FARM SIZE AND SOIL LOSS: PROSPECTS FOR A SUSTAINABLE AGRICULTURE IN KWAZULU-NATAL

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Abstract

Considerable literature has linked the increasing concentration of agricultural production to severe ecological problems. There is an argument that large-scale farmers are less concerned about the environment and, therefore, less likely than small-scale farmers to employ environmentally sound methods and practices. However, this paper advances an alternative hypothesis predicting that small-scale farmers are less able to preserve the environment than large-scale farmers because of environmental and institutional constraints such as farming on highly erodable and marginal soils. To test this hypothesis, the relationship between farm size and estimated soil loss using data obtained from a random sample of farmers in a KwaZulu-Natal midlands community was examined. Large farms were found to have lower estimated soil loss than small farms, mainly because the land farmed had less potential for erosion. The implications of these findings for developing an effective soil conservation policy are discussed

The differential productivity of farmland must be represented in any analysis of the changing structure of agriculture and the efficiency of large and small farms. The most productive farmland in this country has a relatively low soil-erosion potential and lends itself to capital-intensive agricultural production. Capital-intensive agriculture is not attracted to the marginal land that has higher erosion potential. Marginal lands are, however, the most accessible and affordable for smaller farmers. Soil erosion, then, is a problem of small-farm agriculture, not capital-intensive agriculture.

1. INTRODUCTION

The loss of society's soil resource is perhaps more likely than any other single factor to threaten the sustainability of agriculture. Sustainability is here defined as the maintenance of the necessary conditions for sustained production, including the regeneration of topsoil from parent material at a rate exceeding the erosion rate (Russell, 1998:30; Camp, 1981). Soil erosion directly reduces the capacity of the land to produce food, fibre and timber. Continued soil erosion can lead to a reduction in the production potential of land, in some instances to zero (Russell, 1998:2). The overuse of soil has resulted in its depletion, particularly fertile topsoil, which is probably the most important resource from the viewpoint of rural communities (Pelser & Kherehloa, 2000).

In recent years the planet has lost in excess of 25 billion tonnes of topsoil, which is enough to grow nine million tonnes of grain and thus make up the diets of at least 200 million undernourished people (Meyers, 1998:25). In South Africa, it is estimated that three tonnes of topsoil per hectare are being lost every year, more than the 0.1 tonne per hectare that is regenerated annually (Yeld, 1997:35-36). Traditional methods of crop production such as shift cultivation and inter-cropping are arguably more sustainable in this regard.

For some time now, the government of South Africa has spent substantial amounts of money on projects aimed at reducing soil loss (Russell, 1993; Scotney, 1981). Beginning in the early 1980s, the Conservation of Agricultural Resources Act, No 43 of 1983 represented an attempt to improve land protection by reducing the effects of farmland degradation on the environment. The Act sets out the moral obligation that a farmer has towards the land she or he manages and the procedures to be followed when farming practices are in conflict with the requirements of the Act. However, the lack of success in solving the soil erosion problem suggests that the major obstacles are social and political constraints and not technical in nature.

A growing body of international literature has linked the increasing concentration of agricultural production to severe ecological problems (Pelser & Kherehloa, 2000; Buttel, 1979; Buttel & Larson, 1979; Buttel *et al*, 1981). Ostensibly, not much work has been done in South Africa on this aspect. Hence, this article examines the relationship between farm size and soil loss. If the trend toward fewer and larger farms is leading to an increase in soil erosion, it may have important consequences for the sustainability of conventional agricultural production systems in South Africa.

2. THEORETICAL FRAMEWORK

There is a paucity of information on the factors that affect soil conservation practices by farmers. Most studies examining conservation behaviour rely on the adoption-diffusion model (Rogers, 1983) and use the characteristics of farmers to predict the adoption of soil conservation practices (Pampel & Van Es, 1977; Taylor & Miller, 1978). Many of these studies conclude that research on the adoption of soil conservation practices supports the hypotheses of the adoption-diffusion model; however, there is no consensus in the literature on this matter (cf. Ervin & Ervin, 1982; Hooks *et al*, 1983; Korsching *et al*, 1983; Napier *et al*, 1984; Mallett *et al*, 1981; Frenkel *et al*, 1989).

A second approach to examining conservation behaviour asserts that the logic of capitalism (the desire to maximise profit being the primary goal) causes environmental degradation in agriculture. This literature argues that the technologies involved in large-scale agriculture and the infrastructure surrounding it place several constraints on implementing environmentally sound methods and practices (Rwelamira & Kleynhans, 1997; Buttel, 1979; Buttel & Larson, 1979). The most common proposition in this literature is that large-scale farmers are less likely to be concerned with the use of chemicals and soil and water conservation than are small-scale farmers. This implies that increased concentration of production in South African agriculture will accelerate degradation of the environment.

