AN ECONOMIC ANALYSIS OF THE KENYAN SISAL INDUSTRY

By

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This research paper is my original work and has not been presented for the degree in another University.

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ABSTRACT

Kenya is an important producer of sisal fibre in the world market. The sisal crop not only provides cash income to producers but is also an important source of foreign exchange resulting from exported fibre and fibre produc[illegible] However, the Kenya sisal industry not only faces stiff competition from other fibres thereby reducing its market share, but also faces constraints that adversely affect production. Some of these constraints led to the contraction of the sisal industry from 1960 to 1985.

This study investigated producers' production behaviour. In particular, a sisal production system that consists of factors that motivate acreage, harvesting, labour, production, sales, and stock of sisal fibre is identified. A model is developed to identify and estimate the effects of these factors.

Other issues that affect sisal processing and marketing are also discussed. A comparison of the two techniques, the "field" and "factory" decorticators is discussed. This is based on production costs, revenues, and opportunity cost of wasted fibres in the drums per ton of finished fibre to determine the appropriate technology.

Marketing arrangements for sisal fibre, the roles of the Sisal Board and the marketing agents and the international fibre market are evaluated and discussed.

TABLE OF CONTENTS

PAGE

LIST OF TABLES IN TEXT

List of Figures

LIST OF TABLES IN APPENDIX

CHAPTER ONE

INTRODUCTION.

Kenya is an important producer of sisal fibre in the world market. This crop is important as a source of foreign exchange and also as a source of cash income to its producers . The production and sales of sisal fibre have been declining in recent years (1970-1986) compared with production and sales in the early 1960s. In the same period, Kenya's imports of synthetic and soft fibres have increased. These alternative fibres have reduced the share of sisal in both international and domestic markets. Fibres that are superior in quality, price, and other aspects are preferred by consumers.

The Kenyan sisal industry not only faces stiff competition from other fibres, but it also faces various constraints that adversely affect production. The contraction of the sisal industry in Kenya during the period 1960 to 1985 is a result of constraints on the industry. Important constraints that reduce sisal production are discussed in the subsequent section.

Due to the importance of sisal to the country, an effective policy for sisal production is necessary.

To do this requires knowledge of important factors that influence farmers' acreage and output decisions. This study therefore identifies key issues that influence sisal production in Kenya. Further, the key issues that affect sisal processing and marketing are also identified. Moreover, a sisal output, production, and sales systems model is developed with a twin goal of identifying the main factors influencing sisal output and of estimating the effects of these factors. Factors such as sisal prices, cost of sisal inputs, and prices of alternative crops are shown to affect production and sale of sisal fibres. The period 1960 to 1985 was characterized by falling sisal acreage, shortage of labour for cutting leaves, declining marketed output, and poor marketing arrangements. This paper therefore examines policy options to prevent further declines in sisal production.

1.1 Background

The acreage and output of sisal in Kenya has been falling since 1970. The slight decline in production in 1986 is attributed to low rainfall towards the end of that year. Hence most large sisal estates produced less than their normal output.[1] Table 1.1 shows the trend of the area under sisal for the period

1960 to 1985. The sisal acreage cut each period as well as the acreage planted with new sisal plants also declined steadily over the period 1970 to 1979. However over the recent years 1980 to 1985 sisal acreage increased steadily.

Table 1.1 Average area under Sisal in acres: 1960-1985

Period	Acreage at the beginning of the period	Area cut during the period	Area planted during the period	Acreage at end of the period	Percentage Charge
1960-1964	257,230.8	13,382.2	21,883.4	262,339.6	-
1965-1969	255,382.6	19,536.8	5,394.2	239,903.6	- 8.6
1970-1974	163,893.6	12,356.6	2,855.6	151,823.8	-36.7
1975-1979	129,694.6	9,378.6	7,639.0	127,751.0	-15.9
1980-1985	130,455	5,830.1	12,057.1	136,682	+ 7.0

Source: Kenya Sisal Board, Annual Reports, 1960-1985.

The decline in sisal production becomes clearer when the number of estates that are currently in operation is compared with that in operation in 1961. As can be seen from Table 1.2, the number of sisal estates declined by nearly fifty percent between 1963 and 1986.

Table 1.2 The Sisal Estates in Operation in Kenya*

Province	Year						
	1961	1963	1967	1973	1977	1983	1986
Coast	11	10	7	6	6	7	7
Central and Nairobi	24	24	16	9	5	2	2
Rift Valley	8	8	7	8	6	6	6
Others	8	12	6	15	11	10	11
Total	51	54	36	38	28	25	26

* Including factories processing smallholder fibre and leaf.

Source: Kenya Sisal Board, Annual Reports, 1961 - 1986.

Table 1.3 Annual average sisal production and exports at current prices, 1953-1985.

Period	Production ('000 tons)	Exports ('000 tons)	Production exported (%)	Local consumption and change in stocks	F.O.B value (K£'000)	Average Price (K£ per ton)
1953-1960	45.48	41.82	92.0	8.0	2619.91	62.65
1961-1965	64.81	58.41	90.1	9.9	5185.97	88.79
1966-1970	50.08	43.33	86.5	13.5	2165.13	49.97
1971-1975	54.74	46.68	85.3	14.7	6564.37	140.62
1976-1980	36.45	30.16	82.7	17.3	5113.87	169.56
1981-1985	47.49	39.11	82.4	17.6	1152.53	294.62

N.B. Figures for 1961-1985 are calculated from Appendix A and B
Figures for 1953-1959 are derived from Kenya Sisal Board, The Sisal Industry in Kenya, 1983 p. 3.

The decline in sisal acreage has been attributed to adverse economic conditions created by uncertain and falling real prices for sisal fibre. Shortage of labour for cutting leaves, expensive leaf decorticating technology, inappropriate sisal marketing arrangements, and competition from synthetic and soft fibres also contributed to this decline.

1.2 Objectives of the Study.

The objectives of this study are three-fold:-

1. To identify the key factors influencing sisal production in Kenya and to statistically estimate their effects.

2. To investigate the economic viability of the recent--field and old--factory-based technologies for decorticating sisal in a cross-section of medium and large-scale sisal estates.

3. To study the marketing arrangements for sisal fibre and to determine whether transfer pricing is practiced in the sisal industry.

1.3 Justification of the Study

Sisal is a drought resistant plant that can be grown in a variety of soils and climatic conditions where other crops cannot do well or even survive. It can grow in areas where rainfall is below 760 milimetres per annum. Thus, as a cash crop, sisal is important because it can grow in the large, semi-arid portion of Kenya's land.

In addition to providing cash income, sisal is also important as a source of foreign exchange. Sisal exports earned Ksh. 273 million in 1985 and Ksh. 253 million the previous year. Sisal fibre is used for producing various products such as sisal sacks suitable for exporting valuable cereals like Arabica coffee.

The proportion of sisal exported in each period is high but falling (See able 1.3). The remaining sisal fibre is stored for future exports or is consumed locally. The percentage of fibres exported is declining due to increased local consumption of sisal fibre. The percentage of local consumption and stocks has increased. However, the volume consumed locally has fallen in 1985. Consumption since 1967 fluctuates considerably (See Appendix A).

Kenya also imports large quantities of sisal fibre substitutes and related products (See Appendix C). For example, during the year 1960, 5,595 thousand kilograms of fibres and related products were imported, and 10,380 thousand Kenya shillings was spent. In 1984, 1,734 thousand kilograms were imported for Ksh 281,320 thousands. An increase in local production of sisal fibre would save foreign exchange that is currently spent on imported fibres.

With appropriate wage incentives, the sisal industry has the potential to create employment for many people in the agricultural sector. Most activities such as transplanting and weeding are not mechanized. The sisal industry, which is facing a shortage of labour especially for cutting leaves, could therefore assist in alleviating the excessive rural-urban migration and rural unemployment. Leave cutters earn Ksh 25.40 per 100 bundles. Each bundle consists of 27 leaves. Weak workers cut 100 bundles in two days along the coast, thus earning low wages per month. Assuming one month has 22 days, a worker cutting 100 bundles a day earns Ksh. 558.80 in a month. Even a good cutter only earns between Ksh. 698.50 and Ksh. 974.60 a month. Low wages discourage increased employment and this affects production.

Sisal estates with complete and fully established factories, machinery, and infrastructure face difficulties should they decide to abandon sisal in favour of alternative crops or animal husbandry. Most of the machinery (e.g the leaf decorticators and combing machines), factory and other infrastructure are unsuitable for non-sisal uses. The costs of uprooting sisal would also discourage new investments especially in semi-arid areas where other crops might not survive.

