AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

ECONOMIES OF SCALE FOR SMALL AND LARGE SUGAR CANE FARMS IN KWAZULU-NATAL[1]

S. Mbowa, and W.L. Nieuwoudt[2]

This paper gives a profile of a sample of a small and large sugar cane farms in the North coast region of the KwaZulu-Natal sugar cane belt. The survey was conducted during May 1995. Farms studied varied between one and 600 hectares. Values for small farms were significantly lower than large farms for human capital resources, farm resource utilisation, rate of search and utilisation of farm information, and adoption of appropriate and improved cultural farm practices. Such differences may account for the differences in farm productivity between small and large farms that exist in the South African sugar industry. A linear discriminant function model shows that small and large farms studied differ significantly on lines of human resources and cost of borrowed capital (market related). The findings of the study show that large cane farms face lower market related interest rates, are relatively better equipped in human resource capital, and are in a position to implement appropriate and recommendable farm practices (soil analysis and use of certified seedcane) compared to small farmers.

EKONOMIE VAN SKAAL VIR GROOT EN KLEIN SUIKERRIETPLASE IN KWAZULU-NATAL

Hierdie studie bied 'n profiel van 'n monster van klein en groot suikerrietplase in doe Noordkusstreek van die KwaZulu-Natal suikerrietstrook. Die opname is gedurende Mei 1995 gedoen. Bestudeerde plase het tussen een en 600 hektaar gewissel. Waardes vir klein plase was aansienlik laer as vir groot plase wat betref menslikekapitaalhulpbronne, plaashulpbronbenutting, bekom en benut van plaasinligting, en aanvaarding van toepaslike en verbeterde kweekpraktyke op die plaas. Sulke verskille mag die verskil in plaasproduktiwiteit tussen klein en groot plase verklaar wat in die Siud-Afrikaanse suikerbedryf bestaan. 'n Linêre diskrimineringsmodel toon dat bestudeerde klein en groot plase aansienlik verskil wat menslikehulpbronkapitaal en die koste van geleende kapitaal (markverwante) betref. Die bevindings van die navorsing toon dat groot suikerrietplase laer markverwante rentekoerse ondervind, relatief beter toegerus is met menslikehulpbronkapitaal en in 'n beter posisie is om toepaslike en aanbevole landboupraktyke (grondontleding en gebriuk van gersertifiseerde saadriet) toe te pas in vergelyking met klein plasies.

---

[1] T*he financial assistance of the Centre for Science Development (HSRC South Africa) and Tongaat Hulett (Sukumani Development Company) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the authors and are not necessarily attributable to the Centre for Science Development.*

[2] *Department of Agricultural Economics, University of Natal, Pietermaritzburg.*

1. INTRODUCTION

The debate on small or large farm development is currently a central issue to agricultural policy makers in South Africa. The focus has addressed how land redistribution can address the problems of poverty, low incomes and how to insure some minimum standard of living for farm people in rural areas, while ensuring that land resources are efficiently utilised. The debate to decide the future structure of the country's agricultural sector has been met with a mixture of opinions. Small farm strategists advocate a policy of breaking up large farms into smaller farms on the grounds that productivity per hectare is higher on a smaller farm. The emergence of small-scale farms is supported because of the intensive utilisation of labour and capital, therefore fulfilling employment and equity goals (Ellis, 1988:192) which large farms do not meet. The use of family labour on small farms is thought to cost less than hired labour as there are no search and hiring costs (i.e., transaction costs are zero) and supervision costs may indeed be lower for family labour. The opportunity cost of a unit of family labour employed on the farm is likely to approximate the expected wage rate (adjusted by the probability of employment). On the other hand, it is argued that some gains from agricultural innovations are scale dependent (Thomson & Lyne, 1991). Likewise, adoption rates are related to farm size (Welch, 1978; Feder *et al.,* 1982, Feder, 1985 and Shaw & da Costa, 1985), therefore technology is more productive the larger the scale of activities to which it is applied. Increases in scale increase incentives for 'correct' decisions resulting not only in the 'purchase' of more education by operators with larger farms, but also in investments that enhance response (Welch, 1978:274).

Large farmers are often deeply committed to agricultural development, technologically sophisticated and dynamic, with technically efficient and high volumes of output (Binswanger, 1994). Farm size has therefore been quickly identified as one of the key issues when the question is raised on why some farmers did better than others (Stanton, 1978). It is however argued that the relative efficiency of large farms is due to market imperfections in which specific public policies have played a crucial role (Van Zyl, 1994 and Binswanger, 1994). Size economies exist in information gathering about technology, marketing and credit (Binswanger, 1994). Transaction costs associated with many small loans act as a disincentive for lenders and the cost of credit to small farmers is likely to increase (Carter, 1988). In the presence of fixed transaction costs, the cost of borrowing in the formal credit market is therefore a declining function of the amount of owned land (Binswanger *et al.* 1992:26).

