relatively high rates of evaporation and raising a dam wall incurs both construction expenses as well as greater water losses by evaporation over a larger surface area.

Decreases in sediment carried from South Africa's major river catchments have been reported (Adler, 1985: 12). The reasons for this are unclear as effective conservation measures seem unlikely. A possible explanation is only the coarser less erodible material remains, and invading plant species which follow naturally on the phase of erosion are keeping the soil in place (Roux and Vorster, 1983).

2.2 The significance of erosion's consequences

As previously stated, assigning monetary values to repair costs does not demonstrate the value of economic damage. Time and the non-linear relationship between erosion and productivity makes it difficult to extrapolate damage estimates into the future (Phipps, 1987:349). The significance of consequences for agriculture and society are illustrated by the following perspectives.

2.2.1 Physical significance

In South Africa, only three percent of the 15 percent of agricultural land regarded as arable, has a high agricultural potential (McKenzie and Tapson, 1993). The accepted minimum requirement of 0.4 hectares of arable land per capita will have declined to 0.32 hectares in less than two decades (Schoeman and Scotney, 1987: 260). Nevertheless, arable land continues to be utilized for urbanisation, industrial development and mining with no apparent concern for corresponding implications for future agricultural development (DEA, 1992: 55). Lal and Stewart (1992a: 6) note that in order to maintain the current level of food intake for an increased population, agricultural production will have to be 50 to 60 percent greater in 2000 than in 1980.

Currently total impacts of commercial agriculture (incorporating indirect effects) on GDP and employment are 12,3 and 24,4 percent respectively (McKenzie and Tapson, 1993). As the majority of soils are nonrenewable within a human lifetime (Friend, 1992: 156), they are a relatively scarce factor of production in South Africa and cannot be wasted. Implications for food production, and foregone costs associated with the concept of hectare equivalents, creates a daunting perspective that should not be ignored. Furthermore, future sustainable management of this country's soil resource will necessitate restorative as well as preventive measures.

2.2.2 Economic significance

The following explanation considers relative supply and demand shifts for agricultural products to illustrate erosion's overall economic impacts (Crosson *et al*, 1985: 485). Changing production costs over time reflect the interplay of factors affecting supply and demand shifts for agricultural output. Demand shifts are caused by changing consumer preferences, higher per capita incomes, and population growth. Nieuwoudt and Van Zyl (1990) estimate that growth in demand for food in South Africa will increase by 20 percent and almost 30 percent if per capita incomes grow by one and three percent respectively. Increasing input prices, technological advance, and erosion-induced on-farm costs and productivity losses, will shift supply.

Relative slopes of supply curves represent increasing or decreasing unit costs over time, and assuming the second and more likely scenario discussed in chapter one: Figure 1 (page 9, use of inputs but no conservation), the ensuing conclusions are based on plausible assumptions (Crosson *et al*, 1985: 485-487). Erosion's on-site costs and productivity losses are compensated for provided input costs are lower than their relative productivity. In the short-term, there will be a trade-off between costs and expected benefits from reduced erosion through conservation, or compensating for it through increased use of inputs. Benefits from increased input use are realised earlier than those from conservation, and incorporation of these interacting factors causes a net rightward shift and a flatter supply curve in the medium-term. However, in the long-term, the relative productivity of inputs decrease, yields decline, and unit costs increase as soil erodes. The supply curve shifts leftwards and its slope increases, reflecting these erosion-induced on-site costs. If conservation measures are implemented, returns to this investment and the complementing effects of technological advance result in lower unit costs, and supply shifts further rightwards than in the medium-term.

In the long-term and without soil conservation, agricultural output prices will increase and production will decline with the leftward shift in supply. The relative contributions of erosion, technology, input prices, and demand effects, to this price increase are not easily isolated. However, if the soil were conserved, this and complementary effects of technological advance, (causing a rightward shift in supply), would result in lower prices and greater output. Whether future real prices are less than current prices depends on the ability of advances in technology to compensate for growth in demand (Crosson *et al*, 1985: 485). The difference between prices realised with and without conservation represent direct and indirect erosion-induced costs. If off-site costs were internalised, the leftward shift in supply would be much greater, and the slope steeper, with corresponding impacts on price and production.

2.3 Discussion

According to McKenzie and Tapson (1993: 3), there is "no room for further lateral agricultural expansion" in South Africa. This has serious implications for sustainable agricultural and economic development, (ie. that which satisfies present needs without compromising the ability of future generations to meet their needs (Doyle, 1991)). While excessive erosion persists, costs of agricultural production will continue to increase, as will off-site costs imposed on society. As illustrated in the preceding paragraphs, these costs are substantial and have far reaching repercussions for the environment.

Clearly, further uncontrolled soil loss can only be detrimental to South Africa's future, and conserving this country's most basic resource should be a priority. In the following chapter, South Africa's past and current soil conservation policies are reviewed, highlighting problems associated with implementing soil conservation policy.

CHAPTER 3

PAST AND CURRENT SOIL CONSERVATION POLICIES IN SOUTH AFRICA

In this chapter, past and present soil conservation policies are reviewed. According to Benbrook (1980), obstacles to soil conservation are not technological, but rather in the design of institutional arrangements that influence the incorporation of this technology into farming systems. In this regard, agricultural policy implications for soil conservation programs are also briefly discussed. Objectives are to highlight deficiencies in previous conservation policies, for consideration in recommending improvements to the current soil conservation policy.

3.1 Historical review of soil conservation policies

In 1914 and 1923, respective reports of the Select Committee on Droughts, Rainfall and Soil Erosion, and the Drought Investigation Commission, related economic losses sustained by farmers as a result of periodic droughts, to soil erosion (Fuggle and Rabie, 1992: 13). The Soil Erosion Advisory Council was established in 1930 to administer and provide financial and technical aid to farmers, yet hardly 10 percent of the farming community took advantage of these programs (Rabie, 1976: 24). The division of Soil and Veld Conservation was created in 1939, and subsequently soil conservation legislation was contrived in the Forest and Veld Conservation Act 13/1941 (Adler, 1985: 30). The National Veld Trust, established in 1943, was the first non-government organisation to support the cause for soil conservation.

The Soil Conservation Act 45/1946 intended to change prior policy focus from corrective action to prevention. It relied on local farming communities to establish Soil Conservation Committees and enforce this legislation, yet of 21 prosecutions instituted in terms of the Act countrywide only 14 were successful (McKenzie and Tapson, 1993: 15). In an attempt to improve enforcement, the Soil Conservation Act 76/1969 vested the executive powers held by conservation committees in an inspectorate of the Division of Soil Protection (Rabie, 1976: 34). Penalties were increased from a maximum fine of R400 and/or imprisonment of 12 months to R1 000 and/or 2 years. Until 1983, only 36 of the 1672 farmers identified as contravening the act were prosecuted (Fuggle and Rabie, 1992: 197).

Other past soil conservation efforts include a drought insurance scheme for stock farmers as recommended by the Fodder Bank Committee (1949), a veld reclamation scheme (1966) encouraging farmers to rest a portion of their pasture by paying compensation for livestock removed from grazing, and a similar stock reduction scheme (1969). Under this latter scheme, it has been estimated that over five million head of livestock were withdrawn from the land over five years, at a cost of R29 million (Rabie, 1976).

Rabie (1976: 29) stressed that legislation could not succeed if the majority of South Africans were ill-informed and unconcerned about soil erosion. A survey by Adler and Ackerman (1981), indicated that many people regarded soil erosion and related consequences less important than other forms of environmental degradation. Despite estimates of R130 million being spent by the State, throughout South Africa, on financial aid for soil conservation between 1948 and 1983, (and at least as much again by landowners), there was little evidence that soil erosion had been curtailed (Adler, 1985: 32). Chronic staff shortages to undertake surveys and prepare farm plans and the fact that criminal sanction secured compliance with its provisions were major constraints. Causing soil erosion was not in itself outlawed, only failure to obey a direction of the Minister was considered an offence.

3.2 Current soil conservation policy

Establishing a soil conservation ethic among farmers, by providing advice and promoting the conservation of agricultural resources in the area, is entrusted to Soil Conservation Committees under the Conservation of Agricultural Resources Act 43/1983 (Russell, 1992: 7). However, neither the requirements for securing compliance with its provisions, nor the administrative difficulties in monitoring and enforcing soil conservation legislation have changed. There are only 14 inspectors serving the whole country (Fuggle and Rabie, 1992: 203), and criminal law remedies are not prohibitive, only punishing after the harm has been perpetrated (Glazeaski *et al*, 1991: 143).

Objectives of Act 43/1983 are to provide for the conservation of natural resources through maintaining the production potential of soil by preventing erosion (Russell, 1992: 2). The Act's provisions apply to all land except virgin soil which cannot be cultivated in terms of Section 2(1) (Government Gazette No.9238, 1984: 20). The Soil Conservation Scheme established under this Act provides subsidies and low interest loans for the construction of the following soil conservation works:

Protection works : including weirs that stabilize a water course, structures in dongas[5], storm-water furrows and contour banks that protect

[5] gullies created by excessive erosion

cultivated land against excessive soil loss, and fencing and cover cropping where the objective is to reclaim eroded land.

Drainage works : aimed at preventing waterlogging or salination of land.

Veld utilisation works : camp fences and stock watering systems for implementing rotating camp systems.

Drought relief works : fodder storage facilities and feedlots or feed paddocks (*ibid*, 1984: 21).

Eligibility for subsidy payments necessitates an application by the land owner to have the farm unit entered into the scheme. If the application is approved, the extension service compiles a farm plan (which may be amended at the request of the farm owner), relating to the utilization and conservation of the natural agricultural resources. The farm owner must apply for and receive consent in writing from the executive officer, before constructing soil conservation works proposed in the farm plan. This written approval will also stipulate the date by which conservation works should be completed, materials to be used, and be accompanied by plans and specifications in accordance with which conservation works must be constructed. The executive officer shall inspect and compile a report on the construction of these, having received notification of their completion (*ibid*, 1984: 22-30).

Subsidies may be paid provided provisions described above have been met, and moneys appropriated for this scheme are available. These payments are subject to maintenance of conservation works and compliance with the farm plan (*ibid*, 1984: 28-30). Subsidy payments and loans provided over the last five years by the Department of Agriculture for the construction of soil conservation works are recorded in Table 2 and Table 3 respectively.

Table 2: Subsidies paid by the Department of Agriculture for Soil Conservation Works (R Millions) (Directorate: Agricultural Economic Trends, 1993).

1988/89	1989/90	1990/91	1991/92	1992/93
6,876	7,365	5,899	5,457	11,558

Subsidies received for soil conservation works are defined as "gross income" in the Income Tax Act 58/1962 and are therefore taxable[6].

Table 3: Loans provided by the Department of Agriculture for constructing Soil Conservation Works (R Millions) (Directorate: Agricultural Economic Trends, 1993).

1988/89	1989/90	1990/91	1991/92	1992/93
1,23	2,77	3,15	3,26	2,41

During the period 1988/89 to 1992/93, 96 percent of loan applications for constructing soil conservation works were approved, resulting in 332 farmers countrywide benefitting from this scheme (Directorate Agricultural Economic Trends, 1993).

Executive officers are permitted to issue directives to landowners to correct transgressions. Penalties for violating the Act's provisions range from fines of R500 or three months in prison or both, to R10 000 or four years in prison or both (Russell, 1992: 7). However,

6 Establishing the extent to which this may off-set subsidy payments and discourage applications for subsidies is beyond the scope of this study.

enforcement of the Act has been relatively ineffective. Throughout the country in 1988/89, 1143 cases of contravention of the Act received attention. Of these, 419 directives were served of which only six resulted in prosecution (Fuggle and Rabie, 1992: 204).

Apart from the high administrative costs involved, the effectiveness of a cost-sharing subsidy policy for controlling erosion is questionable. It does not target areas where erosion damage is greatest and benefits received in terms of money spent are not always maximized (Larson *et al*, 1987: 22). Hughes (1988: 274) argues that such policies give farmers the right to access government farm programs while freely eroding the soil. With this division of rights, reductions in erosion desired by society, can only be obtained by bribing farmers with taxpayers money, while current farm income either remains the same or increases due to economic rents. Furthermore, subsidies remove any dynamic incentives as farmers do not realise that it is in their interests to conserve the land (Lal and Stewart, 1992b: 437). Subsidies enable the symptoms of erosion to be treated, however its causes are not identified and dealt with. As a result there are no on-farm benefits to be gained, schemes operate continuously, and are very expensive.

Other legislation making provisions for soil conservation include the Water, Forest, Mountain Catchment Areas, Common Pasture Management, and Settlement Acts (Fuggle and Rabie, 1992: 206-208). The South African Roads Board has powers (rather than the obligation) to prevent erosion on a national road, or as a result of the construction of a national road (*ibid*: 210).

3.3 Agricultural policies and soil conservation policy objectives

To the extent that agricultural policy structures determine enterprise types and the farming methods utilized, it is plausible that rational decision making within this framework presents obstacles to maintaining or enhancing the quality of the environment (Buttel and Gertler, 1982: 102). This study does not attempt to measure magnitudes of agricultural policy impacts on resource management objectives, however these implications cannot be ignored. The following review highlights the need for Agricultural Departments at national, provincial, and local levels, to ensure policy objectives do not contradict those of other divisions.

According to LaFrance, (1992) higher commodity prices lead to more erosion as land is cultivated more intensively. Frank and Nieuwoudt (1987: 367), show that maize price policies in South Africa caused substantial market distortions, increasing the profitability of crops relative to livestock. They estimate that if a free market prevailed seven percent of land under crop production would switch to livestock production, and agriculture would be better adapted to its environment. McKenzie and Tapson (1993: 5) declare this seven percent only represents 0.4 percent of the available grazing land in the commercial farming sector, and therefore environmental effects of these policies are negligible. Osteen (1987: 297) contends that when agricultural programs reduce price and/or production risk, increased potential benefits will induce soil conservation. However Barrett (1991), emphasizes conservation decisions will be based solely on relative output and input prices, and only decreases in the relative productivity of additional non-soil inputs will encourage soil conservation.

Tax incentive structures may have indirect consequences for soil conservation, encouraging increased farm size, mechanization, specialization, and absentee ownership (Buttel and Gertler, 1982: 111) . In South Africa, the Income Tax Act 58/1962 permits farmers to record livestock values at 20 percent higher or lower than the purchase price, enabling them to reduce taxable income (Scott, 1992: 227). The reason for this is to enable farmers to build up their herds without carrying large tax burdens. However Fiske (1993), argues that in good years income tax payments can be deferred by buying in animals, and veld carrying capacities are often exceeded with overgrazing the consequence.

Insurance programs reduce yield and price risks, discouraging producers from diversifying their farming operations. Diversification may be environmentally preferable and more profitable in the long-term. Farming in less productive regions is also encouraged, promoting erosion and land degradation through inappropriate land use (Van Kooten and Kennedy, 1990: 750; and Doyle, 1991: 12). Flood and drought relief schemes have similar effects as expectations of relief aid eliminates associated risk, and these can be incompatible with conservation policy objectives. Cooper (1991: 53) reports a case where a farmer having removed fig trees from a river bank to plant bananas was fined R5 000 for contravening soil conservation legislation. The following year, the farmer claimed R70 000 in flood compensation payments from the government for lost production. In drought periods provision of livestock feed subsidies encourages farmers to keep animals rather than de-stock. Schemes have been defended on the basis of maintaining quality animals for breeding stock and disease resistance (Le Roux, 1993). Subsequent extensive overgrazing, particularly around water points, is thought to be a major unrecognized contributing factor to soil erosion in commercial farming areas (De Villiers, 1993; and Adler, 1985).

In order to meet greater market demands and remain competitive, farmers expanding their operations to capture economies of scale have relied on capital-intensive technologies and debt financing to operate their farms. Direct impacts of mono-cropping and compaction on soil erodibility are linked to short-term gains in productivity and profit motives to service debt obligations (Dumanski *et al*, 1986: 205). This has also directed technology development toward output expansion without recognizing the damage to environmental quality and sustainability (Becker, 1989: 187). Land saving technologies imply less erosion, but often require more fertilizers, chemicals, and pesticides which have additional external effects.

3.4 Discussion

Prior soil conservation efforts have not necessarily gone unrewarded. However, indications are substantial improvements can be made to the current soil conservation policy. As discussed in section 3.2, a subsidy policy for controlling soil erosion has several drawbacks. With reference to the Soil Conservation Act 43/1983, staff to fulfil enforcement functions, and potentially high transactions costs incurred by both farmers when applying for subsidies, and extension staff when developing and monitoring farm plans, could be major constraining factors.

The effectiveness with which soil conservation objectives are achieved depends on the level of farmer and public support for these initiatives. This is influenced by the level of acceptance of the erosion problem, and the degree to which benefits of programs are realised. Pressures through regulatory controls are often perceived as infringements on farmers' private property rights and, creating incentives that induce voluntary implementation of conservation works may be more successful (Batie, 1987: 338).