1.4 Data and Methodology

Since sisal production, processing, and marketing systems are linked, these were studied together. Primary and secondary data were collected for this study. The secondary data were obtained from Kenya Sisal Board and from the Central Bureau of Statistics. Field data were collected through a survey of sisal estates. Questionnaires were formulated and used to gather data on various aspects of sisal production, processing, and marketing. A field trip was carried out to enable the author observe actual estate farm practices. Discussions held with the owners, managers, and workers on the estates were also documented and used for this study.

Nearly the entire population of medium and large sisal estates in operation during the period 1986 were considered for this study. Only three estates were omitted due to transportation and time constraints. A list consisting of medium and large sisal estates was provided by the Kenya Sisal Board and used in the survey.[2] The small-scale sisal producers including the hedge-sisal growers and producers of less than one ton of sisal fibre per month were not studied due to time limitations. These producers are scattered throughout the country.

An analysis of sisal output was conducted after identifying the key factors in sisal output. A model of sisal output was developed that jointly explains acreage, harvesting, production and marketing decisions. A separate model that links labour demand to area harvested and technological changes was developed and estimated. This model can be used to evaluate the employment impact of sisal plantations. Also modelled are factors that affect changes in stocks. Time series data for the period 1960 to 1985 were used to estimate the model using ordinary least squares.

Data on processing were also gathered and used to evaluate two techniques of sisal decortication, namely, "factory" and "field" decorticating techniques. Specifically, production costs of sisal fibre, fibre wastage and other aspects of the field and factory decorticating techniques were compared. With regard to sisal marketing, the international fibre market was analysed briefly. Sisal marketing in Kenya was also investigated paying particular attention to agency-producer relationship and the institutional arrangements of the Kenya Sisal Board.

1.5 Limitations of the data.

A comparison of data on different aspects of production, processing, and marketing across estates was difficult due to some estates withholding information regarding price of sisal fibre, and also due to differences in data filing. For example, except in cases where two or more estates are owned together, the production cost structures differ due to differences in the cost categories used. For this reason, the author used data collected from estates owned by one individual to compare different aspects of production costs for the field and factory decorticators. This limits the data to one source for field and a second source for factory decorticators as these have similar cost structures. The data concerning "crane" field decorticator were only available from the promoters of the "crane". This is because the decorticator is fairly new. As a result, the new technology has not yet been assimilated by the other estates. Data concerning fibre wastage is available for both field and factory decorticators, on estates where experiments have been carried out. To overcome the possible biases in the data provided by the promoters of the "crane" field decorticator,[3] additional data selected randomly from a group of estates on experiments carried out for fibre wastage will also be discussed.

Another data limitation is due to differences in age between the new crane-field decorticator and the old corona-factory decorticators. The comparison is between new and old decorticating techniques. Thus only the new technology incurs depreciation costs because the "corona" is very old machinery whose depreciation cost today is nil. Age differences also determine labour requirement for maintaining the decorticator. Hence we expect more labour for maintaining and servicing the "corona" decorticator than for the new "crane" decorticator due to frequent breakdowns,a result of old age.

Limitations of time series data stem from use of data stretching many years back. For example, inflation affected a number of variables. To remove inflation effects, all prices and input costs were deflated using Gross Domestic Product (GDP) deflators to calcualte 1976 constant prices.[4]

Another limitation of using available time series data arises from differences in data for overlapping years. Statistics for the series 1980 - 1985 may show quite different data for the year 1980 from those indicated in former issues of statistical abstracts, say,for the series 1976 - 1981. To overcome this limitation, the most recent Statistical Abstract issue was used for deriving data for the time series because newer issues revise old data and hence remove previous errors in calculations.

1.6 Organization of the Paper

The remainder of this paper is organized as follows.Chapter two describes the agronomic characteristics of the sisal plant and the required farm practices. Chapter three provides a historical account of the sisal plant and of sisal manufacturing and processing factories in Kenya. This is followed by a desription of the structure and geographical distribution of the Kenya sisal industry and ownership of existing estates. Sisal production, fibre processing, and kenaf are then discussed. Chapter four covers the international fibre market, the significance of Kenya in the international sisal market and sisal marketing in Kenya. Chapter five discusses fibre extraction technology. This chapter compares "factory" and "field" decorticating methods with particular reference to costs and revenues of these technologies, wasted fibres, and the disadvantages and advantages of each method. In chapter six, an econometric analysis of sisal production is presented. This chapter begins by reviewing existing econometric studies on sial production. A model of sisal production that ecompasses acreage, harvesting, production, sales, labour employed and sisal stocks is presented. Time series data were used to estimate the parameters of these models using ordinary least squares. The empirical results of the models are then discussed. Chapter seven presents the conclusions and recommendations of the study. Policy actions to stimulate sisal output and sales are highlighted.

CHAPTER TWO

AGRONOMIC CHARACTERISTICS AND FARM PRACTICES

2.1 Introduction

This section discusses sisal characteristics and agronomic practices relevant to both researchers and policy makers in designing strategies for improved performance of output and sales. Due to a lack of recent research, information drawn from previous studies by Lock (1962) and Osborne (1967) together with the field survey will be used.

In 1974, the sisal research station, the High Point Station at Thika, and later the sisal research station at Mlingano (Tanzania) were closed.[1] Formerly the stations conducted experiments on agronomic characteristics of the sisal plant and on suitable farm practices. The results of such experiments were then passed on to sisal producers. For example, information on improved and drought resistant plant breeds was given to farmers through demonstrations and field trips organized by the research stations.

Since the closure of the research stations, no renewed efforts on sisal research have occurred because the farmers lack skills, time, and money required for research. As a result, outdated methods of spacing, planting, propagating, weeding, and plant breeding continue to be used in most sisal estates in Kenya. For example, no efforts have been made to mechanize transplanting of sisal.

2.2 Types and Characteristics of Sisal Plant

As many as two hundred and seventy-four species of agave (i.e fibre plants) exist (Lock, 1962). In East Africa two species are commonly grown: A. Sisalana (ordinary sisal) and Hybrid No. 11648.[5] The sisal plant in Kenya has a short stem, with a terminal bud, from which three to four leaves open per month. In ordinary sisal (A.Sisalana), leaves measure 80 - 120 Cms long, whereas mature leaves are two metres on average. Between 1,200-2,000 fibres are produced per leaf, so that a one metre long leaf has about 1,100 fibres (Lock, 1962). The leaf is 10-15 cms wide and weighs 7,000 grams. In Kenya, differences exist in plant breeds and climatic conditions. Thinner leaves are found mainly in drier coast areas with semi-arid conditions.[6] Producers estimate that the sisal plant produces between 200-250 leaves after a life cycle of eight to ten years. The plant flowers once during its entire life cycle by producing a vertical flowering pole. After flowering, the plant produces small bulbils which are collected and raised in nurseries for transplanting. After this period, the plant dies and new plants are raised.

Hybrid No.11648, unlike A. Sisalana, has a short life cycle in high altitude areas where poling begins after three to five years due to stress. This is half the time taken by ordinary sisal to produce a pole (Lock, 1962). Altitude further reduces the number of leaves and fibre yield. However, under normal altitude and climatic conditions, the hybrid plant yields more fibre per year because of a higher rate of leaf formation Hybrid No.11648 does very well along the coast due to the low altitude. The plant's life cycle in this area is eight years which makes this plant suitable for growth in this area. In high altitude areas, the plant's life cycle is reduced to four years in which case the producer can plant two cycles of Hybrid No. 11648.

Climatic conditions in sisal growing areas of Kenya differ. Sisal does well in areas that receive 1000-1500 millimetres of rainfall per annum, in hot and humid climates where the temperatures average roughly 27-32 degrees centigrade. Sisal also grows in a variety of soils ranging from loamy-clay soils found along the Rift Valley to sandy soils found along the Coast Province. The crucial soil elements necessary for sisal growth include potassium, magnesium, calcium, nitrogen and sulphur (Lock, 1962).

2.3 Sisal Farming Practices in Kenya.

The following is a brief description of the activities observed on the sisal estates in Kenya. Information for this section was gathered from the field survey.

Land preparation: Before planting, the land is cleared and ploughed. This destroys weeds. The land is prepared in blocks measuring at most ten hectares. This type of land preparation facilitates leaf transporation during harvesting.

Planting: Planting occurs every year on large estates because old plants cease to produce fibres after poling and flowering.

Along the Coast, planting begins just before the long rains in March and April. In the Rift-Valley, new land is planted in August. Young plants are first raised in a nursery from bulbils or suckers. These grow for about eight months to a year before being transplanted into the fields.