Sugar cane is a very important cash crop in the economy of KwaZulu-Natal province. Productivity differences are evident between small and large sugar

cane farms, as average yield on small farms is 40 tons per hectare, compared to 55 tons per hectare on large scale farms (SACGA, 1994). The South African Cane Growers' Association (SACGA), is directing resources to develop small sugar cane growers (Chadwick & Sokhela, 1992) to uplift living standards of people in rural areas in KwaZulu-Natal. This is compatible with recent policy shifts in SA agriculture where policy makers and the World Bank, believe small farmers can and should play a key role in developing rural areas in SA.

This paper provides information on features of small and large sugar cane farms, aimed at identifying salient characteristics between the two farm groups. Information on attributes of small and large farms would provide a better indication of how agrarian structures affect resource use, and thereby of the likelihood of being able to achieve both growth and equity. This is undertaken using data collected from a sample of 160 large and small-scale private and independent sugar cane farm operations in the North Coast region of the KwaZulu-Natal sugar belt. The data were stratified into small and large-scale farms to maximise the differences between farm sizes. Farms studied range between one to 600 hectares. Linear discriminant analysis (LDA) is employed to investigate on what lines the two groups differ, and principal component analysis (PCA) (Norusis, 1990:318-323) is used as a variable reduction scheme (Stevens, 1986:337), and to examine interrelationships between variables.

2. STATISTICAL PROCEDURES

2.1 Linear discriminant analysis (LDA)

Multiple linear discriminant analysis (LDA) (Manly, 1994:107) was used to determine factors important in classifying 'small' and 'large' sugar cane farms. The main objective was to 'discriminate' between small and large sugar cane farms, on the basis of some set of characteristics, evaluate how well the two groups discriminate, and to determine which characteristics are the most powerful discriminators. The LDA model takes the form:

$$D_i = \sum_{j=1}^{n} B_j X_{ij}$$

The standardised weighting coefficient estimates $(\mathbf{B}_j)$ are particularly important for policy analysis, since each shows the relative contribution of its associated variable $(\mathbf{X}_j)$ to the linear function. Discriminant scores $\mathbf{D}_i$ estimated for each farm are compared to the mean score for each farm group and the farm is classified into the group with the score most similar to his own. Success in discrimination

between groups is assessed by observing the proportion of correct group classifications and the Wilk's lambda statistics (Klecka, 1980). The variable categorising farms as small and large was captured as dichotomous, equal to one if a farm is classified as large, and zero if a farm is small[1]. The postulated function to classify small and large farms took the form:

$$Z_i = a_1 AGE + a_2 EXPNC + a_3 EDUC + a_4 XRTNG + a_5 TRNG + a_6 VST + a_7 ADOPT + a_8 INFRM + a_9 MG + a_{10} INPTC + a_{11} LABOR + a_{12} YIELD + a_{13} NAP$$

Where; Z_i is the discriminant score for each farm, and a_1, ..., a_n are the weighing (standardised discriminant function) coefficients of variables; age of farm operator (AGE), farming experience (EXPNC), education (EDUC), number of training workshops attended (XTRNG), agricultural training status of farm operator (TRNG), visits by field extension officer (VST), level of adoption of appropriate farming practices (ADOPT), use of farm information (INFRM), input costs per hectare (INPTC), labour costs per hectare (LABOR), average sugar cane yield (YIELD), and natural agro-climatic potential of a region (NAP). Details of variables in function 2 are given in Tables 1, 2, and 3. The weighting given to each of the original characteristics must be determined so that the resulting composites score Z, will have maximum usefulness for classifying the two farm groups (Dunn & Frey, 1976). While these weights may be positive or negative, their relative contribution centres on the absolute value, that is, the coefficients identify the variables which contribute most to differentiating between the two farm groups (Klecka, 1980:29). The major problem with LDA is the assumption that independent variables in the two groups come from populations with a normal distribution. If the independent variables are not from normal populations, or the variance-covariance matrices are not equal, then the estimators are not consistent (Turvey, 1991). The LDA is however, robust to departures from the normality assumptions (Lachenbruch, 1975:40-50). In addition, a weaker sufficient condition to justify the LDA is that the $\mathbf{D}_i$ be univariate normal (Truett *et al.* 1967).

3. DATA SOURCES

Data on farmers' personal, social and economic characteristics, and agro-climatic farm attributes for the 1993/94 season were collected from a randomly selected sample of 160 large and small-scale sugar cane growers, in the North Coast region of the KwaZulu-Natal sugar belt. This was achieved through a survey designed in collaboration with the SACGA and Sukumani Development Company (PTY), conducted during March-May 1995. Only privately owned farms were sampled and farms under communal tenure were excluded as they do not have the same investment incentives as those on privately owned farms. Farmer independence in farm decision making was also an important

consideration in the selection of the sample, especially in small-scale sugar cane farming, where the mills influence decision-making processes[2]. An address list of 380 North Coast registered quota growers, obtained from the SACGA, was used as a sample frame of large-scale farms. Questionnaires were posted to all 380 large-scale farmers. A response rate of about 30% was anticipated based on similar mail surveys conducted in the region (e.g. Woodburn *et al*, 1994; and Bullock *et al*, 1995). A sample of 100 small-scale farmers was randomly selected from a list obtained from Tongaat Hulett (Sukumani Development Company). Because postal addresses were not readily available for these farmers, they were surveyed by personal interview using a similar structured questionnaire.