Major limitations relate to the inability to accurately predict the extent of erosion damage and its subsequent consequences over time. Information about erosion's irreversible impacts on the environment and associated uncertainty inherent in the process, may change perceptions about respective future costs and benefits. Consequently, net current benefits will adjust to account for these interacting factors (Arrow and Fisher, 1974: 314). In addition, links between sectors in the agricultural economy and their conflicting interests cannot be ignored and must be taken into account if soil conservation policies are to be successful. It is essential the combined social, political, and economic system provides rewards and incentives that encourage responsible management and allows sustainable development to take place (DEA, 1992: 171).

Evidently solutions need to integrate objectives (agricultural, environmental and social) into an holistic approach to the problem, and identifying important influential factors that need explicit consideration when formulating conservation policies is therefore vital. The next chapter summarizes variables influencing soil erosion, and reviews research that identifies factors motivating farmers' conservation decisions and incentives.

CHAPTER 4

VARIABLES AFFECTING EROSION AND FACTORS INFLUENCING SOIL CONSERVATION: RESEARCH IMPLICATIONS

Natural factors and those directing land use decisions in agriculture are most relevant to this study. Natural characteristics (vegetation, soil type, topography, climate), significantly influence farm enterprise combinations (crop, livestock, or mixed production systems). Agricultural management decisions and goals (directed by farmers' personal attributes, perceptions, opinions, and knowledge), are motivated by incentives and constraints created in various institutional arrangements (environmental legislation, property rights, financial capacities, and agricultural policies), within the agricultural sector. These interacting factors are expected to have direct implications for soil conservation decisions.

4.1 The land's natural characteristics: Implications for soil conservation

In South Africa most land is too dry, shallow, stony or steep to be cultivated (Van der Merwe, 1985). Rainfall is relatively low, evaporation rates high, and drought relatively common, making soils extremely susceptible to soil loss (Rabie, 1976: 16). Only 31 percent of the country records annual rainfall figures above 600mm, while 65 percent receives less than 500mm annually - the minimum requirement for successful dry land farming (Adler, 1985: 27). Schoeman and Scotney (1987), believe approximately 40 percent of the country has a high erosion hazard.

Based on Natal's physiographic history, Murgatroyd (1979) estimates a geological normal erosion rate of 0.16 tons per hectare per annum, for the Tugela River's drainage basin. The observed rate of 4.63 tons per hectare is 28 times this, illustrating the extent of "man-induced" erosion in this region. More recently, soil loss through human-induced erosion in South Africa is estimated at 300 to 400 million tons per annum (DEA, 1992: 99), and losses in excess of four tons per hectare occur on at least 30 percent of soils (Fuggle and Rabie, 1992: 191).

For agricultural systems to be sustainable, inherent differences in land quality and productive capability need to be recognized (Berg and Gray, 1984: 21). Productivity benefits from soil conservation need to be emphasized and successful conservation initiatives require land management research be conducted at a variety of locations, over reasonable time periods, to provide reliable data (Lal, 1993: 7).

In South Africa, most studies on soil erosion deal with erosion rates and sediment yield (Weaver, 1989, and Rooseboom, 1992). A survey initiated in 1971, aims to provide an inventory of soils, terrain forms, and climate for the whole of South Africa[7], with results providing reasonable assessments of erosion hazard (Schoeman and Scotney, 1987: 261). In 1978, Schulze assessed erosion impacts from thunderstorms, and produced iso-erodent maps for Natal. Although useful, these studies provide limited information and do not directly measure the impact of erosion on productivity.

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7 Although not yet complete, large areas throughout the country have been surveyed and assessed, with information being provided on 1 : 50 000 maps as it becomes available (Dent, 1994).

The Universal Soil Loss Equation (USLE), combines rainfall erosivity, soil erodibility, land attributes (slope and length), land use, and management characteristics, providing a practical tool for estimating site-specific erosion levels (Wild, 1993: 241). However, its application requires a relatively complex data base that is not available in South Africa.

The Erosion-Productivity Impact Calculator (EPIC) has been developed in the United States to assess effects of erosion on soil productivity (Williams *et al*, 1985: 216). It comprises physically based components for simulating erosion, plant growth and related processes, and economic components for assessing the cost of erosion and determining optimal management strategies. The EPIC model has produced reasonable results in the USA (Follet and Stewart, 1985: 102), and proved useful for quantifying costs of soil erosion, and benefits of soil conservation research (Jones *et al*, 1991: 341). To take advantage of EPIC and USLE models, conservation objectives in South Africa must facilitate research to collect appropriate data.

This information should contribute significantly to shaping farmers' perceptions about benefits of appropriate land-use, and preserving the land's productive potential. As discussed in 4.2, subsequent effects are expected to be reflected in the agricultural land market.

4.2 Farm land values and soil conservation investments

In chapter one, it was established that if soil conservation investments are not capitalized into land values, benefits are not realised because of imperfect information, and it is not rational for farmers to implement them. Given a well functioning land market and perfect information, implications of erosion and conservation activities will be captured by market forces, and reflected in land values. A flexible right to transfer land induces an owner to operate with an infinite planning horizon (Furubotn and Richter, 1991: 6), and internalising costs of erosion is feasible (Trudgill, 1990: 82). Nonetheless, information required to ensure the market accounts for these effects is not costless, and market prices for land may understate its true long-term social value (Crosson and Stout, 1983).

Studies to determine if conservation investments are capitalized into farm land prices show land with "visible" erosion sells for lower prices (Gardner and Barrows, 1985; and Ervin and Mill, 1985). Gardner and Barrows (1985), conclude conservation investments only pay once severe erosion has already occurred. Sinden and King (1988), found better conserved land sells for higher prices. Significant explanatory variables in this study are immediate and future yield expectations, the desire to obtain and maintain a fully productive resource, and the desire to avoid costs of improving land in poor condition. They conclude land condition is reflected in market prices "if buyers are well informed".

In support of these conclusions, Oberholzer (1994), explains visibly eroded commercial farm land in KwaZulu-Natal sells for relatively less. However, as new owners incur costs of establishing conservation measures and improving land in poor condition, they realise knowledge of these costs prior to purchasing the farm would have discounted the farm's value further. Similarly, although well conserved farms sell for more, these higher prices do not reflect the true value of established conservation measures (*ibid*, 1994). This enforces the notion that due to imperfect information, costs and benefits of visible erosion or conservation are only partially captured in the land market.

Included in the cost of providing information about erosion's impacts is the relatively long time period required to establish accurate assessments of erosion's consequences. In addition, since natural characteristics cannot be readily manipulated, it is essential agricultural systems operate within the land's natural constraints. In this regard, farmers' decisions and goals, and incentives or constraints created by various institutional arrangements within the agricultural sector, will affect the soil erosion process. From an economic perspective, information pertaining to these relationships, as discussed in 4.3, is equally important for developing soil conservation initiatives to encourage widespread implementation of conservation activities. Figure 2 illustrates how interactions between natural factors and those directing land use decisions in agriculture contribute to soil erosion.

4.3 Factors influencing farmers' adoption of soil conservation: Literature review

As far as the author is aware, Basson's (1962) is the only study in South Africa to analyze implications for soil conservation from an economic perspective. Therefore, the present research has relied mainly on soil conservation studies completed in the United States which identify the following as influencing conservation adoption; personal (age, education, farmer perceptions, management skills), physical (erosion/conservation characteristics of farms, farm size, farm enterprise mix), socio-economic (tenure arrangements), financial (farm debt, farm income, government payment receipts), and institutional factors (legislation, agricultural assistance programs) (Featherstone and Goodwin, 1993; Sinden and King, 1990; Gould *et al*, 1989; Norris and Batie, 1987; and Ervin and Ervin, 1982). These studies do not employ a standard theoretical model of soil conservation adoption and use, and each defines dependent variables differently.

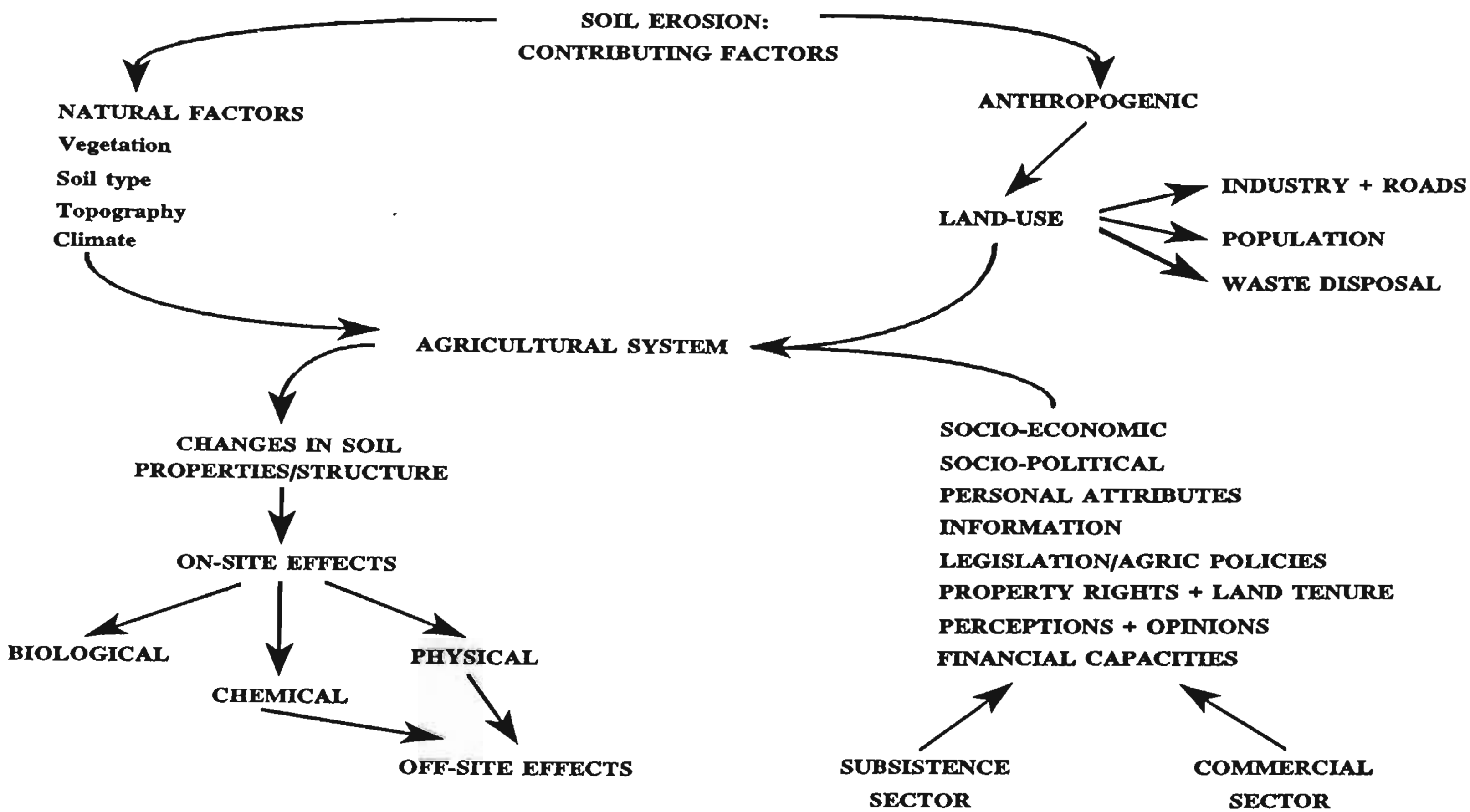

Figure 2: Factors affecting soil erosion (Adapted from Lal and Stewart, 1992a: 2-3).

Norris and Batie (1987: 80-81), assume conservation expenditures reflect farmers' willingness and ability to actually use conservation practices, while conservation tillage acreage reflects conservation effort. Using Tobit analysis, they found farmers' perceptions of erosion, farm size, income, education, and a farm conservation plan, to be significantly positively related to conservation expenditures. Off-farm employment, debt levels, and higher proportions of rented land relative to that operated are negatively related to this measure of adoption.

Different factors are significantly related to the measure for conservation effort. The intention to pass the farm onto a family member and area under crops are positively related, while farmers' age, income, off-farm employment, and erosion potential represented by factors of the Universal Soil Loss Equation, are negatively related. They conclude there are significant financial constraints to adoption, perception of an erosion problem is necessary before adoption will occur emphasizing the importance of relevant education and information, and adoption and effort depend on different factors. A variable representing cost sharing and subsidy payments was not significant in either adoption or effort models. This is attributed to limits set for these funds, which may be too low to affect affordability of conservation (*ibid*, 1987: 86).

Similarly, Featherstone and Goodwin (1993), used Tobit analysis to determine explanatory variables affecting expenditures on long-term conservation measures. Farm size, frequent contact with the extension service, and higher debt levels are positively related to long-term investment in conservation. Higher debt levels imply this may be a source of funds to finance conservation investments and/or lenders require conservation to protect their collateral value in the land (*ibid*, 1993: 70-71). Government payment receipts are associated with larger conservation expenditures suggesting conservation compliance programs are effective. However, results imply large government outlays or stricter compliance requirements are necessary to bring about significant increases in conservation activities, and appropriate targeting of these policies may be more effective (*ibid*, 1993: 80).

The intention to pass the farm onto a family member is positively related to long-term conservation expenditures, while older farmers, and livestock farmers compared to crop farmers, are less likely to make these investments. This latter result supports a priori expectations that crop farmers in the study area were expected to be better informed about benefits of conservation (*ibid*, 1993: 72).

Other studies are based on perceptions that conservation adoption is a multi-stage decision process, where realization of a soil erosion problem is not necessarily followed by action to correct it (Ervin and Ervin, 1982; Gould *et al*, 1989; and Sinden and King, 1990). Individuals would otherwise be perfectly rational, appropriate corrective action would internalize exclusive benefits (economic or otherwise), and decision makers would not face constraints (Duff *et al*, 1992: 403).

Ervin and Ervin (1982) conceptualize adoption of conservation activities to be determined by the following three stages; recognition of the erosion problem, number and type of conservation practices adopted, and conservation effort reflecting effectiveness and extensiveness of practices implemented. Multiple regression analysis was used to test hypothesized relationships.

Recognition of the erosion problem is significantly related to farmers' education and the land's erosion potential. Farmers' conservation attitudes and importance of contact with the extension service are positively related, but not significantly. This implies the value of the extension service in stimulating recognition through education, is secondary to their technical assistance role (*ibid*, 1982: 286). Actual adoption is positively influenced by education and the degree of erosion, negatively related to farmers' age, and less likely on crop farms. Effort is significantly positively related to farm erosion potential, farmers' education, farmers' perceptions about benefits of conservation, and subsidy and cost sharing arrangements. Crop farms are associated with less effort, although it was not possible to explain this given the studies limitations. Extension contacts are not significant in these last two stages.

Ervin and Ervin (1982: 289-291), conclude younger farmers are more aware of erosion and willing to implement conservation practices but need financial assistance, while older farmers require technical advice and educational programs to promote awareness of erosion problems. They suggest targeting homogeneous groups of farmers according to specific conservation needs may improve conservation, and emphasize the importance of financial variables for promoting effort as opposed to adoption.

Gould *et al* (1989), examine the effect of various factors on use of conservation tillage, using the same multi-stage decision process as Ervin and Ervin (1982). The recognition stage was estimated using a probit model, and the next two stages were estimated using a two-limit Tobit procedure (Gould *et al*, 1989: 171). Results and conclusions similar to Ervin and Ervin (1982) were derived, with most emphasis on education and the need to provide information. Adoption is less likely for higher levels of off-farm income. Individuals less reliant on farm-income may not perceive economic impacts of erosion large enough to justify conservation investments or develop conservation management skills (*ibid*, 1989: 180).

Sinden and King (1990), estimate models for three separate stages in the adoption process using logistic regression. The perception stage measures farmers' awareness of the erosion status of the land, the recognition stages determines if farmers are likely to recognize erosion as worth resolving, and the final stage reflects decisions to implement conservation measures. Results show farmers personal characteristics (education, perceptions, age, and adherence to a conservation ethic), and land characteristics (extent of visible erosion), are important for perceiving and recognizing the erosion problem. Economic factors (expenditure necessary to reduce erosion, those willing to invest their own funds, higher farm production) are important for resolving it.

Conclusions indicate information enhancing overall perceptions about the erosion problem should relate specifically to on-farm erosion impacts. The value of the extension service in promoting conservation, and a need to simplify processes and legalities involved in reaching conservation assistance agreements, are also important considerations (*ibid*, 1991: 191).

Esseks and Kraft (1991) assert the success of soil conservation policy depends on the extent to which farmers apply and maintain appropriate conservation measures. Effectiveness of monitoring and enforcing regulations, and farmers' assessments of the costs of non-compliance in terms of penalties levied, are therefore important considerations when making conservation adoption decisions (*ibid*, 1991:365). For successful compliance, farmers should believe there is a relatively high chance of both detection and penalization occurring. A majority of respondents perceive both detection and penalization to be likely, which is conducive to successful implementation of conservation policy (*ibid*, 1991:369). In a later study (Esseks and Kraft, 1993), perceptions of the likelihood of detection are shown to vary with farmers' expectations about how monitoring is conducted. Use of aerial photography as a monitoring tool significantly increases the perceived likelihood of detection (*ibid*, 1993: 465).