To assess these propositions, Buttel *et al* (1981) examined factors accounting for variation in farmers' environmental attitudes. They found that small-scale farmers, and those with a non-economic orientation to farming, had attitudes more supportive of soil conservation. A major problem with such studies, however, is that they are attitudinal and thus make an implicit assumption that at least a moderate relationship exists between attitudes and behaviour. Furthermore, they are contradicted by studies that have found a positive correlation between farm size and the use of conservation practices.

Although most recent literature suggests that large-scale farmers are more likely to exploit the environment than small-scale farmers, a competing hypothesis that is more consistent with the empirical studies examining farmer behaviour could also be derived from the same literature. Small-scale farmers may have been settled on already eroded and severely degraded land by design (Laker, 1976; Van Rooyen & Nene, 1996). Again, small farmers do not farm the best, and enter into environmentally risky farming practices due to a shortage of good land. As such, poor soil conditions may not necessarily be attributed to their behaviour.

The adoption of new machinery and capital-intensive technologies to reduce erosion increases capital expenditures and possibly the debt of large-scale farmers, but may not create economic insecurity for them. Large-scale farmers with a substantial debt may be more economically secure than small-scale farmers with a proportionately smaller debt and less access to capital. In addition, several other factors may lead large-scale farmers to preserve the environment better than small-scale farmers. Large-scale farmers tend to farm land that has lower soil erosion potential, while small-scale farmers are usually forced to farm less desirable land often located on steeper hills (Ervin *et al*, 1984).

Capital requirements and institutional constraints may also keep small-scale farmers from adopting conservation farming practices (Frenkel *et al*, 1989; Scotney, 1981; Mallett *et al*, 1981; Russell, 1991). However, empirical evidence in KwaZulu-Natal has shown that large-scale commercial farmers are not necessarily better in terms of soil conservation when compared with their small-scale counterparts. Russell (1998b) in a recent survey of a 3 000 000 ha area of commercial farmland in the interior of KwaZulu-Natal found 50 600 ha with bad erosion and 2 500 000 hectares of veld in a fair to poor condition.

Many soil conservation practices, such as terracing, require large capital outlays and may also reduce yields for the first few years. Given the increasing size and cost of new equipment, small-scale farmers often depend on rentals or the purchase of used equipment. One of the major methods of soil erosion control is the use of reduced tillage practices. However, the best practice, no-till, requires special equipment introduced quite recently and not yet readily available on the used equipment market. Although farmers with limited resources may be as concerned (or more concerned) about the environment, economic constraints limit their flexibility and options to change practices.

Most previous farm support programmes have been beneficial for large-scale farmers but not for small-scale farmers (van Rooyen & Nene, 1996); the programmes provide greater income and reduce some of the risk associated with market forces. The reduction of risks may enable large-scale farmers to preserve the environment better than small-scale farmers since capital formerly used in production may be shifted to other uses (e.g. environmental protection). Finally, large-farm farmers have access to more and better information and have more contact with representatives of agribusiness, the extension service, and other government agencies (Booth *et al*, l994).

The major point of this discussion has been that a competing hypothesis can be derived from the "ecological critique of large-scale agriculture" (Buttel *et al*, 1981). The most prevalent hypothesis has been that small-scale farmers preserve the environment better than large-scale farmers because the capital-intensive technologies large-scale farmers use force them to take a short-term view of their farming operation. Similarly, it has been proposed that the capital-intensive nature of these technologies increases the economic insecurity of large-scale farmers. The hypothesis in this paper is the reverse of this view: Small-scale farmers are less likely to preserve the soil than large-scale farmers because of economic constraints and the nature of landholding patterns.

3. METHODOLOGY

Data were collected from personal interviews with 244 randomly selected farmers in the moist midlands of KwaZulu-Natal. The area in which the farmers are found is diverse in that it spans different rainfall regimes and topography, thus quadrants were used in the sampling procedure. To ensure the geographical randomness of the sample, the number of farmers drawn from each quadrant was compared to the number expected, based on the actual proportion in each quadrant. The statistical results demonstrated that the sample of farmers represents the geographical distribution of farmers within the area. The 244 farmers surveyed comprised a mixture of small-scale farmers on communal land and commercial farmers on title deed land.

3.1 Independent and dependent variables

A farm's soil-erosion potential was defined as the weighted average product of the erodibility (K), slope (S), and slope length factors (L) in the Universal Soil Loss Equation (Wischimeir & Smith, 1978). This information was obtained from soil maps of the province. Each field was weighted by the percentage it represented of the farm's total owned cropping land. The soil erosion potential rate is calculated so that the larger the value, the higher the soil loss potential. This variable, not included in most studies of conservation behaviour, is important because it measures the relative need for conservation. The estimated soil-erosion rate included the above three variables plus the crop rotation and tillage methods used by the farmer. This information was obtained through interviews. The soil-loss rate is expressed in tonnes per hectare (ha) per annum.