Ninety large-scale farmers responded to the postal survey (24% response rate), of which 64 (16.4%) returned usable questionnaires. Despite the low response rate, sample statistics for farm size and yield are not significantly different to population data provided by SACGA, giving some credibility to the sample data. Ninety six of the small-scale independent commercial cane farmers provided usable information. Information on the 160 respondents was used in this analysis.

4. RESULTS

4.1 Descriptive statistics

A pooled t-test of mean difference of selected characteristics on small and large sugar cane farms are presented in Tables 1, 2 and 3. Descriptive statistics illustrating a demographic profile of respondents in the sample are presented in Table 1. Table 2 illustrates characteristics specific to land use and performance indicators for small and large-scale farms within the sample. Table 3 shows adoption rates of appropriate farm practices, and evaluation of sources of farm information by small and large- scale farmers.

From Table 1, no significant difference in the average age or years of farming experience between small and large-scale farm operators was recorded. As regards formal education, there is a significant difference between the two farm groups, with large-scale farmers recording an education level of above matric (Standard 10), compared to standard 6 to standard 9 in the small-scale farmer group. Data on farmer's education was captured using the scale ranging from zero to four followed in Makary & Rees (1981) to symbolise; no education, standard 5 and below, standard 6 to 9, standard 10 (matric), 4 for tertiary education, respectively. Farming is a full-time occupation to ninety two percent (58) of large-scale farm operators with eighty seven percent (54) having received practical training in cane growing, attending over two training sessions on average in two years. Eighty percent (76) of small-scale farmers are full-time

farmers, and forty six percent (44) have been trained in cane growing with an attendance rate of one training session on average in two years.

Table 1: Mean difference in farmers' personal and demographic characteristics according to farm category

Characteristics	Small	Large	t-values
Age (years)	50 (95)	49 (58)	0.74
Farming Experience (years)	22 (96)	24 (62)	0.83
Education	2.3 (96)	3.5 (64)	8.09**
Training workshops attended in two years	1.2 (96)	2.9 (64)	2.44*
Full-time farming	0.80 (96)	0.92 (64)	2.09*
Training	0.46 (96)	0.87 (63)	5.77**

*Significant at; **1 percent, and *5 percent level. Figures in parenthesis represent valid cases.*

From Table 2, significant differences in the means of selected land use characteristics and performance indicators are visible between small and large cane farms. Average farm size operated is 12.5 hectares and 263 hectares for the small and large-scale groups, respectively. Average area under sugar cane for the small farm group is 8.3 hectares, and 197 hectares for the large scale farmers. Large farms have a relatively high percentage of land under sugar cane, utilising 81.6 % of operated land as compared to the 76.5 % on small farms. The results of the small farmer group are consistent with those reported in the small grower development survey (Quantum research, 1990:47), with over three quarters of the Asian (Indian) respondents claiming that 75 % or more land is under cane compared to 76 % in this study (Table 2). Sugar cane production contributed respectively, 91% and 98.3% of gross total farm income on small and large farms. This shows that sugar cane growing is the most important farm activity on farms studied (small and large).

As regards measures of economic performance considered, the average yield on farms in the study area was lower on small-scale farms (47.6 tons/ha) compared

Table 2: Mean difference in land use and performance indicators between small and large-scale sugar cane farms

LAND USE	SMALL	LARGE	t-VALUES
Farm size (Ha)	12.5 (96)	263.4 (63)	9.47**
Area under sugar cane (Ha)	8.3 (95)	197 (62)	8.44**
% of area under sugar cane	76.5 (95)	81.6 (61)	1.42
Sugar cane income per gross farm income (%)	91.0 (95)	98.3 (59)	2.65**
Rented land under cane per total area under cane (%)	33 (19)	25 (24)	0.44
PERFORMANCE INDICATORS			
Average Yield (Tons/Ha)	47.6 (95)	54.6 (61)	1.91
Net Income (R/Ha)	438 (87)	1519 (51)	2.69**
Interest on borrowed capital (%)	23 (85)	15 (32)	13.22**
Input costs (R/Ha)	1036 (92)	635 (57)	3.71**
Labour cost (R/Ha)	1995 (87)	1147 (57)	3.25**
Quantity of fertiliser (Tons/Ha)	0.55 (91)	0.49 (35)	0.72
Agro-climatic potential	2.9 (96)	2.8 (57)	0.28

*Significant at; **1 percent level. Figures in parenthesis represent valid cases.*

to large-scale (54.6 tons/ha), although the difference is not significantly different. Net farm income per hectare is significantly higher on large farms (R 1519) compared to smallholdings (R438). The market related interest rates charged on borrowed capital are lower for large farms (15 %), compared to small-scale farms (23 %). Mortgage bond rates (unsubsidised) paid by large farmers recorded during the survey ranged between 15% to 18.5%. While the actual subsidised interest charged to small farmers was 12.5% in 1993/94 season (Bates, 1996), a shadow price of 30% on average was used to cost funds lent to small borrowers in light of data supplied by Bates[3] (1996).