As illustrated in Figure 2 and enforced by the preceding review, a wide variety of factors influence conservation decisions. It is essential soil conservation policy is formulated so these factors and their interactions are accounted for. In chapter five, the government's role in formulating a soil conservation policy that meets these objectives is discussed. Current soil conservation initiatives in South Africa are also briefly revised.

CHAPTER 5

FORMULATING SOIL CONSERVATION POLICY

5.1 Considerations for soil conservation policy formulation

Although physical conservation measures to reduce erosion exist, it appears these are not widely adopted. If, due to imperfect information, market forces do not attach prices to the use of environmental goods, true opportunity costs of economic activities are not realised. Without market accountability, costs are passed onto future generations in the form of resource degeneration and depletion (Thompson Jr., 1992: 377).

Soil conservation policy objectives need to facilitate the realization of impacts of individual activities, by internalizing costs of erosion, and rewarding conservation activities (Siebert, 1992: 130). Farm land values will reflect these if a well functioning land market operates, where property rights are well-defined, enforceable, and transferable (Pasour, 1990: 200). Provided benefits, as reflected in market prices, exceed the costs, there will be incentives for soil conservation.

Although market prices are likely to account for future economic conditions more accurately than can be done through central direction (Pasour, 1990: 210), in the case of soil erosion, the market's effectiveness in internalizing costs of erosion and rewarding conservation activities, appears to be restricted by imperfect information. In section 5.2, the merits of government intervention to improve this market deficiency are discussed.

5.2 Government intervention and soil conservation policy

According to Prato (1985: 228), if soil conservation maintains long-term productivity of agricultural land and reduces off-site damages, its net social value is positive and government intervention is justified. This usually entails regulations, imposition of penalties or taxes, or provision of subsidies. These policies redefine individual incentive structures and resulting transactions costs play a crucial role in determining how resources are used (Coase, 1988: 12). Transaction costs include search and information costs, bargaining and decision costs, policing and enforcement costs (Dahlman, 1979: 148), and effectiveness of policies is determined by the governing bodies ability to absorb these.

It is unlikely that government has the necessary information about magnitudes, identities, preferences, and the dynamic nature of technologies, specific to each policy option, and since erosion is not uniformly distributed, policy enforcement and administrative functions are complicated. Therefore, due to high transactions costs, the mere existence of market failure does not in itself provide any reason for government intervention (Coase, 1988: 26).

Consistent policies and development incentives also require political continuity (Lal and Stewart, 1992b: 437), yet inherent in the political decision process is a relatively short five year planning horizon (Friend, 1992: 156). Furthermore, as illustrated in the historical review of South Africa's conservation policies, institutional change is likely to be an incremental process, minimizing disruptions to existing institutional arrangements (Libecap, 1991: 218 and Hughes, 1988: 76). Its repetitious nature, and high advertising costs, necessary to keep soil conservation issues in the spotlight, also make it difficult to ensure an unending stream of facts and publicity. (Kelley, 1984: 25; and Berg and Gray, 1984: 24).

Therefore, the government's role in formulating soil conservation policy is possibly best suited to minimizing transactions costs and developing an institutional framework that encourages pricing of environmental assets through market forces. This would involve providing information through research and education about soil erosion and conservation, and is distinct from having a clear advantage over market forces in using this information (Wills, 1987: 48). The extension service and Soil Conservation Committees could play valuable roles in fulfilling these functions. This information should narrow the gap between private and social discount rates with private actions leading to socially optimal land management.

5.3 Current soil conservation initiatives in South Africa

The following developments are relevant for soil conservation policy:

A recent amendment to the South African constitution allows provincial legislatures to make laws for protecting the environment, including soil conservation (Government Gazette, 1994a).

Draft legislation proposed by the Minister of Environmental Affairs suggests environmental impact reports will have to be submitted in respect of activities that have detrimental effects on the environment (Government Gazette, 1994b). These activities include: cultivation of virgin soil as referred to in Act 43/1983, overstocking, and farming operations that pollute public, private, or underground water.

To encourage farmers to operate according to their land's carrying capacity, only those registered with the Directorate: Financial Aid for the Disaster Drought Aid Scheme for Stock Farmers, and who submit stock numbers every three months for at least a year, will qualify for future government assistance (SAAU, 1993: 2).

A Landcare program is being initiated by the National Veld Trust. The main objectives are to demonstrate benefits of land care for land users, and initiate incentive schemes, research and integrated information collections, to foster sound land use (Havinga, 1994: 20).

Although site or region-specific policies may be appropriate, and targeting of conservation programs is expected to improve their economic effectiveness (Ribaudo *et al*, 1989: 43), the first two initiatives will incur high transactions costs associated with monitoring and enforcement. Objectives of the Landcare program are the most likely to generate market driven solutions to the erosion problem, and from an economic perspective, this project is optimal. Constraints in this approach relate to inadequate research methodology to identify and quantify site-specific soil erosion impacts, and the length of time required to obtain usable results.

5.4 Discussion

The framework for integrating development and conservation must be adaptive and responsive to changing circumstances, and development, environmental, agricultural, and soil conservation policies and programs, need to be consistent and complementary (Trudgill, 1990). The preceding literature indicates a wide variety of factors influence conservation decisions, implying an integrated, multi-disciplinary, holistic approach to the erosion problem, is required.

From a policy formulation perspective, factors easily manipulated by policy-makers and influencing land-use decisions in agriculture, are most relevant to this study. The success of conservation initiatives depends on the level of acceptance of the erosion problem, and the degree to which benefits are realized. Do farmers realize the magnitude of the soil erosion problem, and what motivates them to conserve their soil? While incurring the costs of conservation, do they receive benefits? (Trudgill, 1990).

Economists can contribute by providing information about costs and benefits relating to these issues. If the significance of parameters explaining excessive rates of soil erosion can be determined, then improvements to the current soil conservation policy can be recommended. Chapter six defines conceptual models, and outlines hypothesized effects of explanatory variables used in the empirical analysis. This aims to test theoretical relationships between, and establish the relative importance of factors influencing farmers' soil conservation decisions.

CHAPTER 6

CONCEPTUAL SOIL CONSERVATION MODELS AND HYPOTHESIZED EXPLANATORY VARIABLES

The literature review in chapter four implies adoption of soil conservation measures involves a multi-stage decision process, where each stage is influenced by different factors. Formulating soil conservation policy, according to constraints in each of these stages, could be an effective means of achieving improvements in soil conservation (Sinden and King, 1990; Gould *et al*, 1989; and Ervin and Ervin, 1982). South Africa's current soil conservation policy suggests the provision of both technical and financial assistance to farmers, and penalties for violations, will ensure soil conservation measures are adopted (Government Gazette No.9238, 1984). However, its effectiveness is questionable if all farmers do not face both technical and financial constraints, if transactions costs associated with meeting its provisions are high, or if legislation is not enforced.

Consequently, this study's empirical analysis is directed at isolating short-comings of this policy, compiling results that will be useful in recommending improvements, and identifying areas requiring further research. Models to represent a multi-stage adoption process and conservation effort are outlined below. Finally, a framework for analysing respondents' perceptions regarding detection and penalties for violating provisions of Act 43/1983 is discussed.

6.1 Conservation adoption

The adoption-decision process is assumed to incorporate the following four stages: awareness of erosion occurring, perception that erosion is worth trying to resolve, ability to implement conservation measures, and finally actual adoption of conservation practices. Identifying constraints within this decision process will enable appropriate assistance to be targeted at homogeneous groups of farmers.

The primary objective is to justify theoretical relationships between, and establish the relative importance of: managerial characteristics, enterprise combinations, erosion/conservation characteristics of farms, relevant institutional controls, farmer perceptions and opinions, and farm financial characteristics, in the conservation adoption process. As specific influences of explanatory variables will be useful in developing target strategies, separate estimation of models for each stage is pertinent (Ervin and Ervin, 1982: 290).

6.1.1 Conceptual models and hypothesized effects

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 (except in the adoption stage, see 6.1.5). If more than one measure were used to define an attribute, a simple chi-square test was conducted to ensure homogeneity between variables (Steel and Torrie, 1981: 281). This verifies variables measure similar dimensions in the data, and can therefore be combined.

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 reflects a low rating, negative perception, or less of the characteristic in question (ie. less erosion), and five represents a high rating, positive perception, or more of the characteristic in question (ie. 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.

6.1.2 Awareness model

As suggested by Ervin and Ervin (1982: 280), awareness of erosion occurring is presumed a prerequisite in motivating decisions to implement conservation measures. Farmers that either indicated erosion is at least a moderate problem on the land they own considering the climate and soil types, or agreed that erosion is a problem in their farming area, are defined as being aware and score one for this variable. These two measures guarantee farmers without on-farm erosion are not classified as unaware.

The following variables, relating to farmers' personal factors, physical farm characteristics, information factors, and conservation attitudes are expected to influence awareness. The extent of erosion on the farm when the farmer began managing it; the current percentage of farm area visibly affected by erosion; agents and media providing information on soil erosion and conservation, (eg. Soil Conservation Committees, extension officers, other farmers in the area, farm consultants, the farm's work force, field days or conferences dealing with soil conservation, farm magazines and agricultural news letters); changes in farm input costs and crop yield variability; and values attached to maintaining the land's market value and preserving a fully productive resource for future generations through soil conservation, are all expected to affect awareness levels positively.

Years of formal and agricultural education, and farmers' knowledge of erosion's implications for water pollution, silting up of reservoirs, and outdoor recreational activities on rivers and lakes, are also expected to have a positive influence on awareness levels. This is distinct from values attached to benefits of soil conservation associated with reducing these off-site erosion impacts. Off-site benefits from conservation may not be internalized on the farm and therefore their influence on awareness is uncertain.

6.1.3 Perception model

Farmers aware of erosion are likely to take corrective action only if they perceive it as something worth trying to resolve (Sinden and King, 1990: 182). Given erosion's implications for agricultural productivity, land values, and its off-site effects, it is worth considering corrective or preventive action, although costs of appropriate measures may exceed the benefits. The following two measures are used to define the perception attribute. Farmers score one for this dependent variable if they agree that bad conservation practices lead to losses in productivity, and agree that bad conservation practices are reflected in lower land values.

Similar variables, representing the same groups of factors modelled for awareness, (personal, physical farm characteristics, information variables, and conservation attitudes), and financial aspects, are expected to be relevant in the perception model. It is assumed that farmers investing their own capital when implementing soil conservation measures, and taking appropriate steps enabling them to introduce these with no outside technical assistance, do this because they perceive erosion as worth resolving. Therefore variables measuring these qualities are expected to be positively related to perception.

On-farm erosion that has had or is having impacts[8] on input costs, productivity and income; years of agricultural education; agents and media providing information on erosion and conservation; values attached to maintaining the land's market value and preserving a fully productive resource for future generations through soil conservation; knowledge of erosion's implications for water pollution, silting up of reservoirs, and outdoor recreational activities on rivers and lakes; perceptions relating to short-term farm financial and managerial benefits derived from soil conservation; the opinion that it is appropriate for the government to establish soil loss limits based on recommendations from Research Institutes; values attached to benefits of soil conservation associated with reducing off-site erosion impacts; risk aversion[9]; and the influence of financial institutions, in as much as they are a source of credit and will aim to protect their collateral value in the land (Featherstone and Goodwin, 1993: 71), are presumed to have positive implications for perception.

6.1.4 Ability models

According to Padgitt and Lasley (1993: 398-399), and as implied by provisions in Act 43/1983, farmers facing technical and/or financial constraints will be unable to implement effective soil conservation measures. Therefore the ability stage is divided into two components;

i) technical ability - reflecting farmers' knowledge about implementing and maintaining required soil conservation measures, and

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8 Erosion's impacts may only become apparent after a relatively long time period, rather than within a single production season, so past experience of these is also expected to be important.

9 A risk aversion index was constructed from questions 3 and 7 in section 4 of the questionnaire (Appendix A). Average scores for each statement represent an overall risk index, where a low score indicates more risk aversion and a high score indicates low risk aversion (Ervin and Ervin, 1982: 295).

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

6.1.4.1 Technical Ability model

Farmers believing they have the technical knowledge to construct and maintain soil conservation practices required for their farms, and rating their soil conservation management skills as four or five, on the scale of one (low) to five (high), are assumed to have the necessary technical ability. Accordingly farmers with these characteristics score a one for this dependent variable.

Factors expected to affect technical ability relate to managerial and farm characteristics, and information variables. The frequency with which farmers attend soil conservation courses, and assist others to implement conservation measures; years of formal and agricultural education; knowledge of soil conservation legislation; opinions relating to whether legislation to control soil erosion should be binding on the landowner and/or the farm manager, and if it is appropriate for the government to establish soil loss limits based on recommendations from Research Institutes; and agents and media providing information on erosion and conservation, are expected to be positively related to technical ability.

Risk aversion and educational programs, as a policy tool to promote soil conservation, are also expected to have positive influences on technical ability. As discussed in 4.3, relationships between enterprise types and conservation activities show mixed results. Therefore, the effects of farm enterprise combinations on technical ability are uncertain. Irrespective of who operates a farm (ie. the owner or a lessee), land owners stand to lose if their land is not properly conserved, especially if a well functioning land market operates and erosion is reflected in lower land values. Consequently, lease agreements are expected to incorporate conditions relating to soil conservation activities. Therefore, proportions of farm land rented and owned should not affect conservation decisions. However, if farmers who rent additional land have relatively better management skills, then the proportion of farm area owned relative to that operated may be negatively related to technical ability. The significance of this variable is tested in this model.

6.1.4.2 Financial Ability model

Farmers believing they have the financial resources to construct and maintain soil conservation practices required for their farms score a one for this dependent variable. This measure may not distinguish between "having the financial ability" and "being willing" to invest money in soil conservation measures. This should be considered when interpreting results for this model.

Farm financial characteristics, farmer perceptions and enterprise types are the main hypothesized explanatory variables for this model. Farm financial characteristics; debt to asset ratios, farm profit, government payment receipts, credit reserves, and off-farm income are expected to be influential factors in the adoption process. Soil conservation has significant costs in the short-term due to installation, maintenance operations, and changes in both management and farming practices, with direct impacts on returns in the year of adoption. Reductions of between three and five percent in gross farm receipts attributed to land degradation in Canada over 25 years, is relatively insignificant compared with monthly cash flow constraints (Miller, 1986: 12). As a result, soil conservation is often overlooked to survive immediate economic crises.

In studies by Lynne *et al* (1988: 17), and Hansen *et al* (1987: 369), it is shown that adopters of soil conservation activities are less risk-averse. Therefore, farmers' risk aversion; perceptions with respect to short-term financial benefits derived from soil conservation; the frequency with which they are prepared to invest their own capital in soil conservation measures; annual expenditures on construction and maintenance of soil conservation works; and opinions as to whether the government should compensate those who adopt soil conservation measures, are presumed to have positive impacts on financial ability. It is anticipated that predominantly livestock enterprises will be negatively related to financial ability, since establishment of rotating camps requires large capital expenditures on fencing (Ervin and Ervin, 1982: 289).

6.1.5 Conservation Adoption model

Conservation adoption is associated with the number of different soil conservation practices implemented and does not correspond to effectiveness or extensiveness of their use (Ervin and Ervin, 1982: 280). The dependent variable for the adoption model is defined as follows: it is the ratio of the number of different types of soil conservation practices used on a farm, to the maximum number applicable for a particular farm enterprise mix. Contouring (run-off control), conservation structures in dongas, minimum tillage, and rotating camps, are deemed applicable conservation practices for farms with both crop and livestock enterprises. Adoption scores for mixed farms are therefore out of four. Rotating camps and minimum tillage are not applicable if farms have only crop, or only livestock enterprises respectively, and adoption scores for single enterprise farms are out of three. Windbreaks are excluded as a possible conservation measure as only 13 farmers indicated using them and this is highly site-specific. This model therefore predicts the probability that a farmer will adopt all applicable soil conservation practices according to the farm enterprise mix.

Explanatory variables for this model include those whose coefficients' are significant in each of the previous models, and variables used to define the dependent variables in these models, incorporating the need to overcome prior constraints. In addition, institutional factors that may encourage implementation of conservation measures, such as discovery of violations specified in Act 43/1983 and subsequent prosecutions, are expected to have positive impacts on adoption.

6.2 Conservation Effort model

According to Ervin and Ervin (1982: 291), adoption of soil conservation practices and soil conservation effort are not conceptually substitutable, despite the obvious link between the two. For example, a livestock farm utilizing rotating camps may be effectively conserved, and, a farm with mixed enterprises while using several conservation practices, may only be partially conserved. This distinction has important implications for policy formulation, since factors affecting adoption decisions will not necessarily provide information pertaining to soil conservation effort (Norris and Batie, 1987: 80). If the primary objective of soil conservation policy is to minimize erosion, it is imperative that factors affecting the extent to which soil conservation is applied, are also considered.