Cutting: Cutting begins after two to three years. At this time, the lowest leaves are about 60 centimetres long. The first cutting has a two-fold effect. It speeds up the growth of the other leaves, and makes future cutting of leaves easier. As a rule, the leaves which are 45 degrees to the stem are cut. The number of leaves cut per plant ranges from 16 or 17. In extreme drought conditions only five to six leaves are cut since the plant's growth is retarded, leaf formation is slower, and the bottom leaves are lost due to withering of bottom leaves. The leaves are bound in bundles of 27 leaves after cutting as specified by the Kenya plantation and workers union in a circular that shows wage schedule per bundles cut. For the first through fifth cuts, the plants are cut every six months. The interval increases to every seventh and eighth month for the sixth and subsequent cuts. Generally, eleven to twelve cuts are made during the entire life of the plant. Intensive cutting of leaves increases the tonnage of fibre produced due to increased leaves. If cutting occurs before the plants are mature, this adversely affects the plant (Lock, 1962).

Weeding: Weeds and grass compete with the sisal plant for food and hence the need to cut or to remove them. However, along the coast, clean sisal fields endure heavy moisture loss. Hence, low grass is maintained to prevent loss of moisture. In the Rift Valley, leguminous plants (cover crops) such as beans are grown in-between the sisal rows. This has a two-fold effect. First, it serves as farming land to sisal estate workers who otherwise would require land to grow their crops; and secondly, interplanting increases the yield of sisal fibre per plant.[7]

In conclusion, the yield of a sisal plant depends on the type of soil, climate, plant breed, and farm practices. For instance, the time and frequency with which the sisal plant is cut and the way the plants are raised before being transplanted affect both the quality and quantity of sisal fibre.

CHAPTER THREE

HISTORY AND STRUCTURE OF THE KENYAN SISAL INDUSTRY

3.1 History

Sisal was introduced in Kenya in 1903 by the officials of the Department of agriculture, who obtained it from Tanzania. In 1904, 1,500 additional plants were imported from West Indies and planted in Kenya. However, the pioneers of the Sisal Industry[8] in Kenya were R. Swift and E.D. Rutherfoord who established sisal plantions at Punda Milia, between Thika and Murang'a areas in 1907, having imported it from Tanzania (Lock, 1962).

Sisal manufacturing in Kenya started in 1934, when the Kenya sisal manufacturing company was formed. In 1936, the company went public and changed its name to Sisal Products (East Africa) Limited. Expansion of the company began in 1938, when a sisal mill was set up. In 1954, a jute processing mill was also established. Four years later, a separate company, East African Mattings Limited, was set up. East African Bag and Cordage Company[9] owned half of its shares. The premises of the defunct East African Mattings Limited are located within the Bag and

Cordage Factory till today. In 1977, the cordage company purchased machinery for weaving synthetic products and in the following year, production of polypropylene products began. An extrusion line of the synthetic plant was completed in 1981. In 1983, the E.A. Bag and Cordage Company bought Acif Ltd and renamed it KENSACK Ltd. Currently, 2,600 workers and 1,400 others are employed in the E.A. Bag and Cordage and KENSACK Companies.

In addition to the above manufacturing plants, are four semi-processing factories processing small quantities of fibre and leaf from smallholders. Large and medium sized estates have their own semi-processing factories for leaf decorticating.

3.2 Geographical distribution and ownership

Geographically, the estates and plantations are located in the Central, Nairobi, Coast, Rift Valley and Eastern Provinces. In 1986, twenty-two sisal estates and four smallholder sisal processing factories were in operation in Kenya. Table 3.1 shows the ownership , location, and date of establishment of sisal producing estates and fibre extraction processing factories. Most large estates are foreign owned.

Table 3.1 Location and structure of the Kenyan sisal industry: 1985

Estate or Factory	Nationality of Owner	Location	Date of Establishment
Banta Group: Banita Estate	Greek	Nakuru	N/A
Athinai Sisal Estate	"	Kampi-ya-moto	1964
Majani Mingi Estate	"	Nakuru	1963
Lomolo Sisal Estate	"	Migotio	1962
Keneboo Limited			
Kakuzi Estate	"	Kibwezi	N/A
Donyo-Sabuk Estate	"	Makuyu	1927
Dandora Sisal Estate	"	Nairobi	1968
Kalimoni Sisal Estate	"	Juja	N/A
Kenani Sisal Estate	"	Athi River	N/A
Marwa Fibres Ltd.	"	Nairobi	N/A
Kenya Trade Development			
Taveta Sisal Estate	Kenyan/Greek	Taveta	1937
Jipe Sisal Estate	"	Taveta	N/A
Ziwani Sisal Estate	"	Taveta	1965
Dwa Sisal Estate	British	Kibwezi	1946
Vipingo Sisal Estate	Swiss	Vipingo	N/A
Samar Sisal Estate	Swiss	Maragua	1945
Kilifi Plantations	British	Kilifi	1963
Migotiyo Plantations	Greek	Migotio	1947
Voi Sisal Estate	Kenya	Voi	N/A
Teita Estate	British	Taita	1952
Nyari Sisal Estate	Greek	Samburu	N/A
Barina Sisal Estate	Greek	Nakuru	N/A

Table 3.1 Contd.

Estate or Factory	Nationality of Owner	Location	Date of Establishment
Licenced Semi-Processing Factories			
Wandaka investments	Kenyan	Kisumu	N/A
African Fibres	Kenyan	Kisumu	N/A
Kenebco Limited	Greek	Nairobi	N/A
Tworo Industries Ltd.	Kenya	Kisumu	N/A
Processing Factories (manufacturing)			
E.A. Bag and Cordage	Kenyan	Juja	
KENSACK Ltd.	Kenyan	Thika	

Source: Kenya Sisal Board.

.3 Sisal Production.

Between 1963 and 1978, the production of sisal in Kenya was declining steadily. The production figures for different grades are shown in Appendix B at the end of the paper. The decline in sisal production is a result of a number of factors, one of which is the decline in smallholder sisal sales to the factories that process fibre and leaf. The reduction in smallholder sales was partly due to poor marketing outlets and to use of old, slow hand-decorticating methods. The hand method for instance requires more human energy to decorticate large quantities of leaves. High transport costs and poor transportation to the sisal processing factory also hinder output of sisal fibre by small scale producers. When costs of production of sisal fibre increases relative to costs of alternative crops, many small producers abandon sisal production. Over the recent years, however, production of U.H.D.S.[10] (Unwashed Hand Decorticated Sisal) especially from the largescale producers has increased. Thus the overall production of U.H.D.S for the entire country in relation to total production of sisal fibre increased due to output from large and medium sisal estates (See Table 3.2).

Table 3.2 Unwashed Hand Decorticated Sisal (UHDS) in relation to total production: 1979-1985.

Year	Total production (metric tons)	U.H.D.S. (metric tons)	Percentage of Total %	Change in U.H.D.S Production
1979	36,858	4338	11.75	-
1980	46910	8377	17.86	+ 93
1981	41335	7803	18.88	-7
1982	50028	13950	27.88	+ 78
1983	49728	10269	20.65	- 26
1984	51438	14162	27.53	+ 36
1985	44915	-	-	-
1986	41507	-	-	-

Source: The Kenya Sisal Board, Annual Reports, 1979-1985 and Daily Nation, 3/April/87, p. 11.

The Coast and Rift Valley provinces are the top producers of sisal fibre in Kenya. In 1985, the two provinces produced 69.2% of the country's sisal production. Table 3.3 shows output of sisal fibre by province for the period 1976 - 1985. Production of sisal has been increasing in recent years. However, output is still much lower than the earlier 1960's.

Table 3.3 Production of Sisal fibre by province ('000s metric tons)

Year	Provinces					TOTAL
	Central and Nairobi	Coast	Rift Valley	Eastern	Nyanza	
1976	5.8	14.1	10.9	2.0	0.8	33.6
1977	6.2	13.1	12.3	1.5	0.4	33.5
1978	3.6	12.7	13.3	1.6	0.2	31.4
1979	2.7	13.3	13.1	2.3	5.5	36.9
1980	4.8	15.4	12.8	2.3	11.6	46.9
1981	5.5	15.6	9.8	2.8	7.7	41.4
1982	6.6	16.7	11.8	3.10	11.8	50.0
1983	6.1	18.3	18.3	3.8	3.3	49.8
1984	5.1	14.3	14.9	4.6	12.6	51.5
1985	3.6	15.6	15.9	4.2	6.2	45.5

Source: Kenya Sisal Board, Annual Reports, 1976 - 1985.

3.4 Fibre processing.

Fibre is processed in two stages. During primary processing, fibres are extracted from the leaves at the estate factories, cleansed, washed, and brushed. Final processing occurs at the manufacturing factories.