Quantity discounts on bulk purchase for fertilisers and herbicides may explain

the lower input costs per hectare on large-scale farms. Labour costs per hectare (including imputed family labour costs) are higher (R 1995) on small farms compared to the large farms (R 1147). There is no significant difference in the measured agricultural potential between the two studied groups. This is attributed to the fact that the sample of farms studied was from a region (the North Coast of the sugar cane belt) with relatively homogeneous agro-climatic conditions. The agro-climatic potential between regions in the study area was captured on a scale ranging from one to four to symbolise regions with; poor, average, good and very good potential. The scale is based on four of the agro-ecological zones which provide a broad framework for evaluating land productivity in regions at the SA Sugar Experiment Station (SASEX).

Table 3 shows significant differences in mean adoption rates of appropriate farm practices, and evaluation of farm information sources between small and large farm operators. The adoption rate of improved farm practices is relatively higher amongst large-scale cane growers. Overall, large-scale farmers turn to a relatively wider source of farm information (INFRM) for technical advice. This supports the concept that incentives for managers to learn and adjust their activities arises from expected losses due to ignorance, which are high for large-scale farmers (Huffman, 1974). Another implication is that small-scale farmers are slow adopters of innovations, due to the costs involved in seeking information. Direct interaction with extension officers (EXOF) is the most important source of farm information, especially for small-scale farmers. This may be attributed to the high frequency of seasonal visits (VST) by extension officers to small-scale farmers compared to large-scale farmers (Table 3). The South African Sugar Experiment Station (SASEX) is ranked the second most important by both farm groups in assisting farmers to develop managerial capacities.

Data on farm information sources available in the SA sugar cane industry (i.e., ECAD, EXOF, SASEX, DEMON, OHFRM, MGZ) were captured on a likert-type scale ranging from zero to four representing rankings; not useful, less useful, useful, and very useful respectively, indicating the importance of a range of extension facilities to individual farmers. This reflects the relevance of issues discussed when farmers seek external extension assistance (Zinnah *et al.,* 1993). INFRM is the average score of the ratings for all the farm information source data. Whereas VST measures the frequency of visits by field extension officer on a farm in a season captured on a scale as ranging from zero to four to symbolise respectively; none, 1-3 times, 4-6 times, 7-9 times, and 10+ times.

Table 3: Mean difference in adoption rates of appropriate farm practices,

and farmers' evaluation of sources of farm information

FARM PRACTICE		SMALL	LARGE	t-VALUES
Adoption of soil analysis	(SOIL)	0.87 (93)	1.68 (62)	7.49**
Adoption of certified seedcane	(CERTF)	0.27 (93)	0.65 (62)	4.98**
Adoption of farming practices	(ADOPT)[a]	1.13 (93)	1.48 (62)	4.57**
FARM INFORMATION SOURCES				
Visits by field extension officer	(VST)	2.46 (94)	1.05 (62)	-6.58**
SAGCA economists	(ECAD)	0.91 (93)	1.97 (60)	5.45**
Extension officers	(EXOF)	2.65 (93)	2.34 (60)	-2.19*
Experiment research station	(SASEX)	1.92 (92)	2.30 (60)	2.30*
Field day-demonstrations	(DEMON)	0.75 (92)	1.83 (60)	6.25**
Other farmers	(OHFRM)	1.99 (94)	2.02 (60)	0.17
Farm magazines	(MGZ)	1.15 (93)	1.55 (60)	2.46*
Information	(INFRM)	1.53 (94)	2.01 (60)	4.72**

[a] *ADOPT is derived from combining the response scores on the rate of soil analysis and use of certified seedcane by the ith farmer. Significant at; **1 percent level and *5 percent level, respectively. Figures in parenthesis represent valid cases.*

4.2 Characteristics of small and large farms

Social and economic characteristics of cane farms were included in the discriminant function as independent variables. Due to intercorrelations between variables, principal component analysis (PCA) was performed to condense the variables into fewer orthogonal variables. Perfectly correlated variables cannot be used in a discriminant function at the same time (Klecka, 1980:9). The lack of correlation between explanatory variables is a useful property because it means that the indices are measuring different 'dimensions' in the data (Manly, 1986:59).

PCs can then be substituted instead of the original **(x)** variables in the derivation of a discriminant rule, thus reducing the dimensionality problem (Jolliffe, 1986:157). The extracted components are given in Table 4. Variables with factor loadings greater than 0.5 were used to interpret the PCs. PC_1 has high loadings on field extension staff farm visits (VST), hired management (MG), farmers' formal education level (EDUC) and market related interest rate on borrowed capital.

Table 4: Interrelationships between social and economic characteristics of sugar cane farms studied

VARIABLE	EIGENVECTOR FOR COMPONENTS				
	PC_1	PC_2	PC_3	PC_4	PC_5
Farm visits by field extension officers (VST)	-.715				
Hired manager (MG)	.709				
Education of farm operator (EDUC)	.685				
Interest rates (RATER)	-.678				
Training (TRNG)		.769			
Information (INFRM)		.767			
Training workshop (XTRNG)		.607			
Adoption of farming practices (ADOPT)		.589			
Net farm income/ha (NFI)			-.870		
Labour cost/ha (LABOR)			.865		
Input costs/ha (INPTC)			.515		
Farming experience (EXPNC)				.919	
Farmers age (AGE)				.889	
Average yield (YIELD)					.756
Agricultural potential (NAP)					.743
Eigenvalue	3.32	1.98	1.48	1.40	1.25