Various studies have defined conservation effort differently. Possibly the most appropriate measure is the difference between the estimated farm erosion rate without soil conservation practices and that erosion rate where practices are used (Ervin and Ervin, 1982: 282). It was not possible to collect this information for this study. Norris and Batie (1987: 80) measure conservation effort using total capital expenditures and operation and maintenance expenses on soil conservation practices. They concede these expenditures do not consider the amount of soil conservation achieved, and rather reflect farmers' willingness and ability to actually use conservation practices. Prundeanu and Zwerman (1958), use a physical measure of conservation effort based on the type and extent of practices used on farms. They measure conservation effort by the extent to which soil conservation measures, as recommended by Soil Conservation Service technicians, have been implemented (*ibid*, 1958:904).

In this study, farmers provide estimates of the percentages of arable land and veld on their farms currently protected with soil conservation practices. This information is used to approximate conservation effort on crop and livestock farms respectively. For farms with both crop and livestock enterprises, the sum of weighted averages of the percentages for arable land and veld, (according to their respective areas), are assumed to represent conservation effort. This is similar to the measure used by Prundeanu and Zwerman (1958), and although incomplete in that it does not necessarily reflect conservation effectiveness, it is the most appropriate considering the available data.

Since implementing all the farm's necessary soil conservation practices is likely to involve large expenditures, financial characteristics are expected to be the most important explanatory variables in this model.

The hypothesized relationship between effort and debt is uncertain. Higher debt obligations could mean less capital available for conservation expenditure and therefore the relationship would be negative. However, when farmers use their land as collateral to obtain credit, financial institutions may stipulate a conservation plan to protect their collateral, or debt finance may be a source of funds for soil conservation expenditures, and the relationship would then be positive (Featherstone and Goodwin, 1993: 70-71). Financial variables expected to influence effort positively are those representing the effect of existing conservation measures on farm profit, farmers investing their own capital when implementing the required conservation measures, less risk averse farmers, and those favouring subsidies to assist with implementing conservation measures. Similarly, farmers deriving most of their family income from the farm business are expected to protect their source of income, and so conserve their land (Nielsen *et al*, 1989: 12).

Personal factors, such as conservation management skills; intention to pass a farm on to a family member; education; perceptions about the costs and benefits of soil conservation; and years of farming experience, expected to capture knowledge gained about the importance of soil conservation and a time period long enough for all required conservation measures to be implemented, are also presumed to have a positive influence on effort.

Institutional factors relating to discovery of violations specified in Act 43/1983 and subsequent prosecutions, physical factors concerning farm enterprise types and erosion impacts, and information variables (agents and media providing information on soil erosion and conservation decisions), are included in the analysis, and are expected to have positive impacts on effort. Noticeable erosion impacts are expected to be associated with less conservation effort, and as hypothesized for the adoption models, the relationship between enterprise type and effort is uncertain.

6.3 Monitoring and enforcing soil conservation policy

Data reflecting farmers' perceptions regarding the probability that excessive levels of erosion on their farms will be discovered by authorities, and their chances of being prosecuted in these circumstances, were collected in the survey. Unfortunately, this did not include information about how farmers' perceptions about detection vary according to monitoring methods.

Farmers' responses regarding these issues indicates the extent to which they feel compelled to comply with provisions of Act 43/1983. If the extension service compiles farm conservation plans when violations are detected, and subsequently subsidizes their implementation without penalizing farmers, then there is very little incentive to comply with the Act's provisions.

Statistical techniques and model estimation procedures used in the empirical analysis are explained in Chapter seven.

CHAPTER 7

METHODOLOGY AND MODEL ESTIMATION PROCEDURES

As explained in 6.1.1, dependent variables for models representing the stages in the adoption-decision process are defined as binary variables. Therefore it is appropriate to use logistic regression analysis to assess variables influencing each stage. Conservation effort is modelled separately using linear regression. Descriptive statistics are used to assess the adequacy of monitoring and enforcement functions associated with Act 43/1983. SPSS (SPSS Incorporated, 1990), and Genstat (Payne *et al*, 1987) statistical packages are used for the analysis.

7.1 Logistic regression analysis

In logistic regression, 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_i), equation (1), represents the log of the odds ratio in favour of having an attribute (ie. the ratio of the probability of having an attribute (P_i) given X_p, to the probability of not having the attribute). L_i is linear in parameters (B_i) (Gujarati, 1988: 482), which are estimated using the maximum likelihood method (Noru\v{s}is, 1990a: 47). This generates coefficients making observed results most "likely".

$$L_i = \ln[(P_i)/(1 - P_i)] = B_0 + B_1X_1 + B_2X_2 + \ldots + B_pX_p \qquad (1)$$

Interpretations of logit coefficients differ from linear regression coefficients, and represent the change in the log odds associated with a one-unit change in explanatory variables (X_i). Rearranging equation (1), the probability of having an attribute given X_p can be written as:

$$P_i \text{ (Having an attribute/}X_p\text{)} = \frac{1}{1 + e^{-Li}} \qquad (2)$$

Equation (2) represents the logistic function which guarantees that estimated probabilities (P_i)s lie between zero and one and vary non-linearly with X_i. Equation (2) is intrinsically linear since the logit is linear in X_i (Gujarati, 1988: 483).

In SPSS, dependent variables in logistic regression can only have two values, zero or one, and this package was used to estimate the awareness, perception, and ability models. The dependent variable for the adoption stage has a range of possible values between zero and one[10], and it was necessary to use the Genstat package to estimate this model.

7.1.1 Model estimation procedures

A three stage procedure was followed when estimating models for the adoption-decision process. To isolate variables with the maximum number of valid cases, the numerous explanatory variables for each model were divided into two groups (Levin, 1994). The first group contained variables with less than 10 missing values in the data set, and the second, variables with more than 10 missing values. There is a high degree of correlation (at least at the five percent level of significance) between several variables in each group. Therefore,

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[10] The dependent variable used in the adoption stage is defined in section 6.1.5, Chapter six, page 57.

in an attempt to reduce the number of explanatory variables, a principal component analysis (PCA) was conducted on each group.

In PCA, variables are standardized in order to avoid one variable having an undue influence on the principal components (PCs), and the analysis is carried out on the correlation matrix (Manly, 1990: 63). Principal components are uncorrelated indices measuring different dimensions in the data (Manly, 1990: 59). Only PCs with eigenvalues greater than one were retained (Norušis, 1990b: 319), each approximately measuring the effects of variables having component loadings greater than 0.3. Finally, correlation coefficients between PCs from the two groups were computed.

In the second stage, all PCs from the first group and those from the second group, not correlated with those from the first (at least at the five percent level of significance), were regressed in a logit model on the dependent variable. In an attempt to identify the best models, equations were estimated using forward-stepwise, backward-stepwise and enter methods for entering independent variables into the model (SPSS Incorporated, 1990: 317). Each method used to enter independent variables into the model retained 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 principal component analysis was conducted on this set of isolated variables, and the new PCs derived regressed in the logit models. All components, including those with loadings less than 0.3, are used to calculate principal component scores. Therefore PC coefficients in each of the predicted models indicate the relative contribution of each component to the dependent variable. 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, were used to select the best models.

Regression coefficients for PCs are difficult to interpret because they are measured in standardized units. For unit changes in the PCs, although their coefficients indicate the relative magnitude of the predicted change in the dependent variable (ie. large or small, positive or negative impacts), the absolute value of this change cannot be interpreted. If individual variables with the largest component loading from each significant PC in these final models, are regressed on dependent variables, the models may be specified more clearly. However, 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 cannot be meaningfully interpreted. Consequently, utilizing principal components is not considered to impose additional limitations.

For the adoption stage, the models estimated using PCs as explanatory variables (measuring those factors described in 6.1.5), were not statistically significant. Therefore, individual variables were standardized, to avoid interpretation problems that may arise due to different units of measurement, and these are used to estimate this model using a stepwise procedure. At each step, the contribution made by the additional variable to the model is assessed. If the change in residual deviance between models with and without this variable is significant (based on the chi-square statistic), then the variable significantly improves the model and is retained despite any correlation with other variables already in the model.

To ascertain whether definitions for the adoption stage dependent variable for specific farm types[11], are significantly different from each other, two dummy variables distinguishing between crop, livestock, and mixed farms[12], were regressed in the final model. The significance of these dummy variables has implications for interpreting the model correctly.

7.2 Linear regression analysis

The conservation effort model is estimated using linear regression analysis. It is appropriate to use a natural logarithmic transformation for the dependent variable (Y_i), when this has a relatively wide range of values (Steel and Torrie, 1988: 235), as is the case in this study[13]. In linear regression analysis, when Y_i is in log form, model parameters represent the constant relative change in Y_i given a unit change in the corresponding explanatory variable (X_i). Multiplying model coefficients by 100 will indicate the percentage change in the Y_i for unit changes in X_i (Gujarati, 1988: 147-148). To avoid complications where respondents may have recorded zero conservation effort, one was added to each conservation effort value prior to the natural logarithmic transformation. SPSS is used to analyze the conservation effort model (SPSS Incorporated, 1990).

A principal component analysis, following the same procedure described in 7.1.1, was also used to reduce the number of explanatory variables for this model. These PCs are regressed

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[11] Adoption score derivations are explained in section 6.1.5, Chapter six, page 57.

[12] Table 23 in Appendix B illustrates the number of specific farm types (ie. crop, livestock, or mixed farms), in each region in the sample.

[13] The dependent variable for conservation effort is defined in section 6.2, Chapter six, page 59.

on the transformed conservation effort variable using the enter method for entering explanatory variables into the model.

Once each of the models in the analysis had been identified, dummy variables for farm region were regressed on 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. Therefore, the significance of these dummy variables is important when interpreting the models' results.

Finally, information relating to monitoring and enforcement of Act 43/1983 is derived from frequency tables, and cross-tabulating responses, using SPSS.

In chapter eight, the method used to collect the data for this study is described, and respondents' characteristics and soil conservation orientations are summarized.

CHAPTER 8

DATA SOURCE, RESPONDENTS' CHARACTERISTICS AND SOIL CONSERVATION ORIENTATIONS

8.1 Data source

Data were collected from five different areas in KwaZulu-Natal, namely Dalton/Wartburg, Camperdown/Eston, Estcourt, Winterton, and Dundee. These were identified in consultation with extension specialists at the Cedara Agricultural Development Institute, and Figure 3 illustrates their relative positions in the KwaZulu-Natal province. Soil conservation incentives are expected to differ according to enterprise types and site-specific circumstances, and stratifying according to these regions accounts for a diverse spectrum of agricultural systems. General soil types; climate variation (particularly rainfall); enterprise types; and farming community viewpoints on soil conservation, are the main distinguishing factors. Dalton/Wartburg is the best conserved district in the sample, and Estcourt the least conserved (Le Roux, 1993; and Oberholzer, 1994).

Respective Soil Conservation Committees were approached, and willingly supported the study. Extension office records indicate there are at least 500 farmers in these five districts. To ensure success of the study, data from a reasonable number of respondents across these five regions, was required. Due to the large number of potential respondents, financial, personnel, and time constraints, it was decided a postal survey would be the most effective means of collecting relevant data. Addresses for 498 possible respondents belonging to

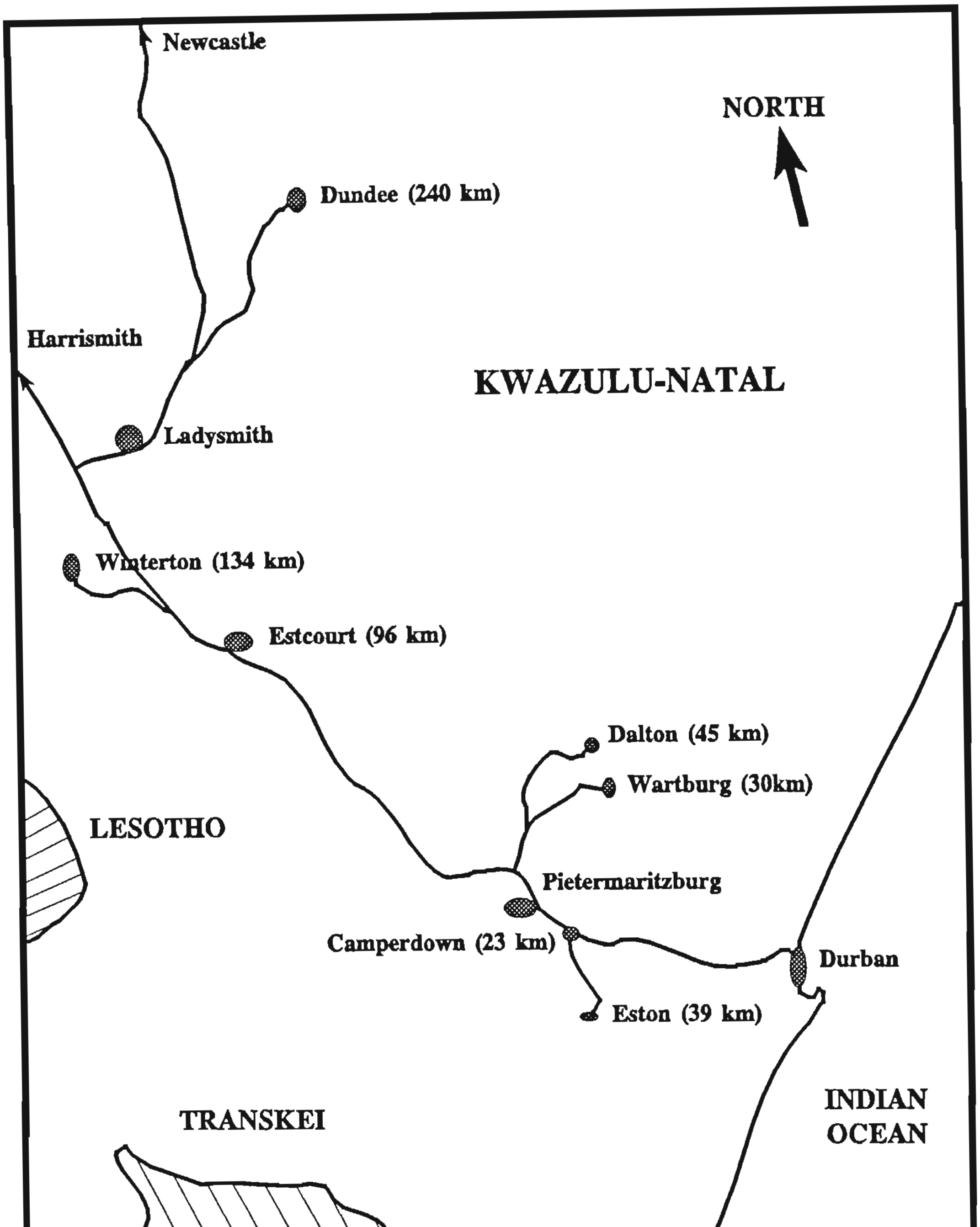

Figure 3: Map indicating farming areas in KwaZulu-Natal where surveys were conducted. (Source: Automobile Association of South Africa, 1993).

respective Farmers' Associations in each region were provided by extension service offices. Duplicate and incorrect addresses reduced the sample to 480.

Survey questions were adapted from studies undertaken in the United States, and the questionnaire is shown in Appendix A. Members of Soil Conservation Committees in each area participated in a pilot survey to ensure questions were relevant and clear. Questionnaires were revised, and mailed to farmers in September 1993. A cover letter from the relevant Soil Conservation Committee Chairman requesting farmers to support the survey, one outlining the objectives of the study, and a self-addressed postage-paid envelope, were also included.

The following steps were taken in an attempt to ensure a good response rate for the survey. Farmers were not required to put their names on the questionnaires. However, to enable reminder letters to be posted to non-respondents, codes corresponding to farmers' addresses were placed on questionnaires (Woodburn, 1993: 22). Afrikaans translations of survey questions and cover letters were copied onto the reverse side of the english versions to accommodate farmers' language preferences. Consideration was given to the possibility that farmers may be reluctant to provide information about their farm financial characteristics. Therefore, questions were structured so financial variables are expressed as a percentage of farm turnover, rather than in absolute values. After five weeks, a reminder letter was posted to those who had not responded, resulting in a further 19 questionnaires being returned during the ensuing six week period.

In total, 37 percent (179 questionnaires) were returned, and 35 percent of the original sample size (159 questionnaires) are usable. Response rates ranged from 29 percent to 41 percent in Camperdown/Eston and Winterton respectively. Surveys to collect information for soil conservation studies in the United States report response rates of 46 percent (Molnar and Duffy, 1988: 183), and 50 percent (Bultena *et al*, 1981: 38), where initial sample sizes were 9250 and 933 possible respondents respectively. A 35 percent response rate for a postal survey of commercial farmers, conducted in KwaZulu-Natal in 1993, was reported by Woodburn (1993). The response rate for this study is therefore reasonable, although results may be biased in favour of those interested or concerned about soil conservation.