Once cut, the leaves must be decorticated within four to five hours. Otherwise the sap and cellular tissue attached to fibres harden and makes decortication difficult. Delay in decorticating lowers the grade of the fibre. The fibres are separated from the leaves by decorticating machines in the factory or by fully mobile field decorticators. The manual and the automatic cross-feed methods are used. The hand method is tedious and produces poor quality fibres because the fibres are unwashed and hence are green coloured. Also, some parts of the leaves remain on the fibres. This method is slow and much fibre is wasted due to broken fibres. For example, twelve raspadors[11] can produce one ton of sisal fibre by processing about 3,000 leaves a day, at a maximum labour cost of 30 shillings per worker. This method is commonly used by very small producers because hand operated machines are cheaper and can be afforded by low income producers. Automatic cross-feed decorticators require twelve workers to decorticate leaves and spread the fibres onto drying lines. The leaves are arranged transversely and gripped by a conveyor rope that then deposits leaves into the decorticating drums. The first drum decorticates half of the leaf whilst a second drum completes decortication. While fibres are simultaneously washed, about 8,000 gallons of water are used per hour of which, four to six thousand gallons drive the waste matter onto the dumping ground. This method is faster than the hand method since it decorticates 25,000 leaves per hour. The " corona" decorticator is the model most in use. It costs eight to nine million Kenya Shillings.

The fibres are dried naturally in the sun instead of by automatic machine driers. The dry fibres are stiff and untidy. The fibres are softened and straightened using brushing machines that beat, comb, and make the fibres parallel. Fibres that drop during combing are swept and bound together to form an inferior grade of sisal fibre called "tow". The fibres are graded according to colour, strength, and fineness and then packed into bales weighing two hundred kilograms. In almost all of the estates, a separate section for rope making is maintained next to the factory. The ropes are used as conveyor belts and also for binding the bales.

Other products of the sisal plant include sisal juice or "sludge" from ordinary sisal leaves. The sludge is used in the manufacture of hecogenin concentrate. This is exported in powder form to a factory in United Kingdom, where final extraction of hecogenin takes time.
At present extraction of this powder for export takes place in only one estate in Kenya. The extracted powder is sold at Ksh 9,000 per ton. Formerly three estates produced this powder for export. Of the two estates that ceased to produce

the powder for export, one discontinued due to high costs of extracting the powder, whilst the other stopped producing the powder after changing into Hybrid No. 11648 plant cultivation. Hybrid sisal is unsuitable for the extraction of this powder due to low concentrate of hecogenin coupled with formation of a poison during extraction process. Hecogenin is used by factories abroad in the production of drugs.

Despite declining production of sisal fibre, little effort has been made by producers to expand their uses of sisal plant and waste. Yet the sisal plant and waste have diversified uses which, if economically feasible, would bring income to producers. The waste matter of the sisal plant is used as manure and also as cattle feed. However, in most estates, the use of waste sisal as manure is limited. The estates prefer to use fertilizer since it is cheaper. The cost of transporting waste matter to the field as manure reduces its attractiveness relative to fertilizer.

After fibres are washed, dried, brushed, and graded, they may be exported or consumed locally. Locally, fibres are used in the craft industry and also in the cordage industry for ropes, sacks, carpets, baskets ("Kiondos"), and related products for the domestic and international markets.

3.5 Kenaf fibres.

The high costs of imported soft fibres (such as jute) motivated search for ways to produce these fibres locally. In 1967, the East African Bag and Cordage factory started a pilot project in the Masailand and Taita areas to grow Kenaf, a soft fibre. This project was abandoned due to financial problems. Later in 1970's, the factory undertook Kenaf pilot projects in Busia and Siaya districts with government assistance. At present, Kenaf is available in quantities enough to cover three years manufacturing needs for soft fibres (Kenya Times, 17 August 1986: 24). Hopefully, this source will substitute for jute fibre imported by the cordage industry. Production of fibre products using this source has not yet begun. Local production of Kenaf fibre will not only save foreign exchange spent on imports, but also provide income for many farmers. Further, Kenaf products manufactured in Kenya are likely to be more price competitive in the international markets and hence be a source of additional foreign exchange. This is because high duties on imported raw materials (30% of the cost and freight value) made manufactured products for export from Kenya unattractive in prices compared to similar products from other countries.

CHAPTER FOUR

FIBRE MARKETING

4.1 The International fibre Market

Overview

The international fibre market comprises four types of fibres,[12] namely: the hard fibres (henequen, sisal and manila), marginal fibres (maguey and blue sisal), soft fibres (jute, flax, kenaf), and synthetic fibres (polypropylene). Whilst the other fibres are natural, synthetic fibres are produced from oil by-products Today, production of synthetic fibres has spread to many countries.

Sisal is an important hard fibre, but it faces stiff competition from other fibres. Sisal is supplied mainly by seven countries (see Table 4.1). The world supply is about 310 thousand metric tons. Brazilian exports accounted for about 44 per cent of the would fibre exports in 1980. Kenya's share in that year was approximately 16 per cent. About half of the exports are raw sisal fibre (see Table 4.1). Some countries, Mexico and Haiti in particular, have even begun to export mostly finished sisal products instead of fibres.

Table 4.1 The international sisal fibre market, 1980.

Producer	Exports (000's metric tons) raw Fibre	Manufactured Products	Main destinations
Brazil	95.4	96.6	E.E.C,U.S.A, Poland, Portug
Tanzania	60.0	36.0	EEC,U.S.A, China,USSR, Canada Japan
Mexico	0.2	58.7	U.S.A., E.E.C
Haiti	2.0	10.0	Dominion Republic, U.S.A, E.E.C Spain
Kenya	39.2	3.0	E.E.C, China, Israel, Japan, Spain
Madagascar	13.5	0.5	E.E.C.
Mozambique	11.0	5.0	Portugal, U.S.A.
Others	11.1	1.5	-
Total	219.2	211.3	

Source: UNCTAD, The Marketing of Hard Fibres; Sisal and Henequen: Areas for international Co-operation. TD(B/C.1/PSC/21/Rev 1), New York, 1982, P. 2.

The quantity of sisal fibre that a country sells in the international market is influenced by the number of sisal substitutes such as jute, kenaf and synthetic fibres. Competition from other fibres reduces the share of sisal in the world market. Hence, if sisal fibre prices increase relative to the price of sisal fibre substitutes, consumers will opt to buy the cheaper fibres. The international market is also influenced by trade restrictions such as tariffs, quotas and import bans. The imposition of tariffs increases the prices of sisal fibres, thus making them unattractive to consumers. Import quotas reduce the amount that a country can buy from another, whilst total import bans stop importation of sisal fibres altogether. In Kenya, a high import duty is placed on imported fibres such as jute, kenaf and synthetic fibres. The duty charged on imported fibres is 30 percent on the cost and freight value whilst no tariff is charged on exported fibres.

4.2 Sisal marketing in Kenya.

Sisal exports from Kenya go through agents licenced by the Kenya Sisal Board. The agents perform certain tasks on behalf of producers. The agents organize the sale, shipment, and insurance of sisal fibre for which they charge a commission. Currently 3.0 percent of the F.O.B value is charged for commission and brokerage. A further 1.5 per cent is charged as handling charges. Today, only four agents operate in contrast to six in 1970. The agents are Wigglesworth and Company, Standard Chartered (formerly East African Acceptances), Mayfield Industries Ltd, and Chipa Farm Supplies Ltd.

In the domestic market, the sisal estates sell their fibres directly to the E.A. Bag and Cordage Company. Small producers sell to the same company through local dealers licenced by the Ministry of Agriculture. The local dealers incur the transport expenses of collecting the sisal fibre from the smallholders. The local traders have collection centres where the smallholders take fibres for sale. This arrangement is commonly used in Machakos and Nyanza districts. In other areas, small producers sell through local dealers or directly to neighbouring estates.

The sisal industry suffers from an inadequately organized and inefficient marketing system. The sisal producers depend entirely on marketing agents to sell their produce abroad. The agents look for markets and organize shipping and insurance on behalf of producers. The agents also negotiate sisal prices on behalf of producers. The commission, brokerage, and handling charged by agents in Kenya especially discourages small estates from selling their produce abroad. In Tanzania most of the marketing arrangements are carried out by nationalized institutions. However, these have been blamed for production declines. This casts doubt on the ability of such a government institution to market sisal fibre adequately.