PC_1 is a contrast between farm human resource capital, and market related cost of borrowed capital (i.e., PC_1 will be high if MG and EDUC are high but RATER and VST are low, and vice versa). PC_2 has high loadings on training (TRNG) in agriculture particularly cane growing, use of farm information (INFRM), number of times the farmer participated in agricultural training workshops (XTRNG), and adoption of appropriate farm practices on a sugar cane farm, that is, soil analysis and use of certified seedcane (ADOPT). PC_2 can be interpreted. Therefore as knowledge index. PC_3 with heavy loadings for net farm income per hectare (NFI), labour (LABOR) and input (INPTC) costs per hectare is a financial index, and

measures labour and input costs per hectare contrasted to net farm income (i.e., farmers with large positive values of PC_3 face high labour and input costs relative to their income, likewise farmers with lower values of PC_3 face lower labour and input costs relative farm income). PC_4 captures the interrelationships between farming experience, another form of training (Stefanou & Saxena, 1988), and age of farm operator. Component PC_5, measures the extent to which the natural agricultural potential of a region is related to the average sugar cane yield.

Components PC_1, PC_2, PC_3, PC_4, and PC_5 were included in the estimated discriminant model. PC_2, a farming experience index and PC_3, a natural agricultural potential index were excluded from the model as they had F-values of less than 1 and statistically non-significant. This may be due to the fact that both small and large farms studied do not differ in farming experience, and are located in a relatively homogenous agricultural potential region. The results are presented in Table 5.

Table 5: Estimated discriminant function for 'small' and 'large' sugar cane farms

Explanatory variable	Standardised coefficient	t-value	Component score group means		
			Small	Large	F value
PC_1	1.032	8.40*	-0.578	0.577	70.61*
PC_2	0.848	5.21*	-0.326	0.637	27.15*
PC_3	-0.499	2.75*	0.161	-0.381	7.55*
PC_4	-	-	-0.087	-0.212	0.51
PC_5	-	-	-0.067	-0.035	0.27E-01
Number of valid cases			82	38	
* significant at 1% level					
F value		118.84*			
Wilk's lambda		0.36			
Canonical correlation		0.80			
Classifications:					
Small scale		90.20%			
Large scale		89.50%			
Total		90.00%			

From Table 5, a Wilk's lambda value of 0.36, and 90% overall correct classification of farms indicates an effective classification ability of the estimated discriminant function. This conveys information that much variability does prevail between small and large sugar cane farm groups studied, and little variability within groups. The two groups of farm sizes (small and large) seem to differ greatly on

lines of human resource capital and cost of borrowed capital (market related), as PC_1 (combining extension, use of hired management, education, and interest rates on borrowed capital) is the main discriminator with the highest standardised coefficient (1.032). The positive sign on the coefficient of PC_1 implies that large farms are better equipment in human resource capital, and face lower market related interest rates, compared to small farms. PC_2 which is an interaction index of training, use of farm information, number of training workshops attended, adoption of appropriate farm practices (an indicator of managerial proficiency) emerged as the second most important discriminating variable with a standardised coefficient of (0.848). The positive sign on the coefficient of PC_2 shows that large farms have high incentives to acquire more knowledge, and are in a better position to adopt appropriate farming methods than smaller farms.

The negative sign on PC_3, the third most important discriminating variable with a standardised coefficient of (-0.499), shows that large farms have high incomes relative to labour and other input costs. The reverse is true, small farms face large labour and input costs per hectare relative to their income per hectare. Frequency distributions of the discriminant scores are shown in Tables 6 and 7. Both small and large farms studied have an approximately univariate normal distribution, the estimates therefore can be accepted with reasonable confidence.

Table 6: Frequency distribution of discriminant scores estimated for the small farm group

Code	Discriminant score range	Frequency	Frequency as percentages
1	-3.043 to -2.464	4	5
2	-2.464 to -1.885	10	12
3	-1.885 to -1.350	11	13
4	-1.350 to -0.726	19	23
5	-0.726 to -0.146	20	24
6	-0.146 to 0.433	10	12
7	0.433 to 1.012	5	6
8	1.012 to 1.592	3	4
		82	100

4.3 Factor relationships in sugar cane production

Principal components analysis (PCA) (Norusis, 1990: 318-323) was used to analyse how social and economic farmer characteristics and environmental

Table 7: Frequency distribution of discriminant scores estimated for the large farm group

Code	Discriminant score range	Frequency	Frequency as percentages
1	-0.090 to 0.526	4	5
2	0.526 to 1.142	5	12
3	1.142 to 1.759	11	13
4	1.759 to 2.375	8	23
5	2.375 to 2.992	6	24
6	2.992 to 3.608	4	12
		38	100

factors are interrelated on small and large sugar cane farms. Principal component analysis methods have been used in previous studies to analyse interrelationships between observable variables (Nieuwoudt, 1977; Horton, 1979; Robertson & Nieuwoudt, 1992 and Odulaja & Kiros, 1996). Its appropriate use involves the study of interrelationships among variables in an effort to find a new set of variables that are fewer in number than the original variables, yet still express what is common among the original variables (Foltz *et al.*, 1993). The area under sugar cane (ASC), is positively correlated to farm operators' education (EDUC) and training (TRNG), farmers' rate of consultation with various sources of farm information (INFRM), and the average sugar cane farm yield (YIELD). Welch (1978), found farm size and educational levels of farm operators, systematically positively related. ASC is also negatively (and significantly) correlated with market (VST) correlated with farm operators' education (EDUC). EDUC likewise, is positively related to the adoption of improved farm practices (ADOPT) that is, soil testing, and the use of certified seedcane. Agricultural Training (TRNG) of farm operators is positively correlated with both net farm income/profitability (NFI), and the rate of consultation with different sources of information (INFRM). TRNG is also positively correlated with adoption of improved farm practices.