8.2 Respondents' characteristics and soil conservation orientations

The average age of respondents is 47 years, while 90 percent (136 respondents) are full-time farmers. Their mean years of formal education is 11, of which 2 years is specifically agricultural training. Twenty percent (31 farmers) have debt-asset ratios greater than 30 percent, and 21 percent (34 farmers) chose not to provide this information. The average area owned is 895.3 hectares, with 36 percent (56 farmers) inheriting their land. Nine of these farmers have since bought additional land. An average 124.0 hectares are cash leased, and 29.5 hectares share leased. This means farmers in the sample own approximately 88 percent of the land they farm.

Dairy, beef, sheep, timber, sugar cane, and maize are the main enterprise types on the farms sampled. To account for differences in conservation incentives and constraints experienced among enterprise types, the proportion of farm area used for cropping activities as opposed to livestock activities, is calculated as hectares of currently cropped land to total hectares operated. These percentages of cropped land are illustrated in Table 4. Area under timber is classified separately.

Table 4: Cropped land as a percentage of farm area, for farms sampled in KwaZulu-Natal (October 1993).

Farming Area	Cropped land (%)
Dalton/Wartburg	60.4
Camperdown/Eston	37.8
Dundee	5.2
Estcourt	2.9
Winterton	31.9

The Dalton/Wartburg district reflects a predominantly crop farming area where sugar cane is the main crop activity. Camperdown/Eston has similar areas under crop activities (mainly sugar cane) and timber. Beef, dairy, and sheep operations dominate Dundee and Estcourt regions, and these are labelled as livestock farming areas. Finally, the Winterton area portrays the best concept of mixed farms within the sample, where maize, beef and to a lesser extent dairy, are primary enterprises.

Percentages showing respondents' use of the following conservation practices: contouring (run-off control), conservation structures in dongas, minimum tillage, rotating camps, and windbreaks, are shown in Table 5. It is noteworthy that minimum tillage is used by 50 and 48.3 percent of respondents in Camperdown/Eston (11 farmers) and Winterton (14 farmers) respectively. However, in Dalton/Wartburg, the predominantly crop farming area in the sample, only 30.8 percent (12 farmers) use this conservation measure.

Table 5: Use of conservation practices on sample farms in KwaZulu-Natal (1993).

Conservation practice	Percentage of farmers using practices
Contouring (run-off control)	87.8
Conservation structures in dongas	52.6
Minimum tillage	35.6
Rotating camps	66.7
Windbreaks	8.3

Sixty-seven percent (98 farmers) believe implementing all the farm's necessary soil conservation measures would be financially beneficial to their farming operation, while 80 percent (114 farmers) perceive this would improve managerial activities. However, only 54.3 and 57.1 percent of respondents from Camperdown/Eston are optimistic about deriving financial and managerial benefits from implementing soil conservation measures. Sixty-two percent (95 farmers) of all respondents report the effect of existing soil conservation measures on the farm's profitability as beneficial. Excluding any government financial assistance, 39 percent of those sampled (59 farmers) believe economic returns to soil conservation measures outweigh the costs of implementation in the short-term, and 72 percent (111 farmers) envisage this in the long-term. Seventeen percent (26 farmers) are 'undecided' in each case.

Only 19 percent of respondents (29 farmers) indicate they are not aware of legislation under which farmers may be prosecuted for having excessive levels of erosion on their farms. Most respondents from Dalton/Wartburg and Dundee, 89.7 and 86.7 percent respectively, are aware of this legislation. Opinions as to whether legislation should be binding on the landowner, or the farm manager vary significantly between regions. Ninety percent believe legislation should be binding on the landowner, 60.5 percent believe it should be binding on the farm manager, and 58.1 percent believe it should apply to both these parties. As few as 42.1 percent of respondents from Winterton agree legislation should apply to both owners and managers, while 68.8 and 68.4 percent of those from Dalton/Wartburg and Dundee respectively, agree with this.

Results of the empirical analysis are presented in the following chapter.

CHAPTER 9

FACTORS INFLUENCING SOIL CONSERVATION ADOPTION AND EFFORT ON COMMERCIAL FARMS IN KWAZULU-NATAL

Results for models representing the various stages in the adoption-decision process, conservation effort, and farmers' views regarding monitoring and enforcement of Act 43/1983 are presented below.

There are two tables to explain results for the logit models in sections 9.1 to 9.4. The first describes principal components that are significant in each model, and the second table presents equations representing the models.

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 (minus two log of the likelihood), indicates the predicted model is not significantly different from the perfect model. The goodness of fit statistic compares observed probabilities with those predicted by the model. There should be no statistically significant difference between observed and predicted probabilities if the model is a good one (Norušis, 1990a: 52). Cases correctly classified by the predicted model, indicated at the bottom of each table, enforce 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 (Norušis, 1990a: 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 coefficients for variables added at the last step are zero (Norušis, 1990a: 53).

9.1 Awareness model

Thirty-five variables representing factors described in 6.1.2, (of which 21 have less than 10 missing values), are expected to influence awareness. In the second stage of the model estimation procedure[14], 12 individual variables represented by six PCs were identified as significantly affecting awareness. In the final stage, the forward-stepwise method for selecting explanatory variables produced the best Awareness model.

Only PCs with coefficients significant at the 10 percent level (or higher), based on the likelihood ratio criterion, are retained (Norušis, 1990a: 48). The model shows three PCs are significantly related to awareness of the erosion problem, and these are presented in Table 6. 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 and perceptions regarding erosion's implications for the broader environment.

The Awareness model is presented in Table 7, where variable labels and their coefficient estimates (B_i) are indicated in the first and second columns respectively. Exponential(B_i), or Exp(B_i), presented in the third column, is the factor by which the odds, or probability in

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[14] Model estimation procedures are described in section 7.1.1, Chapter seven, page 63.

Table 6: Details of principal components that are significant in the Awareness model.

Principal component Label		Variables with component loadings greater than 0.3	
AWR1	=	0.82*Spolut	+ 0.76*Ssilt
AWR2	=	0.81*Erofm	+ 0.80*Erob
AWR3	=	0.76*Yraed	+ 0.75*Envir

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:

Spolut	=	individual ratings reflecting values attached to minimizing water pollution, as a potential benefit from soil conservation.
Ssilt	=	individual ratings reflecting values attached to preventing silting up of reservoirs and maintaining storage capacities, as potential benefits from soil conservation.
Erofm	=	percentage of farm area visibly eroded.
Erob	=	extent of erosion on the farm when the farmer began managing it.
Yraed	=	years of formal agricultural education.
Envir	=	index reflecting perceived seriousness of erosion impacts on the environment.

favour of having the attribute, changes when the corresponding explanatory variable increases by one unit (Noruŝis, 1990a: 49). Only the relative magnitude of Exp(B_i) can be interpreted, rather than its absolute value, because PCs are measured in standardized units. If B_i is negative, Exp(B_i) is less than one and the factors represented by the corresponding PC

Table 7: Logit model; factors affecting farmers' awareness of the erosion problem, on farms sampled in KwaZulu-Natal (October 1993).

Dependent variable = the probability in favour of farmers being aware of the erosion problem

Variable	Coefficient estimate (B_i)	Exp (B_i)	Significance levels for goodness of fit statistics	
AWR1	- 0.69**	0.50	-2 Log Likelihood	0.21
AWR2	1.00**	2.73	Model Chi-square	0.00
AWR3	1.04**	2.84	Improvement	0.01
Constant	0.70**		Goodness of Fit	0.24

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

Number of cases included in this analysis	118
Overall classification	78.8%

decrease the odds. Conversely, if B_i is positive, Exp(B_i) is greater than one and the odds are increased. Therefore, Exp(B_i) 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(B_i) value for AWR1 implies the odds of being aware decrease 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 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[15] 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 individuals' farms (AWR2) increase the odds of being aware. As explained in Chapter one, it should be emphasized that erosion can have adverse consequences for a soil's 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 Conservation Committees, field days/conferences, farmer's own knowledge, and other farmers in the area), and media (extension service reports), providing information on soil erosion and conservation decisions.

Enforcing prior expectations, higher agricultural education levels and more knowledge about erosion's implications for water pollution, silting up of reservoirs, and outdoor recreational activities on rivers and lakes (AWR3), have the greatest positive influence on the odds of being aware. It is important to emphasize the distinction between AWR1, which relates to on-farm or individual benefits, and AWR3, which refers to social benefits, derived from reducing erosion's off-site impacts. The majority of farmers, although aware of effects of soil erosion on the broader environment (AWR3), are not likely to derive individual or on-farm benefits from reducing these off-site impacts (AWR1).

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[15] Farmers rated the statement "Provides benefit of capital gain from property investment" as a reason for farming, relative to other reasons. (Section one, question four in the questionnaire: Appendix A).

9.2 Perception model

For this model, 22 explanatory variables with less than 10 missing values, and 24 with more than 10 missing values are hypothesized to influence the perception that erosion is worth resolving. These comprised similar groups of factors modelled for awareness (see 6.1.3). In the second stage of the model estimation procedure, 10 variables reflected in five PCs had a significant effect on perception.

In the final stage, the best model was obtained using the enter method for entering independent variables into the model. With the enter method, variable coefficients significant at the 10 percent level (or higher) based on the Wald statistic are retained in the model. Three PCs, described in Table 8, are significantly related to the perception attribute.

Investment of farmer's own capital when implementing conservation measures, and the ability to do this with no technical assistance are characteristics measured by PCP1. PCP3 portrays farmers' knowledge of erosion's implications for the environment and the subsequent need for control measures that enforce soil loss limits. Effects of reductions in agricultural productivity due to erosion, and the value of extension officers for providing information on soil erosion and soil conservation decisions are captured by PCP4.

The Perception model is presented in Table 9. 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 (Norušis, 1990a: 48).

Table 8: Details of principal components that are significant in the Perception model.

Principal component Label		Variables with component loadings greater than 0.3
PCP1	=	0.83*Rivest + 0.79*Rintro
PCP3	=	0.81*Envir + 0.77*Loslim
PCP4	=	0.87*Impct + 0.50*Extoff + 0.44*Agprd

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:

Rivest	=	frequency with which farmers invest their own capital when implementing soil conservation measures.
Rintro	=	frequency with which farmers implement soil conservation measures with no outside technical assistance.
Envir	=	index reflecting perceived seriousness of erosion impacts on the environment.
Loslim	=	it is appropriate for the government to establish soil loss limits based on recommendations from Research Institutes (dummy variable: yes = 1, no = 0).
Impct	=	past and current experience of circumstances where significant soil loss has had impacts on inputs, yields, or income[16] (dummy variable: yes = 1, no = 0).
Extoff	=	individual ratings reflecting the value of extension officers for providing information on soil erosion and soil conservation decisions.
Agprd	=	when the farmer began managing the farm, was the loss in agricultural productivity due to erosion significant (dummy variable: yes = 1, no = 0).

[16] Erosion's impacts may only become apparent after a relatively long time period, rather than within a single production season, so past experience of these circumstances is also important.

Table 9: Logit model; factors affecting farmers' perceptions that erosion is worth trying to resolve, on farms sampled in KwaZulu-Natal (October 1993).

Dependent variable = the probability in favour of farmers perceiving erosion as something worth trying to resolve

Variable	Coefficient estimate (B_i)	Exp (B_i)	Significance levels for goodness of fit statistics	
PCP1	0.41**	1.50	-2 Log Likelihood	0.11
PCP3	0.25	1.29	Model Chi-square	0.00
PCP4	0.84**	2.32	Improvement	0.00
Constant	0.83**		Goodness of Fit	0.17

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

Number of cases included in this analysis	131
Overall classification	76.3%

Coefficient signs for the PCs retained in the model are in accordance with *a priori* expectations, and 76.3 percent of cases in the sample are correctly classified by the model. PCP1 implies farmers making financial provision for, and taking appropriate steps enabling them to implement erosion control measures themselves, perceive erosion as worth resolving. PCP1 is positively correlated (at the five percent level of significance) to a PC representing agents (Soil Conservation Committees, field days/conferences, and farmer's own knowledge), and media (extension service reports) providing information on soil erosion and conservation decisions. Knowledge of the seriousness of erosion's off-site impacts for society (PCP3) also has a positive influence on the perception attribute, and is positively correlated (at the five percent level of significance), to a PC representing consultants as agents that provide respondents with information on soil erosion and conservation decisions.

Individual experiences where observable impacts on agricultural production, as a direct result of erosion (PCP4), have the largest positive influence on perceptions that erosion is worth resolving. The value of extension officers is important in these circumstances, presumably in an advisory capacity. PCP4 is positively correlated (at the one percent and five percent levels 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 and maintaining the land's market value. This implies that farmers perceive that soil conservation investments do affect land values.

The PC representing the importance of on-site benefits derived from reducing off-site erosion impacts is negatively correlated to PCP4. These variables have similar effects on perception and awareness, enforcing the earlier implication that off-site benefits from soil conservation cannot be internalized at the farm-level.

Information variables: Soil Conservation Committees, field days/conferences, extension officers, consultants, farmer's own knowledge, other farmers in the area, and extension service reports, make important contributions in these first two stages of the adoption-decision process. It is reasonable to assume that these factors are complementary, an effective means of dispersing 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 models, are inconsistent. The relevant correlation coefficient indicates respondents with higher capital gains motives, (who are apparently less aware of erosion and its implications), are also part-time farmers. However, as implied in 4.2, 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 are perhaps better informed, and therefore realize the true value of soil conservation investments, even though these may not be fully reflected in the land market. This issue requires further research.

9.3 Technical Ability model

Factors expected to influence farmers' technical ability to implement conservation measures are represented by 31 variables (see 6.1.4.1). Ten variables approximated by four PCs were significantly related to technical ability in the second stage of the model estimation procedure outlined in 7.1.1. As in 9.2, 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 10.

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 agricultural education are represented by TABL3. TABL4 indicates the proportion of farm area currently under timber and knowledge of soil conservation legislation. Table 11 shows the Technical Ability model, which fits the data better if TABL4 is retained, despite its coefficient being statistically insignificant.

Table 10: Details of principal components that are significant in the Technical Ability model.

Principal component Label		Variables with component loadings greater than 0.3
TABL1	=	0.82*Rcorse + 0.72*Rhelp
TABL3	=	0.71*Owned - 0.64*Yraed
TABL4	=	0.78*Timpor - 0.68*Legis

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:

Rcorse	=	frequency with which farmers attend soil conservation courses.
Rhelp	=	frequency with which farmers help others implement and/or maintain soil conservation practices.
Owned	=	proportion of area owned relative to that operated (percentage).
Yraed	=	years of formal agricultural education.
Timpor	=	proportion of farm area currently under timber (percentage).
Legis	=	knowledge of soil conservation legislation (dummy variable: yes = 1, no = 0).

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 and/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 represents agents and media providing information on soil erosion and conservation, and the second reflects educational

Table 11: Logit model; factors influencing farmers' technical ability to implement and maintain soil conservation measures, on farms sampled in KwaZulu-Natal (October 1993).

Dependent variable = the probability in favour of farmers having the technical ability to implement and maintain soil conservation measures

Variable	Coefficient estimate (B_i)	Exp (B_i)	Significance levels for goodness of fit statistics	
TABL1	1.13**	3.09	-2 Log Likelihood	0.11
TABL3	- 0.64**	0.53	Model Chi-square	0.00
TABL4	- 0.24	0.79	Improvement	0.00
Constant	0.22		Goodness of Fit	0.22

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

Number of cases included in this analysis	132
Overall classification	71.2%

programs as a policy tool to promote soil conservation and that soil conservation legislation should be binding on farm managers, not necessarily farm owners.

The effect of the proportion of farm area owned relative to that operated was only expected to influence conservation decisions if farmers who rent additional land have better management skills. The Exp (B_i) value for TABL3 indicates the odds in favour of farmers having the technical ability, are less for greater proportions of area owned relative to that operated, supporting this hypothesis. For relatively high levels of agricultural education, TABL3 will be negative. In this case, due to the negative coefficient for TABL3, the net effect on technical ability will be positive as predicted. Furthermore, the negative relationship between (Owned) and (Yraed) suggests farmers leasing additional land have higher levels of agricultural education, strengthening the hypothesis that these farmers may have better management skills.

Although TABL4 is not statistically significant, its inclusion is essential to ensure the model is correctly specified. The effect of enterprise type on conservation decisions was uncertain, and the Exp (B_i) value for TABL4 indicates farmers with large proportions of their farm under timber, are less likely to have the necessary technical ability. This suggests conventional conservation practices are not appropriate for timber plantations, or perhaps these can only be applied during harvesting and planting periods. For farms without timber, TABL4 will be negative. However, the negative coefficient for TABL4 implies knowledge of legislation controlling soil erosion has a net positive effect on technical ability. This suggests farmers may have attended soil conservation courses because legislation penalizes erosion, and this therefore encourages farmers to acquire appropriate soil conservation skills.

9.4 Financial Ability model

Hypothesized explanatory variables for this model are represented by 26 variables (see 6.1.4.2), 17 of which had less than 10 missing values. In the second stage of the model estimation procedure, six individual variables represented by three PCs, were shown to have significant impacts on financial ability. As in the previous two models, the best logit model for financial ability was obtained using the enter method. The two PCs retained are illustrated in Table 12.