4.3 Kenya Sisal Board

The Kenya Sisal Board was established in 1946 under the Sisal Industrial Act. The sisal industry suffers from an inadequately organized and inefficient marketing system. The sisal Board totally relies on information from the marketing agents. The Board does this by maintaining records of prices quoted by different agents on the export application forms. A trading table[13] is prepared based on information gathered from contract forms attached to export application forms. An export licence is issued if prices quoted on the application forms are the same as those indicated on the trading table. This marketing system is inadequate because the Board only relies on information concerning prices obtained from the contract forms. For example, if during one month only one estate applies for an export licence, it means that the trading table is constructed on information from one source. Since marketing agents are few and most large estates are foreign owned, agents and producers could easily collude to under price sisal fibre on the export application forms. This opens a loophole to channel profits made in Kenya abroad. For example, if in one month marketing of sisal fibre is organized by one agent, assuming the other agents have no market in the same month, then the agent may underquote prices on the contract forms. The sisal Board cannot judge the true prices of sisal fibre and would opt to believe that whatever price is quoted on the contract form represents the actual amount payable to the producers. The difference between the true value of the fibre and that quoted on the application forms could then be banked abroad. Some agents also provide financial and capital assistance to some estates. This further strengthens the bond between the agents and the producers. This makes Kenya vulnerable to transfer pricing although, due to time constraints, this issue was not investigated to ascertain whether the practice actually occurs.

The Sisal Board is also ineffective in monitoring the market in other ways. For example, no information regarding market size, demand for fibre or fibre products, quality of fibres sought by consuming countries is kept by the Sisal Board. Nor is the Board knowledgeable about issues pertaining to the sisal industry in other sisal producing countries. Yet this is important. Kenya needs to be aware of the problems and constraints facing the other sisal producing countries.

Kenya might avoid certain problems facing the sisal industry by learning from others. This is only possible if contact and information regarding the sisal industry is passed through an information flow system.

The Sisal Board does not regulate the market through appropriate export licensing procedures, nor does it control sales of sisal fibre. The Board, however, maintains quality control of all exported fibres through it's inspectorate, and it also advises the Ministry of Agriculture about the industry. All fibres for export must be certified by the inspectorate as fit for export. The Board however does not market sisal fibre even though the actions of the Board affect the revenue received by the producers. The Board charges a fee known as a "Cess" for the functions it performs on behalf of producers. In 1986, the cess charge was Ksh 30 per metric ton on all sisal sales in comparison with Ksh. 6 for the same in 1960. This revenue is used in carrying out the Boards' functions.

The Kenya Sisal Board is ineffective in carrying out its functions. Constraints, hinder it from conducting its functions. For example, the Boards' revenue is not sufficient to finance its projects which include construction of sisal collection centres for smallscale producers, and the repair of its godowns in Mombasa. Insufficiency of funds prevents the Board from carrying out trade exhibitions necessary for promoting and expanding the sisal market overseas. Aggressive marketing is required because of prevailing competition from other fibres. The Board also suffers from a shortage of workers necessary for running an effective marketing operation. For example, just one employee issues export licences, collects data from the producers by questionnaires, supervises cess collection, and does other functions. The result is that proper records are not kept. This adversely affects the Board's regulation of the sisal industry.

4.4 Price Setting

International fibre prices are quoted on the basis of F.O.B Mombasa or C.I.F. United Kingdom or U.S.A. ports per ton of fibre. Price differentials exist between grades. Appendix A shows average export prices for all sisal grades for the period 1960 to 1985. In 1985, the average price of fibre was Ksh. 7,111 per ton. This price differs from the average price paid to producers shown in Appendix E which is Ksh 6,740 per ton in the same year. The difference is due to commission, freight, insurance, and other handling charges.

CHAPTER FIVE

FIBRE EXTRACTION TECHNOLOGIES

5.1 Introduction

In Kenya two methods for fibre extraction are used. The oldest methodinvolves stationary or "factory" decorticating and the second method is the recent, mobile or "field" decorticator. This chapter compares the impact of the old and the new technique on various aspects of leaf processing, production costs, fibre wastage in the decorticating drums, and output by each method. The basic problem is to determine the advantages and disadvantages of each technique in the prevailing situation that surrounds the sisal estates today with a view to determine the most appropriate technology for leaf decorticating. Comparative costs and revenues of each technique will be used to determine the appropriate technology.

For a comprehensive comparison, availability and reliability of data is crucial. Hence, some data limitations and other problems in the comparison between the two techniques will be pointed at the very outset.

The "corana" model has been in use for the last three decades; however the "crane" is very new, and is used in estates owned by the promoters of "crane" decorticator. Therefore, data concerning the "crane" comes from the promotors of this techology. Such data and information may be biased because it is geared towards increasing sales. The data and information provided by the promoters of the field decorticator is therefore unlikely to depict the true picture about the "crane". A manual prepared by Deloitte, Haskins, and Sells (1986), a management consultancy, on behalf of Kenebco Ltd and Standard Chartered Acceptances (the promoters of the "crane) provides information used in carrying out the comparison. However, in the opening chapter the authors point out that "other data were given to us by the promoters, which we were unable to verify as part of our work," and later in the chapter "He [The promoter] informed us that those who have seen it in operation have reacted favourably" (Deloitte, _et al_, 1986). This suggests that information and data published in the manual is questionable. To overcome the suspicion of biased data, other data drawn from three other estates in the Rift Valley will be analysed.

A second limitation of the data collected from estates resulted from differences in data classifications. For example, data across estates could not be compared due to differing data categorization. Data used in carrying out the comparison was thus drawn from three estates owned jointly. This overcame the problem of comparability of data because decorticating practices, cost structures, and data classifications were similar.

Despite having similar basic principles for decorticating leaves, other external factors differ. The traditional practices and the age of the decorticators differ making comparison of these difficult. However, some differences will be ignored because the issue is, in fact, the new versus old techniques. Hence, depreciation for the "crane" will be included in the cost structure, and no depreciation for factory decorticators is included since these machines have reached book value.

The models used in carrying out the comparison between the field and factory techniques include the "crane" for field decorticator, "corona" and "stork" for factory decorticating. These have similar basic principles such as an automatic leaf feeding device (cross-feed) and an automatic adjusting mechanism for varying leaf lengths. However the conclusions that emerge from different comparison criteria should be used with caution. The conclusions do not adequately represent all types of "corona" decorticators. These decorticators differ in size, speed, efficiency, reliability, etc. However, the results obtained can reasonably represent the "field" and "factory" techniques. The "crane", "corona", and "stork" are evaluated below using a variety of criteria.

5.2 <u>Production Costs</u>

Differences in production costs exist not only between "crane", "stork", and "corona" decorticators, but also between estates using similar models, say,the "corona". Such differences are a result of differences in the size of the decorticator, decorticating practices, source of water, power or fuel, distance of sisal fields to the factory, water pumps, age of the decorticators, mode of transporting leaves or

Table 5.1 Production Cost Structure per ton of finished fibres in Kenya Shillings

		"Factory" Techniques				"Field" technique
		"Stork"	"corona"			"crane"
		I b/	II a/	III a/	IV a/	V b/
	Field production expenses:					
1.	leaf cutters	670	435.5	749.7	636.8	670
2.	Leaf/fibre transport (labour and fuel)	385	296.5	307.6	377.5	25
3.	Total field costs	1055	732.0	1057.3	1014.3	695
4.	Factory production expenses: Power plant/fuel	185	314.8	629.7	415.1	165
5.	Factory pumps	30	5.8	153.2	11.6	-
6.	Decorticating (mainly labour)	110	167.0	244.0	307.5	60
7.	Washing and Drying	65	49.6	73.7	43.7	25
8.	Brushing and carding	140	177.0	193.2	176.7	140
9.	Baling	115	13.5	11.8	14.5	115
10.	Loading bales and transport to site	12	1.8	3.1*	4.3	12
11.	Rope making	8	25.6	27.7	34.7	8
12.	Depreciation cost as at 31/3/87	-	-	-	-	61.6
13.	Total Factory pro. expenses	665	755.1	1336.4	1008.1	586.6

Table 5.1 (Contd.)

	"Factory" techniques				"Field" technique
	"Stork"	"corona"			"Crane"
Factory Maintenance:					
14. Power plant	160	10.6	47.0	1.4	55
15. Decorticators	25	15.5	1.4	162.2	-
16. Water works	130	0.9	5.1	3.0*	-
17. Drying grounds	5	5.0	12.5	10.4	5
18. Total factory Maintenance costs	320	32.0	66	177.0	60
TOTAL (K sh)	2040.0	1519.1	2459.7	2199.4	1341.6

N.B * An average of the other estate costs was used to represent these costs

Source: a/ Data obtained from estates (i.e. column II & IV)

b/ Data obtained from the manual (Deloitte, Haskins, and sells, 1986).

fibres to the factory, etc. For this reason, the production cost structure of estates using similar models differ. Table 5.1 shows the production cost structure for the "stork" , "crane" and "corona" used for comparing the "field" and "factory" decorticating techniques.