Principal component analysis (PCA) was performed to examine interrelationships between variables. PCA generated five principle components (PC's) that accounted for the variability between farmers on the 16 variables used to reflect the production structure in the SA sugar cane industry. Kaiser's criterion was used whereby only PC's with eigenvalues greater than one (1.0) are retained (Stevens, 1986:341 and Norusis, 1990:319). The value of 1.0 represents the variance of the original variables (Johnston, 1980:190). Five components accounting for 62% of the total variation were retained to best describe the structure of the SA cane industry from the 16 measured variables. Components were rotated using varimax rotation to more easily define groups of related

dimensions (Rummel, 1970). Factor loadings, analogous to correlation coefficients, represent the degree and direction of the relationship between the original variables measured and the newly defined factors. Generally, variables with loadings greater than 0.5 were used to interpret the factor components. The objective is to attach an economic interpretation to the PC's (Stevens, 1986:339). If the PC's can be meaningfully interpreted, this leads to a greater understanding of the variation in the data (Crabtree, 1971). Table 8 shows extracted PCs.

From Table 8, the first component Z_1 appears to be a contrast between area under sugar cane in hectares (ASC), use of hired management (MG), market related interest rates on borrowed capital (RATER), and formal education of the farm operator (EDUC). That is, Z_1 will be high if ASC, MG, and EDUC are high but RATER and VST are low. Likewise Z_1 will be low if ASC, MG, EDUC, and ADOPT are low but RATER and VST are high. Therefore Z_1 can be interpreted as a measure of scale. The second component Z_2, measures the extent to which farmers search for farm information (INFRM), have practical agricultural training, (TRNG) and attend training workshops (XTRNG) specifically in sugar cane growing, and adopt improved farm practices. Z_2 can be interpreted as an

Table 8: Factor pattern showing production relationships in studied sugar cane farms

VARIABLE	EIGENVECTOR FOR COMPONENTS				
	Z_1	Z_2	Z_3	Z_4	Z_5
Area under cane (ASC)	**0.772**	0.175	-0.102	0.111	0.090
Hire manager (MG)	**0.748**	-0.057	0.019	0.100	0.011
Interest rates (RATER)	**-0.677**	-0.375	0.292	0.029	-0.041
Education (EDUC)	**0.656**	0.215	-0.061	-0.256	0.068
Extension visits (VST)	**-0.621**	0.032	0.111	0.205	-0.130
Information (INFRM)	0.129	**0.769**	-0.042	0.045	0.034
Training (TRNG)	0.124	**0.764**	-0.145	0.068	-0.063
Training workshops attended (XTRNG)	-0.083	**0.610**	-0.089	-0.211	0.172
Adoption of farming practices (ADOPT)	0.388	**0.561**	-0.016	0.159	-0.160
Net farm income (NFI)	0.040	0.106	**-0.868**	0.077	0.295
Labour costs/ha (LABOR)	-0.088	-0.086	**0.864**	0.030	0.050
Input costs/ha (INPTC)	-0.206	0.100	**0.517**	-0.096	0.223
Farming experience (EXPNC)	-0.007	0.005	-0.054	**0.916**	0.018
Age of farm operator (AGE)	-0.109	0.022	-0.063	**0.888**	0.032
Average yield (YIELD)	0.160	0.090	0.101	-0.112	**0.753**
Agricultural potential (NAP)	0.060	-0.046	-0.091	0.050	**0.744**
Latent root	3.74	1.99	1.52	1.48	1.23

index of progressive management. The third component Z_3 can be regarded as a financial index and measures labour and input costs per hectare contrasted to net farm income (i.e., farmers with large positive values of Z_3 face high labour and input costs relative to their income). Z_4 captures the interrelationships between farming experience, another form of training (Stefanou & Saxena, 1988), and age of farm operator. Component Z_5, measures the extent to which the natural agricultural potential of a region is related to average sugar cane yield.