Table 12: Details of principal components that are significant in the Financial Ability model.

Principal component Label		Variables with component loadings greater than 0.3
FABL1	=	0.71*Rivest - 0.69*Offmin + 0.64*Cropor
FABL2	=	0.90*Prcpcon

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:

Rivest	=	frequency with which farmers invest their own capital when implementing soil conservation measures.
Offmin	=	current proportion of family income from off-farm sources (percentage).
Cropor	=	proportion of farm area currently cropped (percentage).
Prcpcon	=	index reflecting perceptions about on-farm financial and managerial benefits of soil conservation activities.

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 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 13.

Table 13: Logit model; factors influencing farmers' financial ability to implement and maintain soil conservation measures, on farms sampled in KwaZulu-Natal (October 1993).

Dependent variable = the probability in favour of farmers having the financial ability to implement and maintain soil conservation measures

Variable	Coefficient estimate (B_i)	Exp (B_i)	Significance levels for goodness of fit statistics	
FABL1	0.85**	2.34	-2 Log Likelihood	0.11
FABL2	0.60**	1.82	Model Chi-square	0.00
Constant	0.56**		Improvement	0.00
			Goodness of Fit	0.32

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

Number of cases included in this analysis	111
Overall classification	71.2%

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 conservation measures, having relatively large crop enterprises, and less family income from off-farm sources, are more financially able to implement conservation measures (FABL1). This result supports the expected negative relationship between livestock enterprises and financial ability, due to large capital expenditure on fencing, required to establish rotating camps.

Farmers with larger off-farm incomes, are less financially able to implement conservation measures. Larger off-farm incomes are expected to improve a farm's cash flow position, reducing financial constraints to implementing conservation measures, and therefore their effect on financial ability would be positive. The negative relationship suggests farmers with large off-farm incomes are not prepared to invest in conservation measures[17], 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 not to invest in conservation measures, as returns to these investments are not realized.

The greater perceived on-farm benefits from soil conservation (FABL2), the more likely necessary financial resources will be available. Together with inferences from FABL1, these results imply farmers with the financial ability to implement required conservation measures are well informed, and possibly allocate financial resources for conservation activities as an investment decision. FABL2 is positively correlated (at the five percent level of significance), to a PC capturing risk perceptions, and farm expenditure on construction and maintenance of conservation works as a percentage of farm turnover. As expected, this implies financially able farmers are likely to be less risk averse. However, this issue needs more detailed research.

Dummy variables for farming region were regressed as explanatory variables in each of the four models presented above. These are not statistically significant in any of the models based on the chi-square test. This indicates any apparent differences between regions can be attributed to variations in explanatory variables within each model.

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[17] In 6.1.4.2, page 56, the point that the dependent variable for the Financial Ability model may not distinguish between "having the financial ability", and "being willing" to invest money in soil conservation measures, is raised. This may be relevant when interpreting Offmin.

9.5 Conservation Adoption model

Hypothesized explanatory variables for this model include those that are significant in each of the previous models, those used to define dependent variables for these models, and variables measuring effects of institutional factors. Two techniques are used in assessing how well the stepwise logistic regression model fits the data. Firstly, the significance of the change in residual deviance (based on the chi-square statistic) indicates both the number and specific variables needed to define the model adequately (see 7.1.1). Secondly, as in the previous models, cases correctly classified by the predicted model are an indication of the model's goodness of fit (Norušis, 1990a: 50). Again, cases used for classification are also used to predict the model, therefore cases correctly classified may be slightly biased upwards. Table 14 defines variables that are retained in the Conservation Adoption model.

Results from the stepwise logistic regression are presented in Table 15, where variable labels and their coefficient estimates (B_i) are indicated in the first and second columns respectively. The third column shows t-values which test the null hypothesis that corresponding variable coefficients are zero. Again, because the variables are standardized, only the relative magnitude of $\text{Exp}(B_i)$ can be interpreted. The estimated model correctly classifies 70.3 percent of cases in the sample.

Two separate groups of dummy variables were regressed in this model. The dummy variables distinguishing between crop, livestock, and mixed farms, are not significant. This implies the method used to define the adoption dependent variable for these specific farm types is not statistically significantly different. Similarly, the dummy variables for farm region are not significant. However, the dummy variables for the predominantly livestock

Table 14: Definitions for variables that are significant in the Conservation Adoption model.

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:

Rivest =	frequency with which farmers invest their own capital when implementing soil conservation measures.
Cropor =	proportion of farm area currently cropped (percentage).
Losprd =	reflecting perceptions that erosion causes losses in agricultural productivity.
Erofm =	percentage of farm area visibly eroded.
Fincap =	sufficient financial resources to implement all soil conservation practices required for the farm (dummy variable: yes = 1, no = 0).

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regions, Dundee and Estcourt, are negatively correlated to Cropor at the one percent level of significance.

Larger proportions of cropped land (Cropor), reduce the probability that all applicable conservation measures will be adopted. This result is unexpected, particularly since this variable has a positive influence on financial ability. This irregularity may be related to the fact that Cropor is highly correlated with the dummy variables for the predominantly livestock regions. This variable may be capturing regional differences that have a negative impact on the probability of adopting all applicable conservation practices. Alternatively, although minimum tillage is considered an applicable soil conservation practice on farms with crop enterprises, it is not widely adopted in areas sampled. As shown in Table 5 (page 73), only 35.6 percent of respondents use this conservation measure, and this may explain the

Table 15: Logit model; factors affecting adoption of all applicable soil conservation measures on farms sampled in KwaZulu-Natal (October 1993).

Dependent variable = probability in favour of farmers adopting all applicable soil conservation practices according to the farm enterprise mix

Variable	Coefficient estimate (B_i)	t-values	Exp (B_i)
Constant	0.61**	6.75	
Rivest	0.20**	2.13	1.22
Cropor	- 0.34**	-3.32	0.77
Losprd	0.19**	2.03	1.21
Erofm	0.26*	1.91	1.30
Fincap	0.21**	1.97	1.23

Change in Deviance - 2.80
Chi-square 10% significance level for 6 df = 2.20

** = significant at 5% based on t-value
* = significant at 10% based on t-value

Number of cases included in this analysis 130
Overall classification 70.3%

negative influence of Cropor on the probability in favour of adopting all applicable conservation practices. Increased weed and pest control and associated higher management skills required under minimum tillage, may be reasons why it is not widely adopted (Klein and Wicks, 1987: 319).

As results from the previous models imply, visible erosion on individual's farms (Erofm), perceptions that erosion causes losses in agricultural productivity (Losprd), farmers investing their own capital when implementing conservation measures (Rivest), and adequate financial resources to implement conservation activities (Fincap), all enhance the probability of adoption. It should be noted that, due to the stepwise procedure used to estimate this model, variables correlated with those retained in the model[18] (in particular those representing conservation management skills and regular attendance at soil conservation courses) are also likely to have significant impacts on adoption.

This Conservation Adoption model contains variables representing, or at least correlated to (at the one percent level of significance), attributes of each stage presumed to influence adoption. Therefore it supports the hypothesis that farmers face a variety of constraints when deciding to implement conservation measures. It is interesting to note that although financial resources have significant positive implications for adoption, the variable reflecting subsidy payments for implementing conservation practices, as provided for in Act 43/1983, is not significant.

9.6 Predicted probability scores for each model in the adoption-decision process

Table 16 presents mean predicted probability scores for each model in every region and for the whole sample. These are calculated by substituting standardized variable values or PC scores[19] for each case into the predicted model. An analysis of variance was conducted on logit scores, and the F-statistic used to test for significant differences between regions (Steel and Torrie, 1981: 96). Since dummy variables for farm region are not significant, for

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[18] A correlation matrix is provided in Table 23, page 155, Appendix B.

[19] As stated in 7.1.1, page 64, all components including those with loading values less than 0.3, are used when calculating component scores.

Table 16: Mean predicted probabilities for each stage in the conservation-adoption decision process, for each area sampled in KwaZulu-Natal (October 1993).

Farming Area	P(AWARE)	P(PERCEP)	P(TABLTY)	P(FABLTY)	P(ADOPT)
Entire Sample	0.62	0.67	0.54	0.61	0.64
Dalton/Wartburg	0.63	0.73	0.68	0.78	0.60
Camperdown/Eston	0.58	0.67	0.55	0.73	0.64
Dundee	0.66	0.67	0.49	0.48	0.65
Estcourt	0.59	0.60	0.40	0.45	0.67
Winterton	0.65	0.66	0.55	0.62	0.64
F-statistic	0.77	2.33	6.77	21.35	2.24
Significance level	0.55	0.06	0.00	0.00	0.07

models where the F-statistic is significant, differences between regions can be attributed to variations in explanatory variables in the respective models.

The mean probability score in favour of farmers being aware of the erosion problem P(AWARE) is 0.62, and there are no statistically significant differences in P(AWARE) between regions in the sample. Predicted probabilities in favour of farmers perceiving erosion as something worth trying to resolve P(PERCEP), and in favour of farmers having the technical ability to implement and maintain soil conservation measures 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 measures P(FABLTY) is relatively low at 0.61. The mean predicted probability in favour of farmers adopting all applicable soil conservation practices according to the farm enterprise mix P(ADOPT), is 0.64.

Based on F-statistics, there are significant differences between regions, at the 10 percent level, in P(PERCEP) and P(ADOPT) scores. The F-statistics for P(TABLTY) and P(FABLTY) indicate there are statistically significant differences in these scores, between regions, at the one percent level. Probability scores for the Dalton/Wartburg 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/Wartburg is a predominantly crop farming area, and Estcourt, a predominantly livestock farming area.

Differences in P(PERCEP) 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 inputs, yields, or income (Impct). These variables are expressed in principal components PCP1 and PCP3 respectively, and their mean scores are higher for respondents from the Dalton/Wartburg region. This implies erosion's impacts are more noticeable, and cash flow constraints relatively less, on predominantly crop farms over the sample period.

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 (Rcorse), reflected in principal component TABL1, is relatively higher for the Dalton/Wartburg district. This explains the higher P(TABLTY) score in this region. The fact that respondents from this area score well for P(PERCEP) 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(FABLTY) 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 (Offmin), expressed in principal component FABL1. In Dalton/Wartburg, 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 4 (page 72), the proportion of arable land on farms in Dalton/Wartburg averages 60.4 percent, and in Estcourt, the average is 2.9 percent. This implies predominantly crop 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.

The mean P(ADOPT) score is 0.64, and differences between regions are attributed to 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 whether there are sufficient financial resources available to implement all the farm's required soil conservation measures (Fincap). As with the other two variables, the mean score for Fincap is high for respondents in the Dalton/Wartburg region compared to that from Estcourt. However, although Dalton/Wartburg boasts the highest probability scores for all the previous models, it has the lowest score for the Conservation Adoption model P(ADOPT). It is likely that this is due to the negative influence of Cropor on P(ADOPT), and possible explanations for this relationship are discussed in the preceding section.

9.7 Conservation Effort model

Four PCs are shown to be significantly related to the transformed conservation effort variable, using the enter method for entering explanatory variables into the model. These were derived following the same procedure described in 7.1.1, and are presented in Table 17.

Principal component EFF1 represents the value of short-term farm financial and managerial benefits derived from implementing soil conservation practices. EFF3 measures the effects of farms' debt repayment obligations, and EFF4 reflects the frequency with which farmers invest their own capital in soil conservation activities, the availability of financial resources required to implement all soil conservation practices required for the farm, and farmers' intentions to pass their farm on to a family member or relation. Finally, observable erosion impacts, either visibly or through their effect on farm input use, yields, or income, are captured by EFF5.

Results for this linear regression model are presented in Table 18. If coefficients, (B_i)s, are multiplied by 100, they represent the percentage change in conservation effort given a unit change in the corresponding principal component. As in the previous models, only the relative magnitude of this change can be interpreted rather than its absolute value, because PCs are measured in standardized units. Despite the low value for adjusted R^2, the signs of the estimated coefficients agree with prior expectations and t-values show these to be statistically significantly different from zero. This is supported by the highly significant F-value (Gujarati, 1988: 123), and the model therefore adequately represents those PCs that have a significant influence on conservation effort.

Table 17: Details of principal components significantly related to the natural logarithm of the conservation effort variable.

Principal component Label		Variables with component loadings greater than 0.3
EFF1	=	0.86*Savmon + 0.74*Pnthvt + 0.72*Conpft
EFF3	=	0.80*Dbtass + 0.79*Dbtrep
EFF4	=	0.84*Rivest + 0.68*Pasfm + 0.51*Fincap
EFF5	=	0.77*Erofm + 0.72*Impct

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:

Savmon	=	adoption of conservation practices save farmers money due to lower input costs.
Pnthvt	=	adoption of conservation practices reduces time required to plant and harvest.
Conpft	=	adoption of conservation practices increases farm profits for those using them.
Dbtass	=	debt to asset ratio of the farm business (percentage).
Dbtrep	=	percentage of farm turnover spent annually on debt repayment.
Rivest	=	frequency with which farmers invest their own capital when implementing soil conservation activities.
Pasfm	=	intention to pass farm on to a family member or relation (dummy variable: yes = 1, no = 0).
Fincap	=	sufficient financial resources to implement all soil conservation practices required for the farm (dummy variable: yes = 1, no = 0).
Erofm	=	percentage of farm area visibly eroded.
Impct	=	experience of circumstances where significant soil loss has had impacts on inputs, yields, or income (dummy variable: yes =1, no = 0).

Table 18: Linear regression model; factors affecting conservation effort on farms sampled in KwaZulu-Natal (October 1993).

Dependent variable = logarithmic transformation of percentage values reflecting arable land and veld on respondents' farms, currently protected with conservation practices

Variable	Coefficient estimate (B_i)	t-values
Constant	4.22**	48.55
EFF1	0.28**	3.07
EFF3	0.19*	2.05
EFF4	0.19*	2.23
EFF5	-0.16*	-1.98

Adjusted R^2 13.2%
F-value 5.45**

** = significant at 1% based on t-value
* = significant at 5% based on t-value

Number of cases included in this analysis 150

Farmers realizing there are short-term farm financial and managerial benefits to be derived from implementing soil conservation measures (EFF1), are likely to demonstrate more conservation effort. This PC has the largest positive impact on effort levels. The positive relationship between debt repayment obligations (EFF3) and conservation effort suggests debt finance is a source of funds for conservation expenditures, or that lending institutions are more likely to approve loan capital to farmers if an extensive conservation plan has been implemented.

Levels of conservation effort improve with increases in the frequency with which farmers invest their own capital when implementing conservation activities, and if there are sufficient financial resources to implement all soil conservation practices required for the farm (EFF4). Farmers with these characteristics also intend to pass their farm on to a family member or relation. The adverse effects of erosion (EFF5) are negatively related to conservation effort. Obviously, if farmers have visible erosion on their farms, and are experiencing excessive soil loss with corresponding impacts on inputs, yields, or income (Impct), they are likely to have much lower levels of conservation effort.

Dummy variables for farm region are not significant in this model, and therefore apparent differences in conservation effort between regions can be explained in terms of variations in explanatory variables in the model. This model emphasizes erosion's effects must become conspicuous before the need for soil conservation is realised, and that financial characteristics, in terms of availability of money for conservation expenditures and benefits of cost savings and higher profits, are important to encourage higher levels of conservation effort.

9.8 Mean predicted levels of conservation effort

Mean predicted levels of conservation effort in every region and for the whole sample are presented in Table 19. These are calculated by substituting PC values for each case into the predicted model. An analysis of variance was conducted to test for variations in conservation effort between regions. To ensure validity of the test, it is conducted on the logarithmic transformation of the variances (Steel and Torrie, 1981: 235). The F-statistic shows there are no statistically significant differences between regions for conservation effort.

Table 19: Mean predicted levels of conservation effort represented as percentages, for each area sampled in KwaZulu-Natal (October 1993).

Farming Area	Level of conservation effort (%)
Entire Sample	73.9
Dalton/Wartburg	79.1
Camperdown/Eston	76.1
Dundee	76.2
Estcourt	67.6
Winterton	70.0
F-statistic	0.69
Significance level	0.60

Results in Table 19 indicate farms in the Dalton/Wartburg district have the highest level of conservation effort, and those in the Estcourt region, the lowest. However, P(ADOPT) scores for these two regions are 0.60 and 0.67 respectively. If the lower P(ADOPT) score for Dalton/Wartburg is explained by the fact that only 30.8 percent of respondents from this region use minimum tillage, then these results support the hypothesis that conservation adoption and conservation effort are not substitutable. Although farmers in the Estcourt region are more likely to adopt a greater variety of soil conservation practices compared to farmers from Dalton/Wartburg, their effectiveness and extensiveness could be substandard. The low P(TABLTY) and P(FABLTY) scores for the Estcourt district enforce this.

Table 20 summarizes predicted levels of conservation effort for the farms in the sample. Almost a quarter, 24.4 percent, of the farms in the sample show levels of conservation effort greater than 80 percent, and approximately 32 percent have effort levels below 50 percent.