The measure of farm size used in this analysis was total farm size (ha). Total size of farm owned or operated could be used because all farmers surveyed had some land under row crop production. To assess the independent effect of farm size on estimated soil loss, we included several relevant independent variables in the regression analysis. Of particular importance is the measure of soil-erosion potential. Previous studies have shown indebtedness to be related to environmental concern (Buttel *et al,* 1981). However, because a simple measure of debt does not adequately measure economic insecurity, a ratio of total worth/debt was constructed to measure the relative influence of debt. Presumably, the higher the ratio, the more economically secure the farm. Previous research has also revealed that education and age are strongly related to concern with the environment (Buttel, 1978; Van Liere & Dunlap, 1980). Measures of age and education are included in the regression equation to control for the effects of these individual characteristics of farmers. Age is reported in seven categories. Education is represented with four categories: 0-6 years, 7-9 years, 10-12 years, and over 12 years.

4. FINDINGS

The model to be estimated was:

$$Y1 = f(x1, x2 \ldots x6).$$

The Genstat V programme was used to run two procedures of correlation, a series of simple regressions and multiple regressions. Table 1 presents the descriptive statistics and zero-order correlation coefficients for the selected variables in the analysis. Of particular interest is the relatively high estimated rate of soil loss for farms in the sample of over 10 tonnes per hectare per year. This indicates that, on the average, a rather severe soil-loss problem exists in the area. The variable correlated most strongly to estimated soil loss, as one might expect, is soil-loss potential. Although the correlation between potential and estimated soil loss is 0.5, this is not as strong as might be predicted. This suggests that the conservation effort is still somewhat important in reducing the overall soil loss. To examine this question, we regressed the estimated soil loss on the use of various soil-conservation practices (see Table 2). Use of various conservation practices explained about 21 percent of the variance in estimated rate of soil loss.

Table 1: Zero-order correlation coefficients for selected variables

		(X1)	(X2)	(X3)	(X4)	(X5)	(X6)	Mean	SD
(X1)	Estimated soil loss	1.000	0.503**	-0.312**	-0.172	0.10	-0.178	10.29	6.51
(X2)	Soil loss potential		1.000	-0.124	-0.283**	0.265**	-0.220	0.21	0.06
(X3)	Total fam size			1.000	-0.276**	0.265**	-0.078	5.91	3.28
(X4)	Age[a]				1.000	-0.318**	0.438***	3.81	1.56
(X5)	Education[b]					1.000	-0.045	2.89	0.66
(X6)	Worth/debt						1.000	8.57	13.95

[a]Age measured in six categories (years): 1 = <25; 2 = 25-34; 3 = 35-44; 4 = 45-54; 5 = 55-65; 6 = >65.
[b]Education measured in four categories (years completed): 1 = 0-6; 2 = 7-9; 3 = 10-12; 4 = >12.
**p* < .05; ***p* < .01; ****p* < 0.001, level of significance.

As predicted, total farm size was negatively related to estimated soil loss; large-scale farmers were losing less topsoil than small-scale farmers. Other socio-demographic variables, such as age and education, were shown to be strongly correlated with environmental concern (Buttel *et al,* 1981), have non-significant and relatively weak relationships to estimated soil loss and the potential soil loss is quite similar to those between these variables and the soil loss measure. Although there is a negative relationship between gross farm sales and potential soil loss, it is not statistically significant. However, both age and education are significantly related to potential soil loss, age negatively and education positively. These data suggest that young farm farmers may have access to only the land with more erosive soils (Ervin *et al,* 1984).

Surprisingly, the worth/debt ratio was not significantly related to soil loss potential.

Table 2: Regression analysis of estimated soil loss on use of various soil conservation practices

		Zero-order correlation coefficient							
Conservation practice[a]	**Estimated soil loss**	**(X1)**	**(X2)**	**(X3)**	**(X4)**	**(X5)**	**(X6)**		**Beta**
(X1) Terraces	-0.305	100 0							-0.015
(X2) Contour planting	-0.454**	489**	100						-0.409
(X) Crop rotation	-0.277	0.359*	0.056	1.00					-0.239
(X4) Minimum tillage	0.184	0.122	-0.039	-0.52	1.00				0.251
(X5) No-till planting	-0.231	0.027	0.039	0.52	0.269	1.00			-0.262
(X6) Strip-cropping	-0.87	-0.336	-0.024	0.267	-0.397*	0.048	100		0.083
Mean	10.29	0.63	0.50	0.87	0.81	0.31	0.21	*F*-ratio	2.451*
SD	6.50	-	-	-	-	-	-	Adjusted R^2	0.217

[a]Respondent farmers were asked if they were currently using, or had ever used, the various soil conservation practices. Their responses were coded: 0 = no; 1 = yes.
*$p < .05$; ** $p < .01$ level of significance.