5. CONCLUSIONS

A profile of farm characteristics of small and large sugar cane farms in the selected sample is presented. Descriptive statistical results show significantly lower values for small farms in human capital endowments, farm resource utilisation and performance, search and utilisation of farm information, and differences in adoption rates of appropriate farm practices. Similar findings have often been observed between small and large farms in many countries (Britton & Hill, 1975:9). Investigations of characteristics of sample farmers using discriminant analysis revealed that small and large farms studied differ significantly on lines of human resource capital and cost of borrowed capital (market related). The findings of the study show that large farms are relatively better equipped in human resource capital, and face lower market related interest rates compared to small farms. Human capital (management) is a fixed cost which implies that a farm too small for one operator may be too large for another. If this principal is accepted then the implication is not for a single optimum farm size but rather for an optimal distribution of farm sizes. This is in line with the Groenewald, (1991) and Binswanger *et al.* (1992:25) concept that "the better the manager the larger the optimal farm size". The results also support the finding of Binswanger *et al.*, (1992:26) that cost of borrowing in the formal credit market due to fixed transactions costs is a declining function of farm size.

An interaction index of training, use of farm information, number of training workshops attended, and adoption of appropriate farm practices (an indicator of managerial proficiency) is the second important discriminating variable in classifying farms as small and large. The analysis shows that large farms have a higher incentive to acquire more knowledge, thus supporting the findings of Huffman (1974) and Welch (1978:274). The results also reveal that large farms are in a better position to adopt appropriate farming methods than smaller farms as found by Huffman (1974) for U.S maize farmers. The third and final most important discriminating variable, shows that large farms have high incomes relative to labour and other input costs. The low human resource capital capacities, and low incentives to acquire more farm information have far reaching policy implications for the ability small farms to adopt new technology

Table 9: Variable definitions and measurements

Farm size	(FMSZE):	Hectares
Area under sugar cane	(ASC):	Hectares
Education	(EDUC):	scale ranging from zero to four to symbolise; no education, standard 5 and below, standard 6 to 9, standard 10 (matric), tertiary education, respectively
Experience	(EXPNC):	Years
Training	(TRNG):	Dichotomous (1,0) one for training, zero otherwise
Workshops attended in two years	(XTRNG):	continuous number
Farming occupation:		Dichotomous (1,0) one for full-time, zero otherwise
Agro-climatic potential	(NAP):	scale ranging from one to four depicting areas' potential as; poor, average, good and very good respectively.
Soil analysis	(SOIL):	scale ranging from zero to two, representing farmers who never have farm soils tested, those who test soils only when planting a new crop, and who conduct soil tests seasonally.
Use of seedcane	(CERTF):	Dichotomous (1,0), equal to one if certified seedcane is used, and zero otherwise.
Field extension officer visits	(VST):	scale ranging from zero to four (i.e., none, 3 times; 4-6 times; 7-9 times; and 10+ times, respectively)
Assessment of farm information sources		Likert-type scale ranging from zero to four representing rankings; not useful, less useful, useful, and very useful respectively.
(1) regional economists (ECAD) (2) field extension officers (EXOF) (3) research experiment station (SASEX) (4) field demonstrations (DEMON) (5) other farmers (OHFRM) (6) farm magazines (MGZ)		

which is important in the growth and development of the sugar cane sector. This points towards a policy direction of designing extension provision strategies that will target farmers of varying resource base (human and capital) in order to improve the current productivity levels in the sugar industry. Small-scale sugar cane farmers should be provided with adequate training to improve their capacity to cope with the understanding of better sugar cane farming methods. Therefore, rural development policy implications of low rates of adoption of improved and appropriate farm practices on small farms, indicate that emphasis on small sugar cane farms will certainly require more resources to be invested in the improvement of human capital capacities because small-scale farms are less able to attract high quality management, which will definitely involve intensive extension support and training. On the other hand, the high interest cost on capital on small farms due to transaction costs tends to imply that very small farms can not compete favourably for credit with large farms in the credit market.

NOTES

1. *The South African Cane Growers' Association (SACGA) defines small farms as farms of 20 hectares and below under sugarcane. The same criteria was adopted in the classification of farms as small or large in this analysis.*

2. *The Indian small-scale farmers were found to meet the two conditions, that is, operating under a freehold land tenure system and were identified as more independent in decision making as regards farm operations.*

3. *Richard Bates is the manager of the SA Sugar Association small cane growers financial aid fund (FAF).*

REFERENCES

BATES, R.F. (1996). *The financing of small scale Sugar Cane Growers in South Africa.* Department of Agricultural Economics, University of Natal, unpublished PhD seminar.

BINSWANGER, H.P. (1994). Agricultural and Rural Development: Painful Lessons. *Agrekon,* 33(4):165-174.

BINSWANGER, H.P., DEININGER, K. & FEDER G. (1992). *Power, distortions and reform in agricultural land markets.* Prepared for Handbook of Development Economics, Vol. III, Jere Berman and T.N. Srinivasan, Editors.

BRITTON, D.K. & HILL, B. (1975). *Size efficiency in farming.* Saxon House and Lexington Books.

BULLOCK, W.I., ORTMANN, G.F., & LYNE, M.C. (1995). Use of information and computers by commercial vegetable farmers in KwaZulu-Natal. *South African Journal of Agricultural Extension*, 24: 83-103.

CARTER, E.N. (1988). Equilibrium credit rationing of small farm agriculture. *Journal of Development Economics,* 28(1):83-103.

CHADWICK, J B & SOKHELA, M.P. (1992). *The small grower development trust: A vehicle for rural upliftment through a farmer support programme approach.* Paper presented at South African Society for agricultural Extension, Cape Town.