Table 20: Summary of predicted levels of conservation effort on farms sampled in KwaZulu-Natal (October 1993).

Level of conservation effort (%)	Frequency (number of farmers)	Percent	Cumulative percent
80 - 100%	29	24.4	24.4
60 - 79%	34	28.6	52.9
50 - 59%	18	15.1	68.1
41 - 49%	17	14.3	82.4
0 - 40%	21	17.6	100.0

It is difficult to judge the extent of the erosion problem in these farming areas, from these figures. However, due to the uncertainties surrounding the erosion problem, these results suggest substantial improvements in soil conservation effort are required.

Although a relatively high percentage of cases in the sample, between 70 and 80 percent, are correctly classified by the predicted models, it is likely these do not 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 analyze this dynamic problem, and difficulties in measuring many of the variables accurately (Sinden and King, 1990: 182). 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 activities (Nielsen *et al*, 1989: 12).

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

9.9 Monitoring and enforcing provisions of Act 43/1983

Variables reflecting farmers' perceptions about the effectiveness with which the provisions stipulated in Act 43/1983 are monitored and enforced, are defined in Table 21.

Table 21: Definitions for variables used to assess the effectiveness with which the provisions stipulated in Act 43/1983 are monitored and enforced.

Variables have been re-coded to form dummy variables, where one indicates respondents perceive the outcome as likely or very likely, and zero otherwise. Label definitions are as follows:

Discov	=	the chances that excessive levels of erosion on the farm will be discovered by the relevant authorities.
Prosec	=	the chances of being prosecuted, should excessive levels of erosion on the farm be discovered.
Deter	=	the chances that excessive levels of erosion on the farm will be discovered, and that the farmer will be prosecuted. (Deter equals one if a farmer scored one for both Discov and Prosec variables).

Results indicating proportions of farmers perceiving discovery of excessive levels of erosion on their farms (Discov), that they will be prosecuted in such circumstances (Prosec), and the chances of both these outcomes occurring (Deter), are reflected in Table 22. For Act 43/1983 to be effective in achieving reductions in erosion, farmers should believe there is

Table 22: Percentages indicating perceptions regarding the effectiveness with which the provisions stipulated in Act 43/1983 are monitored and enforced, for respondents from the areas sampled in KwaZulu-Natal (October 1993).

Farming Area	Variable labels		
	Discov (%)	Prosec (%)	Deter (%)
Entire Sample	65.1	26.5	20.5
Dalton/Wartburg	58.3	25.0	16.7
Camperdown/Eston	72.7	22.7	18.2
Dundee	68.8	43.8	31.3
Estcourt	61.8	14.7	14.7
Winterton	67.9	25.9	22.2
Number of cases included in the analysis		152	

a high probability that violations of the Act's provisions will be discovered, and that associated penalties will be enforced.

On average, 65.1 percent of farmers in the areas sampled believe it is likely that excessive levels of erosion on their farm will be discovered by the relevant authorities (Discov). However, only 26.5 percent believe the chances of being prosecuted in these circumstances is likely (Prosec). The most notable differences between regions for this variable (Prosec), occur for the Dundee (43.8 percent) and Estcourt (14.7 percent) regions.

The percentage of respondents believing discovery of, and subsequent prosecution for excessive levels of erosion (Deter), is relatively low at 20.5 percent. Over 30 percent of farmers in the Dundee region perceive this scenario as likely, suggesting they are better informed about this soil conservation legislation. This implies the extension service office and Soil Conservation Committee members in this area, are relatively more successful at promoting soil conservation.

These results raise questions about the effectiveness of Act 43/1983 in achieving reductions in erosion. Although perceptions that violations will be discovered are relatively high, only a fifth of farmers in the sample believe the accompanying penalties will be imposed, and it is unlikely that this improves farmers' motivations to adopt soil conservation measures.

CONCLUSIONS AND POLICY IMPLICATIONS

Data from 159 commercial farms in KwaZulu/Natal are analyzed to determine factors influencing conservation adoption-decisions and conservation effort, and to assess farmers' perceptions regarding monitoring and enforcement of soil conservation legislation. The main results from the empirical analysis are summarized below, and their policy implications discussed[20].

The following four stages were identified in the conservation adoption-decision process: awareness of soil erosion, the perception that it is a problem worth resolving, technical and financial abilities necessary to implement required conservation measures, and actual adoption. In order to achieve substantial reductions in erosion, and improve the effectiveness with which this is accomplished, it may be appropriate to target policies to meet specific soil conservation requirements, at homogeneous groups of farmers. Separate logit models, representing variables associated with each stage, are used to predict probabilities in favour of farmers in the sample having a particular attribute. The models correctly classify more than 70 percent of the cases in the sample, and support the hypothesis that farmers face a variety of constraints when adopting soil conservation measures.

Visible erosion impacts, agricultural education, and knowledge about erosion's off-site consequences are shown to have significant positive influences on awareness levels. Similarly, variables significant in the Perception model reflect circumstances where farmers

[20] Ideally, soil conservation policy should apply to all land users in South Africa. However, as explained in the first footnote, this study focuses on the commercial agricultural sector, and policy implications are discussed in this context.

have, or are experiencing reduced agricultural productivity due to erosion, and knowledge about erosion's off-site impacts. Other variables positively related to perception represent farmers' ability to implement conservation measures without external technical assistance, and use of their own capital in doing so.

The average predicted probability for the Technical Ability model is 0.54, illustrating that almost half the farmers in the sample do not have the technical knowledge necessary to implement all soil conservation measures required for their farms. This could be the biggest constraint faced by farmers who have decided to implement soil conservation measures. Regular attendance at soil conservation courses, higher levels of formal agricultural education, and knowledge of soil conservation legislation positively influence technical ability.

Farmers' willingness to invest their own capital in soil conservation activities, predominantly crop enterprises, perceptions relating to on-farm financial and managerial benefits derived from soil conservation activities, and those less reliant on off-farm income sources for family income requirements, are more likely to have the financial ability to implement all soil conservation measures required for their farms. Predominantly livestock operations, which in the areas sampled also have relatively large off-farm income sources, are apparently less financially able to implement required conservation practices.

As predicted, attributes defining each of the preceding stages are represented in the Conservation Adoption model. Visible erosion on individual's farms, perceptions that erosion causes losses in agricultural productivity, farmers investing their own capital when implementing conservation measures, and adequate financial resources to implement conservation activities, all have positive impacts on adoption. Furthermore, variables reflecting technical abilities to implement soil conservation measures, are positively correlated, (at least at the five percent level of significance), to those in the adoption model.

Although larger proportions of farm area currently cropped, is positively related to financial ability, this variable has a relatively large negative impact on the probability that all applicable soil conservation measures will be adopted. However, it is significantly correlated to dummy variables for predominantly livestock farming regions, and may be capturing regional differences that negatively affect actual adoption of conservation practices. Alternatively, although minimum tillage is considered an applicable soil conservation practice on crop farms, it is not widely adopted in the areas sampled, perhaps explaining this negative relationship. This implies information promoting minimum tillage as an effective soil conservation practice, may be required in these crop farming regions.

Variables associated with conservation effort are determined using linear regression analysis. Results support the hypothesis that conservation adoption and effort are not substitutes, and emphasize the significance of financial characteristics for extensive implementation of soil conservation measures, once adoption has been initiated. The mean predicted level of conservation effort in the areas sampled is 73.9 percent.

Physical characteristics representing erosion's prominent impacts, and the following financial factors are primarily related to effort. Farmers investing their own capital in conservation activities, and perceiving on-farm managerial and financial benefits from soil conservation, are likely to demonstrate greater levels of conservation effort. The positive relationship between farm debt and effort enforces proposals that debt is a source of funds for conservation expenditures, and a well functioning land market would explain incentives behind this.

Lastly, although 65 percent of respondents believe that violations of Act 43/1983 will be discovered, only 20 percent perceive that violations will be both detected and subsequently prosecuted. This implies the transactions costs related to enforcing prosecutions are high, and therefore, the possibility of being prosecuted is unlikely to encourage farmers to implement soil conservation activities.

Generally, results imply conservation measures are less likely to be implemented before erosion's effects become conspicuous. Since this may only occur over a relatively long time period, research, education and extension efforts emphasizing benefits derived from preventing erosion before it becomes evident, are imperative. The negative relationship between the value of on-farm benefits from reducing off-site erosion impacts suggests these efforts should be directed at accentuating individual or on-farm benefits of soil conservation activities.

Throughout the analysis, agents and media providing information on soil erosion and conservation decisions are important, and their role in promoting soil conservation is invaluable. A lack of relevant information about the true costs and values of erosion and soil conservation activities may explain apparent inconsistencies evident in Awareness and Perception models, regarding the effectiveness of the land market to deal with these issues.

Additional information stressing the costs of erosion and benefits of soil conservation, should facilitate improvements in the land market's functions to fully account for these, and further research to clarify this issue is essential. Well functioning market forces are expected to be the most effective means of controlling erosion and encouraging soil conservation, through internalizing the costs of erosion and benefits of soil conservation for land owners.

Developing an accurate and comprehensive data base, through appropriate research, to provide this information is crucial. In this regard, the government can make a significant contribution to improving awareness and perception levels, through the extension service. This is essentially a long-term strategy, due to the time period required to obtain meaningful results and develop appropriate research methodology, and it needs to be initiated immediately. Consideration also needs to be given to the forms of information provision. These must not be too technical and difficult to comprehend, or too simple, where generalisations are unrealistic.

Although the extension service compiles farm conservation plans, including specifications for conservation structures, when farmers apply for soil conservation subsidies, there may be several drawbacks with this strategy. Since a majority of farmers do not have technical soil conservation skills, extension service personnel are unlikely to be able to compile a substantial number of individual farm conservation plans within a reasonable time period. Therefore, it may be more appropriate for the extension service to provide regular soil conservation courses which farmers should be encouraged to attend. Secondly, if the extension service provides farmers with both technical and financial support to implement soil conservation measures when transgressions are discovered, and does not prosecute them, then there is little incentive for individuals to deal with the erosion problem themselves. This is especially so if the land market only partially reflects the true costs and benefits of erosion and soil conservation activities, as is apparently the case.

It is anticipated that improving awareness and perception levels will also initiate a demand for soil conservation courses. Cross-compliance programs, where effective soil conservation is a pre-requisite before farmers are entitled to receive government agricultural program benefits, as is the case in the United States, are also possible short to medium-term strategies to encourage farmers to obtain technical soil conservation skills.

Having overcome constraints posed in these first three stages, farmers are likely to face financial constraints, and those investing their own capital when implementing conservation activities are more likely to adopt conservation measures. This has several implications for future research and policy formulation, particularly if high levels of conservation effort are to be achieved. Firstly, factors motivating farmers to invest their own capital need to be identified. Indications are that these relate to farmers' knowledge about erosion's impacts and benefits of soil conservation, and their subsequent worth being reflected in farm land values in a well functioning land market. Secondly, despite financial characteristics being potentially major constraints, subsidy payments for implementing conservation practices are not significant in any of the estimated conservation models. Since over 80 percent of respondents are aware of soil conservation legislation, this suggests transactions costs incurred when applying for soil conservation subsidies, as provided for in the Conservation of Agricultural Resources Act 43/1983, exceed the benefits of doing so.

Cross-compliance programs will create incentives on the farmer's behalf to obtain appropriate soil conservation skills and implement soil conservation measures. Furthermore agricultural assistance program administrative functions are already in place, and monitoring functions appear to relatively well developed. Therefore, these types of programs may achieve higher reductions in erosion per unit of conservation expenditure, and research to establish the feasibility of these should be a priority.

Although these results are specific to the study area and more research needs to be conducted to clarify these findings, they suggest crop farmers are more likely to perceive erosion as worth trying to resolve, and have the technical and financial abilities to implement and maintain required soil conservation measures for their farms, compared with livestock farmers. Therefore, to achieve higher net soil conservation programme benefits in the short-term, subsidies should possibly be restricted to conservation measures appropriate for livestock enterprises (ie. fencing). Other government conservation expenditure should focus on educating farmers about the individual benefits of soil conservation, and training programs to improve technical soil conservation skills.

SUMMARY

There are widespread opinions regarding the extent of the soil erosion problem. At one extreme, it is perceived as grossly over exaggerated, because induced technological innovations will compensate for any reductions in agricultural potential that may occur. At the other, erosion is recognized as an extensive problem with serious and far reaching implications for long-term agricultural sustainability.

Erosion's anticipated detrimental impacts are readily masked or rectified by induced technological innovations, even over relatively long time periods. Consequently, market forces do not fully account for erosion's costs, or the benefits of soil conservation, and their true values do not appear to be reflected in land market prices. Nevertheless, there is ample physical evidence in both on-site and off-site effects, to suggest erosion's consequences are substantial. Inherent in the process is a high level of uncertainty, due to the inability to accurately quantify and predict the consequences of prolonged erosion, or estimate the time period over which innovations will be able to compensate for it. This uncertainty and lack of relevant information provides sufficient incentive to consider formulating strategies that will achieve tangible reductions in erosion.

Although past soil conservation policies in South Africa have not gone unrewarded, implications are these have focused on treating the symptoms of the erosion problem, rather than its causes. Furthermore, the government's ability to replace the market's functions in administering a soil conservation policy that effectively accounts for the multitude of interacting factors that influence erosion, is questionable. These factors range from climate

and physical land characteristics to farm financial and farmers' personal characteristics, and are obviously unique for site-specific circumstances.

Accordingly, farmers may face a variety of constraints when deciding to implement soil conservation measures, and greater reductions in erosion may be realised if soil conservation policy targets specific soil conservation needs, at homogeneous groups of farmers. In this regard, it is important to justify theoretical relationships between, and establish the relative importance of factors influencing soil conservation decisions. Although there are a variety of factors that affect erosion and soil conservation, necessitating an integrated, holistic approach to the problem, the relevance of economic factors are stressed in this analysis. This should provide policy makers with useful information for developing soil conservation strategies that will accomplish widespread implementation of conservation measures and reductions in erosion.

Adoption of soil conservation measures is presumed to consist of a multi-stage decision process, and logistic regression and principal component analysis are used to estimate a sequence of adoption-decision models. These are: awareness of the soil erosion problem, the perception that erosion is worth trying to resolve, technical and financial abilities to implement conservation measures, and finally the actual adoption of conservation practices. A distinction is made between conservation adoption and conservation effort, and the effort model is estimated using linear regression. Finally, respondents' perceptions regarding the monitoring and enforcement of soil conservation legislation are analyzed using frequency tables.

Data were collected from five different commercial farming areas in KwaZulu-Natal, through a postal survey. The areas are Dalton/Wartburg, Camperdown/Eston, Dundee, Estcourt, and Winterton, and the initial sample size was 498. Of these, 159 farmers returned usable questionnaires. Sixty-seven percent of respondents believe implementing all the farm's necessary soil conservation measures would be financially beneficial to their farming operation, while 80 percent perceive this would improve managerial activities. Over 80 percent of respondents have some knowledge of the current soil conservation legislation.

The results support the hypothesis that there are a variety of constraints to implementing soil conservation. Initially erosion must be visible for farmers to aware of it. Subsequently, its impacts on agricultural productivity must be conspicuous before it is perceived as a problem worth resolving, and farmers are motivated to take corrective action. Having overcome these first two stages in the adoption process, farmers require technical conservation skills to implement appropriate soil conservation measures, and this is perhaps the biggest constraint in the adoption process. Almost half the farmers in the areas sampled do not have these technical skills.

Financial capacities also play an influential role in the adoption process, although these are more prominent determinants of soil conservation effort. Farmers investing their own capital are more likely to implement conservation activities. This raises questions as to the effectiveness of the subsidy program intended to provide farmers with financial support when implementing soil conservation measures.

Agents (eg. Soil Conservation Committees, and extension officers), and media (eg. extension service reports), providing information on soil erosion and conservation play an invaluable role in promoting soil conservation. The government's contribution to reducing erosion is possibly best suited to ensuring this information becomes available, and subsequently providing training programs to improve technical soil conservation skills. Consequently, the land market may operate more effectively, with respective erosion and conservation activities being penalized or rewarded by market prices.

In the short-term, the merits of cross-compliance programs, where farmers only qualify for agricultural assistance program benefits if their farms are adequately conserved, should be considered as a means of encouraging soil conservation.

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APPENDIX A

SURVEY QUESTIONNAIRE USED IN KWAZULU-NATAL

UNIVERSITY OF NATAL
DEPARTMENT OF AGRICULTURAL ECONOMICS

FARMER QUESTIONNAIRE

TO BE COMPLETED BY THE PRINCIPAL FARM
DECISION-MAKER OF THE FARM BUSINESS

This questionnaire attempts to identify factors that influence farmers' decisions to adopt and implement soil conservation measures. Research in the USA indicates that decisions involve complex interactions between social, economic, and institutional factors.

The objective is to highlight factors that need to be considered when formulating soil conservation policy.

To be effective and of assistance to farmers, the policy must specifically account for those problems farmers face when applying conservation measures to protect their valuable soil resource.

All survey responses will be kept strictly confidential.