Field decorticating reduces transportation costs of fibre and leaves since about ninety-five percent of the leaf is left in the field. Hence, only fibres are transported back to the factory; this requires less transport costs, labour, and fuel. In the case of crane-field decorticator, total field costs are Ksh 695 for "crane", Ksh 1055 for "stork" and between Ksh 732 to Ksh 1057 per ton of fibre for the "corona." On average, field costs are 82 per cent higher for factory-based decorticating technique.

At the factory, differences in costs between "field" and "factory" decorticating technique, result because of differences in fuel or power source. For example, the field decorticator is powered by an ordinary tractor that consumes diesel. The "corona" and "stork" may use either generated power or electricity purchased from the power and lighting company. The factory decorticators incur higher costs for the power plant in comparison to the field decorticator. On average, fuel or power costs 57 per cent less for the field decorticator (see Table 5.1). The great differences in fuel or power costs across the estates reflect the source of power or fuel used. The cost of factory pumps is nil for field decorticating since the fibres are not washed and hence, factory water pumps are not required. In factory decorticating, water pumps must be installed not only to wash fibres, but also for driving the waste away from the decorticators to the dumping grounds. Differences in water pump costs across estates is a result of age differences. Decorticating expenses (line 6 in Table 5.1) consisting mainly of labour are lower with the "crane" field decorticator since the speed of decorticating is lower and fewer personnel are required. The cost of decorticating is Ksh. 60 for the field decorticator and between Ksh. 110 to Ksh. 307.5 for the factory decorticator. The "factory" decorticators require additional personnel to drive away the waste onto the dumping grounds. The factory decorticators are very old and this increases the labour required for maintaining the machines. Factory decorticators operate at a higher speed than field decorticators and hence require additional labourers. Washing costs are nil for "field" decorticating and Ksh. 25 for drying sisal. The costs of washing and drying range from Ksh 43.7 to Ksh 73.7 for factory decorticating. The cost of loading bales, transport to site, and rope making are similar. Differences between estates result from differences in efficiency, productivity of workers, management, etc. Depreciation expenses[14] for the "crane" field decorticator is equal to Ksh 61.6; it is nil for factory decorticating due to its old age. The difference in total production costs is great between the factory and the field decorticators (see line 12, Table 5.1). In factory decorticating most of the work is performed in the factory. This increases factory expenses. In field decorticating expenses such as waterpumps, washing e.t.c. are absent and this reduces factory costs

Factory maintenance costs that cover the power plant, decorticators, and water works' maintenance range between Ksh 32.04 to Ksh 177.0 for factory and Ksh 60 for field decorticating. The "crane" field decorticator is fairly new, hence its maintenance costs are negligible. Factory maintenance costs are higher for the factory decorticators because the machines are fairly old and hence frequently breakdown.

The total production costs per ton of finished fibre is equal to Ksh 2040 for "stork", an average cost of Ksh 2054.6 for the "corona", and Ksh 1341.6 for the field decorticator.

5.3 Fibre Wastage

The two methods of decorticating incur different percentage of wasted fibres. To determine the revenue foregone due to fibre wastage, an analysis of existing data and experiments to determine fibre wastage was carried out.

Sisal estates carried out experiments to determine the percentage of fibre lost in the decorticating drums with a view to reduce wastage. Data on such experiments are available in most estates. With the introduction of the new technique, the field decorticator, more experiments were carried out to assess the amount of fibres lost in the decorticating drums using the new and the old decorticating techniques. The results are published in a project manual (Deloitte et al, 1986). The decorticators used in this experiment were the "stork" model 20-12 with 200 horse power (H.P) to represent factory decorticators and the "crane" model BK 36-48 powered by a tractor engine to produce 45 - 50 horse power (bhp) for field decorticator. The results of the experiments published in the project manual are used in deriving the percentage of fibres wasted. However, several shortcomings arise from using these data.

The experiments were conducted on estates owned by the promoters of the crane and hence it is difficult to verify the data. Moreover, the conditions of the sisal estates where these experiments took place favour the use of the "crane" (e.g. older leaves, neglected sisal). To overcome the problem of possibly biased data, results drawn from one estate during the field survey are also analysed in case 2 of Table 5.2. The experiments were conducted with the decorticator running dry for ease of comparison. This should not affect results since the factory decorticators use water only for washing the fibres and driving away the waste. Water is not normally used inside the drums.

The experiment for determining the percentage of waste fibres involves collecting the fibres left in the decorticating drums and drying and weighing these. However, the fibre wastage in the decorticating drums depends on many factors some of which can be controlled in order to reduce normal production waste level. For example, the age of the leaves determines the waste content which is lower the younger the leaves, and more, the older and tougher the leaves. This is even more important in the factory decorticators which are not designed to decorticate very old sisal without increasing the amount of wasted fibres. The percentage of wasted fibres after decorticating young leaves is 8.93 per cent for crane and 16.50 per cent for stork (see Deloitte, et al 1986, Appendix 2, sheet 1). The speed of decorticating affects the quantity wasted. The faster the speed, the more wasted fibres. Finally, the percentage of wasted fibres in the drums depends on the competence of the engineer since he can adjust the decorticator to minimize waste. Nevertheless, due to the structure of the leaves some waste must occur. Therefore, the different results depend heavily on one or more of these factors. For example, if the leaves were more mature than ordinary estate sisal, then the crane field decorticate has an edge over factory decorticators. Infact, the crane decorticator is especially suitable for decorticating sisal on neglected sisal estates, where no factory, machinery and other infrastructure are available.

The fibre loss in the factory and field decorticating techniques is analysed in Table 5.2. In case 1, losses are 45.9 per cent higher using the factory decorticator.[15] In case 2, the difference in fibre loss is minimal, only 4.7 per cent higher using a factory decorticator.[16] In calculating revenue foregone due to fibre wastage, an average percentage of lost fibres in the two cases analysed in Table 5.2 is used. Therefore, the percentage of fibre lost using the corona is 15.8 per cent. This is converted as a ratio of lost fibre to good fibres produced (not wasted in the drums) per ton. The percentage is equal to 18.76 per cent for corona [i.e. 15.8 ÷ 84.2] and 13.25 per cent for the crane field decorticator. However, high profit making estates achieve a better ratio than 18.76 per cent. Therefore, 18.76 per cent fibre loss will be used to represent low ranking estates.[17] Three weekly statistics of fibre lost in the drums were selected from one high ranking estate. [i.e 8.1%, 7.4% and 9.4%]. An average of these was used to represent high ranking estates. The ratio of lost fibres to good fibres is equal to 9.05 per cent. Assuming that medium estates have higher fibre losses than high ranking estates, but lower than low ranking estates, we shall assume that 9.5 per cent of the fibres are lost in the decorticating drums. Accordingly, the percentage ratio of lost fibres to good fibres would be 10.50 per cent. Assuming that the fibres could have been sold abroad,[18] the fibre wasted in the drums for the four categories of estates are evaluated in Table 5.3.

Table 5.2 Total Wasted fibres using the two methods of decortication

Case 1 [a]		"Crane"Field decorticator	"Stork"Factory decorticator
Average length of leaves:		85cm	80cm
Number of leaves decorticated	(a)	209	227
Weight of leaves	(b)	100kg	100kg
Fibre extracted - weight	(c)	3.020kg	2.650kg
Weight of dry waste fibre:			
Extracted from large decorticating drum	(d)	70gms	60gms
Extracted from small decorticating drum	(e)	226gms	463gms
Total weight of fibre in waste	(f)=(d+e)	0.296kg	0.523kg
Total line fibre and waste	(g)=(c+f)	3.316kg	3.170kg
% of fibre extracted from leaves	(h)= (cx100)/g	91.07%	83.60%
% of fibre extracted from large drum	(i)=(dx100)/g	2.10%	1.90%
% of fibre extracted from small drum	(j)= (ex100)/g	6.8%	14.60%
% of fibre loss (measure of superiority)	(k)=(fx100)/g	8.93%	16.50%
Metres per ton	(l)= (100)/ex10)	25.63	31.75

Case 2. [b]	Crane Bk 36-48 Decorticator	Krupp No. 2B factory decorticator
Number of leaves decorticated	337	337
Weight of leaves	214.kg	214kg
Fibre extracted - weight	9.10kg	4.720 k
Weight of dry waste fibre		
Extracted from large decorticating drum	260gms	80gm
Extracted from small decorticating drum	1280gms	765gms
Total weight of fibre in waste	1.540kg	0.845
Total line fibre and waste	10.640kg	5.565

Table 5.2 (Contd.)