As might be expected, several strong relationships exist between the independent variables. For example, gross farm sales are significantly related to age and education. Age is negatively related to education and positively related to the worth/debt ratio. Due to the existence of relatively weak relationships between soil-erosion potential and the other independent variables, it was concluded that multi-colinearity would not be a problem in the regression analysis. Moreover, the relationship between soil erosion potential and the dependent variable was not strong enough to create any statistical problems. Multi-colinearity was not a real problem, as was initially suspected.

To assess the independent effect of the selected variables on soil loss, actual soil loss was regressed on debt, soil loss potential, total farm size, age, and education (Table 3). The results of the regression analysis indicate that only one independent variable has a significant effect on estimated soil loss potential. When the other independent variables are controlled, the relationship between total farm size and estimated soil loss is still negative, yet substantially reduced. Since previous studies have shown that farm size is positively related to the use of soil conservation practices, a much stronger relationship was expected to remain.

The regression analysis indicates that when the other independent variables are controlled for, age, education, and worth/debt are not significant predictors of actual soil loss. These findings suggest that soil erosion potential is an intervening variable between the structural and individual characteristics of farms and farmers and estimated soil loss. Consideration of institutional issues such as land tenure could have helped in clarifying the results, however, data on these issues were not available.

Table 3: Regression analysis of estimated soil loss on worth/debt, soil loss potential, total farm size, age, and education

Worth/debt	-0.196[a]
Soil loss potential	0.638**
Total farm size	-0.051
Age	0.388
Education	0.148
F-ratio	3.307
Adjusted R^2	0.281

[a]Standardised partial coefficient (beta).
**p* < .05; ***p* < .01 level of significance.

5. DISCUSSION AND CONCLUSION

This analysis raises questions about both the adoption-diffusion literature and the ecological critique of agriculture. The findings of this study indicate that ecological conditions influence the relationship between farm size and soil loss. However, most, if not all, of the respondents in this study operated family-labour farms. Whether large corporate farms are similar to larger-than-family farms in environmental conservation remains a research question (Lee, 1980). Data on the differences between owner farmers and tenants with respect to soil loss and the adoption of soil-conservation practices are inconclusive (Ervin, 1982). However, if increased farm size continues to be associated with increased tenancy (Gilbert & Harris, 1983), the relationship between farm size and soil loss may change. Analysis in this study addresses recent pleas to bring the environment into the study of agriculture (Kakonge & Imvbore, 1994; Morah, 1996; Pelser & Kherehloa, 2000). The differential productivity of farmland must be represented in any analysis of the changing structure of agriculture and the efficiency of large and small farms. The most productive farmland in this country has relatively low soil erosion potential and lends itself to capital-intensive agricultural production. Capital-intensive agriculture is not attracted to the marginal land that has higher erosion potential. Marginal lands are, however, the most accessible and affordable for smaller farmers. Soil erosion, then, is a problem of small-farm agriculture, not capital-intensive agriculture. How can this structural fact be built into soil conservation legislation?

Given that a major concern of current farm programmes has been and still is low food production and enticing more small-scale farmers into agricultural production, it is not easy to reduce production on lands that have the greatest soil-loss potential. To a great extent, this would restrict the smaller, more marginal farmers from planting higher income producing crops. Do we simply tell farmers on erodible land that they can no longer produce certain crops that produce more erosion, and let them face bankruptcy? One alternative might be a plan allowing the cropping rights for these marginal lands to be purchased by the government. The government could pay the farmer the difference between the income the farmer would receive from the higher-profit crop and that from the lower-profit crop. Another possibility is government purchase of a crop easement. This may, however, cause legal problems because most land in this country has a market value greater than what can be justified based on its agricultural productivity. Such problems demonstrate the complex nature of the current situation and the failure of past soil-conservation programmes to take these complexities into consideration.

There is an urgent need for a major revision of land planning, taking into cognisance equitable distribution among citizens. Land tenure remains a complex and precarious issue in rural South Africa. The existing land tenure system not only contributes to land degradation (particularly soil erosion) but also no longer even fulfils the equitable social function for which it was intended (Pelser & Kherehloa, 2000). Therefore, land tenure is so vital to changes in land productivity that an urgent and fundamental redress is needed. In keeping with the government's commitment to smallholder development, this review should be done with a view to providing small-scale farmers with secure and negotiable titles to land. This suggestion is supported by Rwelamira & Kleynhans (1997:231) who stated that land use efficiency, agricultural production and rural employment could be increased if land tenure systems were reformed to allow access, environmental sustainability and full utilisation of land resources.

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