The questionnaire consists of six sections. Please answer all questions as accurately as possible. **Even if you don't answer all questions, please return the questionnaire.**

Please mark answers with a cross, [X] unless otherwise requested.

SECTION ONE: FARMER CHARACTERISTICS

1. Please indicate your particulars in the table below.

	Part/ full time	Age (yrs)	Years been in farming	Years expect to remain farming	Years of formal education	Years of agric. education
Manager						

2. Approximately what percent of your family income comes from the farm? ________%

3. Do you intend to pass your farm on to a family member or family relation?

Yes		No		Don't Know	

4. Assuming the reason "provides a good income" receives a base score of 100, please rate the following reasons for you farming, relative to "provides good income." For example, if a reason is twice as good as "provides a good income" assign it a score of 200.

	Score
Provides opportunity for a better home and family life	______
Provides opportunity to be my own boss	______
Gives me a chance to work in the natural environment	______
Provides benefit of capital gain from property investment	______

SECTION TWO: FARM CHARACTERISTICS

1. How many hectares do you own? ______ Ha

   cash rent? ______ Ha

   share lease? ______ Ha

2. What enterprises do you have on the farm (e.g. dairy, beef,timber, sugar cane, maize, other)? If other, please specify.

Enterprise	Size	Enterprise	Size
Dairy (Animals)		Soyabeans (Ha)	
Beef (Animals)		Timber (Ha)	
Pigs (Animals)		Sugar cane (Ha)	
Sheep (Animals)		Citrus (Ha)	
Vegetables (Ha)		Maize (Ha)	
Other (Specify)			

SECTION THREE :
EROSION/CONSERVATION STATUS OF FARM

1. When you began managing the farm, did you think the land was:

very eroded		eroded	
about average		conserved	
well conserved			

2. When **you began managing** the farm, did you think that the **loss of agricultural productivity** due to erosion was significant?

Yes		No		Don't Know	

3. Is soil erosion a problem on the land you own considering the climate and soil types in the area?

no problem		slight problem	
moderate problem		severe problem	

4. Approximately what percentage of your farm area is visibly affected by erosion? ______%

5. Do you have the capacities to construct and maintain the conservation structures or implement the conservation measures required for your farm?

Capacity	Yes	No	Don't know
Technical knowledge			
Financial resources			

6. Approximately what areas of your farm **are currently protected** by conservation measures:

i) Arable land with conservation structures (contours)?	%
ii) Veld with fencing and stock-rotating facilities?	%
iii) Other (please specify) ________________ conservation measures?	%

7. Of the following soil conservation practices, please cross the ones that you use.

Contouring (run-off control)		Minimum Tillage	
Windbreaks		Rotating Camps	
Conservation Structures in dongas			

8. What do you consider the effect of implementing **all the required** conservation measures to be on the following farm activities?

Activity	Greatly Harm	Harm	No Change	Benefit	Greatly Benefit
Financial					
Management					

9. How did the implementation of **existing** conservation measures on your farm affect the profitability of your farm business?

Greatly Harm		Harm		No Change	
Benefit		Greatly Benefit		Don't Know	

For question 10, please **circle** the number that best indicates your answer as indicated by the scale below:

very likely	maybe	don't know	unlikely
1	2	3	4

10. a) Assuming you have excessive levels of erosion on your farm, what are the chances of this being discovered by the authorities? 1 2 3 4

b) If excessive levels of erosion on your farm were discovered by the authorities, what are the chances of you being prosecuted? 1 2 3 4

11.a) If you were to adopt or if you have already adapted your farming operations to facilitate soil conservation measures (eg. contouring, crop rotations, conservation structures, minimum tillage systems), and you did not receive any government financial assistance, would or do the economic returns outweigh the costs:

In the short-term?

Yes		No		Don't Know	

In the long-term?

Yes		No		Don't Know	

11.b) Over the past ten years has there been any <u>significant soil loss</u> on your farm, which has had an impact on inputs, yields, or income?

Yes		No		Don't Know	

12. How often are you involved with/do you apply the following activities? Please <u>circle</u> answers where:

Always = A, Frequently = F, Sometimes = S, Never = N.

Attend soil conservation courses	A F S N
Help other farmers adopt/maintain soil conservation measures	A F S N
Introduce conservation practices with no outside technical assistance	A F S N
Invest own capital in implementation of practices	A F S N

13. Is the employment of casual farm labour for constructing conservation works a feasible option for your farm?

Yes		No	

SECTION FOUR: FARM MANAGEMENT CHARACTERISTICS

1. Please cross the phrase which best describes the farm business with which you are involved.

Individual Owner		Trust		Partnership	
Closed Corporation		Company		Other (specify) ____	

2. If you are the owner, did you:

Buy your farm?		Inherit your farm?	

3. For the following statements, please <u>circle</u> the number that best indicates your answer as indicated by the scale below:

strongly disagree	disagree	undecided	agree	strongly agree
1	**2**	**3**	**4**	**5**

I regard myself as the kind of person who is willing to take more risks than the average farmer.	1 2 3 4 5
I would rather take more of a chance on making a big profit than be content with a smaller but less risky profit.	1 2 3 4 5
Its good for a farmer to take risks when he knows his chance of success is fairly high.	1 2 3 4 5
Farmers who are willing to take chances usually do better financially.	1 2 3 4 5

4. Potential benefits from soil conservation are listed below. Please indicate, **in order of importance**, those that you believe to be most relevant to yourself:

Most important (1) **Least important (7).**

Prevent silting up of reservoirs and maintenance of storage capacities	
Reduction in costs arising from reduced input requirements	
Maintenance of yields and reduced yield variability within fields	
Pass on to future generations a fully productive resource	
Facilitate adequate infiltration rates	
Minimise water pollution	
Maintain land's market value	

5. Please indicate the <u>**effectiveness**</u> of the following policy tools in as much as they may used to influence the use of conservation measures. Please **circle** answers.

Policy Tool	Not Effective — Very Effective 1 2 3 4 5
Government environmental regulations	1 2 3 4 5
State financial aid schemes	1 2 3 4 5
Tax policy - credits - penalties	1 2 3 4 5 1 2 3 4 5
Educational programs	1 2 3 4 5

6. Please indicate the **significance** of the following in as much as they may influence your decision to use conservation measures. Please **circle** answers.

Factors influencing decisions	Not Significant — Very Significant 1 2 3 4 5
Crop yield variability	1 2 3 4 5
Changes in cost of inputs (eg. fuel, fertilizer etc.)	1 2 3 4 5
Changes in your labour force	1 2 3 4 5
Land policies	1 2 3 4 5
Changes in weather/climate	1 2 3 4 5
Maintaining financial/credit reserves	1 2 3 4 5
Farm Soil Conservation Competitions	1 2 3 4 5

7. Considering the risks involved with conservation farming, how willing are you to implement conservation measures?

Willingness

Not Very

1 2 3 4 5

8. How do you rate your soil conservation management skills relative to other farmers in your district?

Relative management skills

Low ______________ High

1 2 3 4 5

9. How do you rate the **value** of the following for providing you with information on soil erosion, and soil conservation decisions? Please **circle** answers.

Agency/Agent	Low ______ High 1 2 3 4 5	**Medium**	Low ______ High 1 2 3 4 5
Extension officers	1 2 3 4 5	Extension service reports	1 2 3 4 5
Consultants	1 2 3 4 5	Farm magazines	1 2 3 4 5
Lenders (banks)	1 2 3 4 5	Agric newspapers and newsletters	1 2 3 4 5
Other farmers in your area	1 2 3 4 5	Radio and television reports	1 2 3 4 5
Feed/Fertilizer sales person	1 2 3 4 5	Newspaper articles	1 2 3 4 5
Soil Conservation Committees	1 2 3 4 5	Farmer's own knowledge	1 2 3 4 5
Your farm's work force	1 2 3 4 5	Field days/conferences	1 2 3 4 5

SECTION FIVE: PERCEPTIONS AND OPINIONS

For each of the statements that follow in questions one through to four, please circle the number that best indicates your answer as indicated by the scale below:

strongly disagree	disagree	undecided	agree	strongly agree
1	**2**	**3**	**4**	**5**

1. Impacts of Soil Erosion on the Environment: Are they serious?

Capacities of water storage facilities are often severely reduced due to soil eroded from farm land.	1 2 3 4 5
Water quality in Natal has been significantly affected by pollution caused by soil erosion.	1 2 3 4 5
Soil erosion from farm land often makes outdoor recreation on rivers and lakes less enjoyable.	1 2 3 4 5
Bad conservation practices lead to loss in productivity.	1 2 3 4 5

2. **Perceptions about soil conservation practices:**

Most soil conservation practices increase farm profits for farmers who use them. 1 2 3 4 5

The adoption of most soil conservation practices usually reduces the amount of time required to plant and harvest. 1 2 3 4 5

The adoption of most soil conservation practices saves farmers money due to lower input costs. 1 2 3 4 5

Most soil conservation practices require a lot of knowledge by the farmer to implement them correctly. 1 2 3 4 5

Most soil conservation practices are appropriate for the type of farming I do. 1 2 3 4 5

3. **Rights and Responsibilities of farmers:**

Soil erosion is a very serious problem in my farming area. 1 2 3 4 5

Insufficient attention is paid to soil conservation programs when one considers the consequences of soil erosion. 1 2 3 4 5

Land owners have responsibilities to protect soil resources for future generations. 1 2 3 4 5

Farmers should not have the right to use their land in ways that will cause damage to the resources. 1 2 3 4 5

The Department of Agriculture has the right to tell farmers what practices to use on their own land in order to reduce soil erosion. 1 2 3 4 5

4. **Assistance programs and the role of government regarding soil conservation.**

The government should compensate farmers who adopt soil conservation measures. 1 2 3 4 5

Farmers should be required to use effective soil conservation practices on highly erosive soil on their farms, or else:

a) be liable for heavy fines 1 2 3 4 5

b) should not be permitted to continue farming 1 2 3 4 5

c) not be permitted to participate in any state financial aid schemes 1 2 3 4 5

For this question please cross the appropriate answer, [X].

5. **General Soil Conservation Issues**

a) Any form of legislation aimed at the control of soil erosion should be binding on the:

Landowner	Yes		No		Don't Know	
Manager	Yes		No		Don't Know	

b) Do you feel it is appropriate for the government to establish soil loss limits based on recommendations from appropriate Research Institutes?

Yes		No		Don't Know	

c) Are you aware of any legislation under which farmers may be prosecuted for having excessive levels of erosion on their farms?

Yes		Yes- but don't know much about it		No	

d) Are the farmers in your area concerned about soil erosion?

Most		A few		None	

e) To what extent are soil conservation measures used in your area?

Widely		Limited		None	

f) Are bad conservation practices reflected in lower land values?

Yes		No		Don't Know	

SECTION SIX: FARM FINANCIAL CHARACTERISTICS

These questions are designed to obtain information about the financial characteristics of your farm **without you having to reveal the actual figures.** Percentage values reflecting the relative contributions of incomes and expenditures are a way of doing this.

1. Please indicate the value of your **typical** farm profit as a percentage of farm turnover. _____%

2. Approximately what percentage of farm turnover is normally made up of government payment receipts? _____%

3. What is the **debt** (Instalments, Acc's Payable, Overdraft, Mortgage Bond) to **asset** (Cash in hand + bank, Vehicles, Machinery + Equipment, Land + Buildings) ratio of the farm business? (ie. Debts/Assets x 100). _____%

4. Approximately what percentage of farm turnover is spent annually on debt repayment ? _____%

5. What are the farm's estimated yearly expenditures on the construction and maintenance of conservation works to reduce erosion, as a **percentage of farm turnover?** _____%

6. How do you finance the running costs of your farm business?

Own funds		Land Bank	
Co-operative credit		Agricultural Credit Board	
Commercial Bank		Other (specify) ___________	

7. If you have any additional comments with regard to soil conservation that you would like to make, please do so in the space provided below.

____

____

____

____

EVEN IF YOU HAVE NOT ANSWERED ALL THE QUESTIONS, PLEASE RETURN THE QUESTIONNAIRE.

Would you be interested in the results of the study?

Yes		**No**	

Your survey responses will be kept strictly confidential.

THANK YOU FOR PARTICIPATING IN THE STUDY

APPENDIX B

TABLES ILLUSTRATING THE CORRELATION MATRIX FOR VARIABLES CORRELATED WITH THOSE RETAINED IN THE CONSERVATION ADOPTION MODEL, AND REPRESENTING SPECIFIC FARM TYPES IN EACH AREA SAMPLED IN KWAZULU-NATAL (OCTOBER 1993)

Table 23: Correlation matrix for variables correlated with those retained in the Conservation Adoption model. (Variable labels are defined on the following pages).

	EROFM	LOSPRD	RIVEST	FINCAP	CROPOR
EROP	**.38****	-.10	.12	-.11	-.10
SPROB	**.25****	.03	.02	-.16	**-.22****
EROB	**.30****	-.04	.12	**-.19***	**-.25****
IMPCT	**.17***	-.01	.04	.10	.10
RCORSE	**.21***	.05	.16	**.24****	**.18***
TIMPOR	**.18***	.09	.10	**.14***	.13
EXPFT	**-.18***	-.05	-.02	.01	-.15
ERPROS	**.18***	.03	.04	-.05	-.01
ENVIR	.00	**.33****	-.09	-.07	-.08
CONSKL	-.01	**.26****	**.22****	.01	.10
PRCPCON	.15	**.23****	.04	.16	**.22****
FINE	.02	**.33****	.05	.02	.01
RESPCT	.03	**.33****	-.01	**.24****	.02
FMRGHT	.06	**.35****	.02	-.09	.02
LDVAL	-.01	**.17***	**.18***	**.17***	**.23****
RHELP	.15	**.20***	.07	.15	.11
RINTRO	-.01	.07	**.34****	.10	-.01
FINCAP	-.14	.15	**.27****	1.00	**.37****
CROPOR	-.02	.04	**.24****	.37	1.00
OFFMIN	-.05	.07	**-.18***	-.11	**-.26****
ATTENT	.08	.13	**-.17***	-.10	**-.36****
RIVEST	.12	.08	1.00	**.27****	**.24****
COMPFM	.12	.00	.01	**-.17***	**-.17***
CONCOM	.11	.16	.08	**.20***	.11
BYFM	.03	.07	-.11	-.07	**-.17***
FLDDYS	.19	.08	-.03	.07	**.20***

** = Significant at 1% level * = Significant at 5% level (2-tailed)

Definitions for variable labels specified in Table 23

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.

EROFM	=	percentage of farm area visibly eroded.
LOSPRD	=	bad conservation practices cause losses in productivity.
RIVEST	=	frequency with which farmers invest own capital when implementing soil conservation practices.
FINCAP	=	sufficient financial resources to implement soil conservation practices (dummy variable: yes = 1, no = 0).
CROPOR	=	proportion of farm area currently cropped (percentage).
EROP	=	extent of erosion problem on farm considering climate and soils types.
SPROB	=	seriousness of erosion problem in farming area.
EROB	=	extent of erosion on the farm when the farmer began managing it.
IMPCT	=	past and current experience of circumstances where significant soil loss has had impacts on inputs, yields, or income (dummy variable: yes = 1, no = 0).
RCORSE	=	frequency with which farmers attend soil conservation courses.
TIMPOR	=	proportion of farm area currently under timber (percentage).
EXPFT	=	positive effect of existing conservation measures on farm profit.
ERPROS	=	chances of prosecution having violated soil conservation legislation.
ENVIR	=	index reflecting perceived seriousness of erosion impacts on the environment.
CONSKL	=	own ratings of relative soil conservation management skills.

PRCPCON	=	index reflecting perceptions about on-farm financial and managerial benefits of soil conservation activities.
FINE	=	farmers not using soil conservation measures should be liable for heavy fines.
RESPCT	=	land owners have responsibilities to protect soil resources for future generations.
FMRGHT	=	farmers do not have the right to use their land in ways that cause damage to resources.
LDVAL	=	bad conservation practices reflected in lower land values (dummy variable: yes =1, no = 0).
RHELP	=	frequency with which farmers help others implement and/or maintain soil conservation practices.
RINTRO	=	frequency with which farmers implement soil conservation measures with no outside technical assistance.
OFFMIN	=	current proportion of family income from off-farm sources (percentage).
ATTENT	=	insufficient attention is paid to soil conservation programs.
COMPFM	=	the government should compensate farmers who adopt soil conservation measures.
CONCOM	=	soil conservation committees provide valuable information on soil erosion and conservation.
BYFM	=	bought farm (dummy variable: yes = 1, no = 0).
FLDDYS	=	field days/conferences provide valuable information on soil erosion and conservation.

Table 24: Specific farm types (ie. crop, livestock, or mixed farms), in each area sampled in KwaZulu-Natal (October 1993).

	Farm types			
Farming Area	Crops only	Livestock only	Mixed farms	Missing
Dalton/Wartburg	18	0	21	0
Camperdown/Eston	7	2	13	0
Dundee	0	13	18	1
Estcourt	1	24	10	0
Winterton	3	5	22	1
Totals	29	44	84	2