	"crane" Field decorticator	"stork" fact decorticato
% of fibre extracted from leaves	85.53%	8482%
% of fibre extracted from large drum	2.44%	1.44%
% of fibre extracted from small drum	12.03%	13.74%
% of fibre loss	14.47%	15.18%
Metres per ton	10.99%	21.18%

Source: a/ obtained from Deloitte, Haskins, and Sells, (1986) Appendix 2, Sheet 2.

b/ obtained from one estate in the Rift Valley Province.

Table 5.3 Value of fibres lost in the decorticating drums per ton of finished fibre produced

	High ranking Estates (A)	Medium ranking Estates (B)	low ranking Estates (C)	Estates Using field decorticator (D)
Percent of lost fibre in the drum	9.05	10.50	18.76	13.25
Value of lost fibres /i.e. % of lost fibre x value of one ton of fibre_/	499.6	579.6	1035.6	731.4
Differential Cost of Wastage	0	80.0	536.0	231.

The differential cost of wastage is then calculated as the difference between the highest ranking estate value of lost fibres to that lost by other estates. Hence high ranking estates differential opportunity cost of wastage is zero /¯i.e. 499.56 - 499.56_7. Estates marked B have a differential cost of wastage equal to 80.04 /¯i.e. 499.56-579.6_7 and so forth.

5.4 Revenue per ton of finished fibre

The value of finished fibre depends on the grade of sisal fibre. Fibres produced by the "crane" field decorticator are inferior because the fibres are unwashed, and hence sold as Unwashed Hand Decorticated Sisal(U.H.D.S.). Assuming that fibres are exported, the value of fibres produced by the field decorticator are Ksh. 5520 per ton of finished fibre. Assuming that fibres produced by all the other estates are valued at an average price of all fibres, the value of one ton of fibre equals Ksh. 6,800 F.O.B value.

We can now construct a table to represent the three aspects considered in comparing the field and factory decorticating techniques. Based on this information we can further construct the net comparative profit per ton of finished fibre. This will be used to determine the appropriate decorticating technique because not only are revenues of fibre considered but also the real financial costs incurred using the "field" and "factory" decorticators.

Table 5.4 Net Comparative profit per ton of finished fibres in Kenya Shillings.

	High ranking estate	Medium ranking estates	Low ranking estates	Estates using field decorti tors
Revenue per ton of Sisal fibre	6800	6800	6800	5520
Less: Real financial cost	2054.6	2054.6	2054.6	1341.6
Less: Differential cost of wastage	0	80.0	536.0	231.8
Net comparative profit per ton of finished fibres (Ksh.)	4745.4	4665.4	4209.4	3946.6

The field decorticator is not worth adopting because the factory decorticators are more profitable. (See Table 5.4). In low efficiency estates the difference between net profits per ton of finished fibre using the factory decorticators and those made using the field decorticator is smaller /i.e. Ksh 262.8_7. Further, the reduction in production costs in field decorticating is more than offset by revenue foregone due to production of inferior sisal fibre grade U.H.D.S. Thus, the net profit from using the field decorticator is unattractive to estate owners who are already established with a complete factory and other infrastructure. In regard to fibre wastage, the "crane" field decorticator is not superior. The wastage statistics from a high ranking estate were lower than those recorded by the field decorticator. Apparently, the factory decorticator has low fibre wastage if properly maintained under good management. Indeed, the percentage of lost fibres may vary considerably from estate to estate.

5.5 Production

The "corona" produces more fibre per day than the "crane" field decorticator. For example, sisal estates with three "corona" decorticators produced an average of 20 tons of fibre per day. This is six to seven tons of fibre per machine. To do this required 17 to 18 hours (two shifts) per day using factory decorticators. The field decorticator processed just five tons of fibre a day using sixteen hours (two shifts). Production was low with field decortication. Low output by this method is attributed to unfavourable working conditions in the field, for example, long hours spent under the hot sun. The different working conditions for the two technologies affect output. Also, during the night, poor visibility slows decorticating in the field due to insufficient electrical lighting. The speed of decorticating differs between the field and factory based techniques and this affects output of fibre. The difference in speed is due to differences in source of power. The field decorticator is powered by a tractor with about 100 horse power (H.P) whereas the factory decorticators is powered by electricty with about 150 to 200 horse power. Thus, the factory decorticators process sisal leaves faster and this increases the tonnage of fibre produced per day.

5.6 Summary

The field decorticator records less fibre wastage than low ranking estates, but higher wastage than high ranking estates (see Table 5.3). However, the percentage of lost fibres in the drums depends on diverse factors. Indeed, the percentage of fibre wasted varies from estate to estate and also from time to time within an estate. Thus the statistics derived in calculating the percentage of fibres wastage should be used with caution.

Field decorticating reduces production costs because most factory expenses are eliminated for instance, for factory pumps, washing, power plant and maintenance. Though production costs are increased by depreciation expenses, total production costs are lower with the field decorticator.

The field decorticator is suitable for small producers and for decorticating very old sisal especially hedge row sisal, neglected sisal, and sisal grown in arid areas where water for washing fibres is unavailable. The cost of a new field decorticator and tractor is Ksh. 2.0 million. This is much lower than the cost of a "corona" valued at Kshs 8 to 9 million. Thus, if the decision were to install a decorticator in a small estate where factory, machinery and other infrastructure are absent, then the field decorticator may be a worthwhile investment. In small estates, the cost of setting up a factory and other infrastructure together with installation of factory decorticators, water pumps, etc would be too costly for a small producer.

Given that most sisal estates are equipped with a factory, machinery, and infrastructure and have adequate water supplies, most producers probably will not adopt the new technology. Existing estates do not require additional machinery since most estates are already well equipped. Also, it would be difficult to sell the factory decorticators because of their low second-hand value. Although the field decorticator has less fibre wastage than low-efficiency estates, high ranking estates with better management and engineers have reduced this cost below the level recorded by the "crane" field decorticator. Thus, the factory decorticators can be superior with good management and engineers. Reduced production costs are more than offset by revenue lost from the production of inferior fibres using the field decorticator. This makes net profits from using the field decorticator unattractive to most producers.

CHAPTER SIX

AN ENONOMETRIC ANALYSIS OF SISAL PRODUCTION

6.1 Literature Review

Various studies on sisal production exist (see Gauilbaud 1966, Lawrence 1971, and Music 1970) The supply response studies are of particular importance to the present study. These studies use regression analysis to estimate output-price relationships.

Labys (1937) noted that the response of perennial crops depends on economic, ecological, technological, institutional, and informational factors. The producer determines his output on the basis of prices of inputs given technological possibilities. Ecological determinants of production include the climate and soils among others. Biological and technological factors also affect crop production. Institutional factors including commodity policies and trade restrictions also affect output. Labys' studies show that the production process associated with perennial crops is different from that of annual crops. He argued that any relationship that estimates the supply response of such a crop must consider the lag between planting and harvesting periods.

Major studies on production of perennial crops include those of Ady (1968), Chan (1962), Behrmen (1968), Stern (1969), Bateman (1969), French and Bressler (1969), Nerlove (1979), French and Matthews (1971), and French, King and Minami (1985). Most of the models developed by these authors are not restricted to sisal supply or production.

Studies related to the sisal crop include Bateman's (1969) study. Bateman constructed a model to explain changes in acreage after considering two determinants of sisal supply, namely, planting and actual output relationships. The output function links output harvested to the acreage planted whereas the planting function describes the forces motivating farmers to plant. In the planting relationship, Bateman considered four planting response models that take into account economic forces motivating farmers to plant. His gross investment model consider crop investment so that acreage planted is related to price expectations for the sisal crop and of alternative crops. Therefore, planting is a function of prices. Bateman also considered two stock adjustment models to explain planting response). . The first considers actual stock of trees as a function of prices. The other considered desired stock of trees, again as a function of prices. The fourth models, the liquidity model, explains the acreage planted as a function of the two sets of expected prices (of sisal crop and alternative crops) and of previous income received by the producer. The relationship between output and planting is linked since actual output is a function of potential average yield of the tree crop in a year after considering the acres planted. Output is also given as a function of the prices of sisal fibre and of ecological, technological and other noneconomic effects. After estimating the planting relationship for his gross investment model, the price variables included in his model did not exhibit the correct signs.

Gwyer (1971) developed a model for sisal production along the lines suggested by French and Bressler (1969), Arak (1967) and Bateman (1969). His model explained the effects of price expectations on sisal supply and he concluded that prices affect both harvesting and planting of sisal.