CRABTREE, J.R. (1971). An assessment of the relative importance of factors affecting criteria of success in diary farming using component analysis. *The Farm Economist*, 12(1):17-30.

DUNN, D.J. & FREY, T.L. (1976). Discriminant analysis of loans for cash-grain farms. *Agricultural Finance Review,* 36:60-66.

ELLIS, F. (1988). *Peasant economics.* Cambridge University Press, Cambridge.

FEDER, G. (1985). The relation between farm size and farm productivity. *Journal of Development Economics,* 18:297-313.

FEDER, G., RICHARD, E.J. & ZILBERMAN, J. (1982). *Adoption of agricultural innovation in developing countries: A survey.* World Bank Staff Working Papers, No 542.

FOLTZ, J.C., HARP, A.R., MAKUS, L.D., GUENTHNER, J.F. & TRIPEPI, R.R. (1993). A factor analysis of the product and service attributes offered by western nursery stock suppliers. *Agribusiness,* 9(3):247-255.

GROENEWALD, J.A. (1991). Returns to size and structure of agriculture: A suggested interpretation. *Development South Africa*, 8(3):329-342.

HORTON, R.L. (1979). Some relationships between personality and consumer decision making. *Journal of Marketing Research,* 16:233-246.

HUFFMAN, W.E. (1974). Decision making: The role of education. *American Journal of Agricultural Economics,* 56:85-97.

JOHNSTON, R.J. (1980). *Multivariate statistical analysis in geography:* A *primer on*

general linear model. Longman Group Ltd., New York.

JOLLIFFE, I.T. (1986). *Principal component analysis.* Spring Series in Statistics, New York.

KLECKA, W.A. (1980). *Discriminant analysis. Quantitative applications in the social sciences: series.* Sage University paper.

LACHENBRUCH, P.A. (1975). *Discriminant analysis.* New York, Hafner Press. First edition.

MAKARY, S.R. & REES, H. (1981). An index of management efficiency for Egyptian agriculture: A case study of large farms. *Journal of Agricultural Economics,* 32:189-196.

MANLY, B.F.J. (1986). *Multivariate statistical methods: A primer.* First Edition, Chapman and Hall, London.

MANLY, B.F.J. (1994). *Multivariate statistical methods: A primer.* Second Edition, Chapman and Hall, London.

NIEUWOUDT, W.L. (1977). Interrelationships amongst efficiency measures: A note. *Journal of Agricultural Economics,* 28(1):77-81.

NORUSIS, M.J. (1990). *SPSS base system users' guide.* SPSS Incorporated Chicago.

ODULAJA, A. & KIROS, F.G. (1996). Modelling agricultural production of small-scale farmers in sub-Saharan Africa: A case study in western Kenya. *Agricultural Economics,* 14:85-91.

QUANTUM RESEARCH. (1990). *Results of small grower development survey.* South African Sugar Association.

ROBERTSON, B.J. & NIEUWOUDT, W.L. (1992). Interrelationships amongst farm labour management variables and factors affecting farm labour remuneration. *Agrekon,* 31(1):29-32.

RUMMEL, R.J. (1970). *Applied factor analysis.* Northwestern University Press, Evanston, 111.

SHAW, A.B. & COSTA, R.C. (1985). Differential levels of technology adoption and returns to scale in the Guyanese rice industry. *Canadian Journal of Agricultural*

Economics, 33:99-110.

SOUTH AFRICAN CANE GROWERS' ASSOCIATION (SACGA). (1994). Statistical Division.

STANTON, B.F. (1978). Perspective on farm size. *American Journal of Agricultural Economics,* 60:727-737.

STEFANOU, S.E. & SAXENA, S. (1988). Education, experience, and allocative efficiency: A dual approach. *American Journal of Agricultural Economics,* 70:338-345.

STEVENS, J. (1986). *Applied multivariate statistics for the social sciences.* Lawrence Erlbaum Associates, New Jersey.

THOMSON, D.N. & LYNE, M.C. (1991). A land rental market in KwaZulu: Implications for farming efficiency. *Agrekon,* 30(4):287-290.

TRUETT, J. CORNFIELD, J. & KANNEL, W. (1967). A multivariate analysis of risk of coronary heart disease in Framingham. *Journal of Chronic Diseases,* 20:511-524.

TURVEY, C.G. (1991). Credit scoring for agricultural loans: A review with applications. *Agricultural Finance Review,* 51:43-54.

VAN ZYL, J. (1994). Farm size efficiency, food security and market assisted rural land reform in South Africa. *Agrekon,* 33(4):156-164.

WELCH, F. (1978). *The role of investment in human capital in agriculture. Distortions of* a*gricultural incentives.* Edited by Shultz T W. Bloomington, Indiana University Press.

WOODBURN, M R., ORTMANN, G F., & LEVIN, J B. (1994). Use of Information Sources by Commercial Farmers in Natal. *South African Journal of Agricultural Extension,* Vol 23: 49-60.

ZINNAH, M M., COMPTON, J L. & ADESINA, A A. (1993). Research-extension-farmer linkages within the context of the generation, transfer and adoption of improved mangrove swamp rice technology in West Africa. *Quarterly Journal of International Agriculture,* 32:201-211.