Studies by French et al (1985) and others, attempt to model crop planting and harvesting activities separately. These two activities are considered important aspects of perennial crop production. In developing their perennial crop production model, French et al, considered the following variables: the profitability of perennial crop, the profitability of the alternative crops, a proxy to represent risk of the perennial crop, and personal factors. The above factors determine desired area allocated to a particular perennial crop. A model for new planting was developed along French and Matthews' (1971) ideas, as a function of past returns for perennial crop and past returns of alternative crops, potential future production from existing plant stocks, changes in perceived risk, and total previous acreage.

Previous studies suffered from data unavailability or short time series making empirical estimations difficult. In yet other cases, the sisal production models were too simplistic. That is, planting and harvesting decisions were considered as a function of too few factors whereas producers' acreage decisions were thought to be influenced by a combination of many factors.

The present study was developed along the lines of Arak (1969), French and Matthews (1971), French and Bressler (1969) and French <u>et al</u> (1985). As in their models, the effects of the price of sisal fibre and the prices of other agricultural crops were considered. Both past and present prices of sisal fibre in addition to other factors are included in the model. However, the producers' planting, harvesting, production, and sales decisions are studied together. This departs from the approach considered by past authors. For example, unlike the past studies, this study considers sisal production along with processing technology and the marketing arrangements. Separate equations identifying the determinants of labour employment and sisal stocks are included in the analysis of sisal supply. The labour equation relates employment to area harvested and to technological change. A separate equation explains inventories held by the estates and sisal agents.

6.2 Modelling sisal production system

This section develops a model of the response of output to price in large and medium sisal estates in Kenya. As stated earlier, small-scale and hedge sisal growers are excluded from the model developed due to data unavailability. These, however, only contribute roughly 22 percent of the country's sisal production. The response of sisal output to price variations (the sisal supply function) was estimated taking into account other factors such as rainfall and price of sisal fibre substitutes. An attempt was made to explain changes in sisal output by estimating the effects of the factors that influence acreage planted, area harvested, the quantity produced, sisal sales, and stock levels. A separate equation that estimates the impact of labour employment in the industry identifies the influence of area harvested on labour demand. Sisal production is studied as a system because sisal production, processing and marketing systems are linked. Hence it would not be proper to study the factors that influence decisions about acreage, area harvested, and the quantity produced without considering the factors that influence sisal sales, stock levels, and labour employed. To remove the effect of inflation, all prices and monetary variables were deflated.

Acreage model

The relationship between sisal acreage and the prices of sisal and alternative crops together with other factors will now be examined. The following variables are assumed to influence the acreage placed under sisal.

<u>Price of sisal fibre</u>. Estate owners are assumed to be profit maximizers. Due to the perennial nature of the sisal crop, and the time lag between planting and first yield, producers are influenced by expected prices ($\overline{P}_t$). Producers presumably form price expectations by considering past and present prices. In this case an average of prices of the past four years is denoted as $\overline{P}_t$ where $\overline{P}_t$ refers to deflated prices.

<u>Price of alternative crops</u>. It is hypothesized that when the price of an alternative crop increases, sisal acreage declines. The crops that compete with sisal may be annual or perennial. The prices of annual crops will be denoted by Z_t and those of perennial crop by C_t. In our case, Z_{1t} refers to deflated prices of wheat, Z_{2t} to deflated prices of maize, and C_t to deflated prices of coffee.

<u>Rainfall.</u> It is expected that the higher the rainfall (R_t), the higher the sisal acreage. Producers plant their sisal crop during the rainy season because during this time the plant growth rate is faster after which the plant is able to resist drought. The average total annual rainfall within the country will be used as proxy for rainfall in sisal growing areas.

<u>Cost of labour inputs</u> (W_t): As the prices of sisal inputs increase, the sisal acreage declines. High input prices increase the cost of planting. In effect this raises output prices and thus reduces profits realized by producers. The average cost of inputs in the plantation sector is used to represent the cost of inputs in the sisal industry. Hence, W_t denotes the cost of labour inputs which form a large proportion of inputs in the acreage model since planting has not been mechanized. Labour inputs are deflated to remove inflation effects.

<u>Time (T)</u>: The time variable is a proxy for the effects of declining soil fertility or productivity. It is hypothesized that acreage under sisal falls with declining soil fertility since infertile areas would not be re-planted. Thus, acreage under sisal is negatively correlated to declining soil fertility. But, other land under sisal becomes more productive over time due to technological improvements.

In light of the above considerations, the acreage model can be expressed as

$$A_t = f(\bar{P}_t, Z_t, C_t, R_t, W_t, T) \text{ ---------- } (6.1)$$

where the expected signs are:

$f_{\bar{P}_t} > 0$; $f_{Z_T} < 0$; $f_{C_t} < 0$; $f_{R_t} > 0$; $f_{W_t} < 0$; and $f_T < 0$

Harvesting model

The area harvested which at maximum is the area with mature sisal, is determined by the labour, technology, previous acreage, and other factors. The area to be harvested however, affects the labour that is employed. Hence, a separate equation is specified to show the impact of area harvested and of technological effects on labour employed in the sisal industry. Following is a discussion of assumed determinants of acreage harvested (H_t). Once again price and input variables are deflated to remove inflation effects.

Capital (K_t): It is assumed that the capital used and the amount of sisal harvested are positively correlated. Hence with increased capital inputs, a larger area of sisal can be harvested.

Previous acreage under sisal (A_{t-1}): It takes time to increase sisal acreage. Thus the higher the previous acreage, the higher the area that can be harvested. In our case, sisal requires three years before first cutting.

Price of sisal fibre (P_t): As in the acreage model, producers are assumed to maximize profits. Thus an increase in prices is expected to induce producers to harvest more sisal. The effect of expected prices ($\bar{P}_t$) will also be examined.

Rainfall (R_t): High rainfall increases the proportion of long leaves harvested, and hence increases profitability of harvested leaves. For this reason, sisal harvests would increase with rainfall since the area of mature leaves is increased with higher rainfall.

Previous stocks (S_{t-1}). Previous stocks of sisal fibres tend to decrease the area of sisal harvested. This is because producers are cost minimizers and hence prefer to use up old stocks first.

Cost of labour inputs (W_t): As seen before, the cost of inputs affects acreage under sisal together with the area harvested because it increases harvesting costs. Inflation effects are removed by deflating these inputs.

Dummy variable (D1): D1 represents the factors influencing abnormal harvests in the year 1969. The year 1969 is represented by a dummy equal to one, and all the other years with a zero.

Symbolically the harvesting model can be expressed as

$$H_t = g(K_t, A_{t-1}, P_t, R_t, S_{t-1}, W_t) \text{ ------ } \quad (6.2)$$

where the expected signs are:

$g_{K_t} > O;$ $g_{A_{t-1}} > O;$ $g_{P_t} > O;$ $g_{R_t} > O;$ $g_{S_{t-1}} < O;$

and $g_{W_t} < O.$

Production model

The production of sisal, which represents the output of sisal fibre, is determined by the price of sisal fibre, the previous acreage, technology, and other factors. Since the area harvested does not adequately represent output of fibre produced, a production model was developed that represents the quantity (in metric tons) of sisal fibre produced. The assumed determinants of sisal production after removing inflation effects on price and input variables are discussed below.

Price of sisal fibre (P_t): As in the acreage and harvesting models, producers are assumed to maximize profits. Thus an increase in prices of sisal fibre are assumed to induce more production of sisal fibre.

Area harvested (H_t): It is hypothesized that the higher the area of mature leaves and the higher the tonnage of leaves and hence the more the production of sisal fibre.

Previous acreage under sisal (A_{t-1}): It takes time to increase sisal acreage which requires at least three years before first cutting. Therefore, the higher the previous acreage of mature leaves, the greater the area harvested and the more the sisal fibre produced.

Rainfall (R_t) As in the harvesting model, high rainfall increases the profitability of fibre produced due to longer leaves being produced and hence longer fibres. Thus, fibre production is positively related to higher rainfall.

Capital (K_t): It is assumed that the higher the capital inputs, the higher the production.

Previous stocks (S_{t-1}): Previous stock of sisal fibre tend to lower the production of fibres because producers are cost minimizers and hence prefer to use up old stocks first.

Cost of labour inputs (W_t): As seen before, the cost of labour inputs affects sisal acreage, area harvested, and production. The higher the cost of labour inputs, the lower the production of sisal fibre because profits are reduced.

Time (T). It is hypothesized that production increases over time due to increased productivity, a result of technological change.

The production model can be expressed as

$$Y_t = y(P_t, A_{t-1}, H_t, R_t, K_t, S_{t-1}, W_t, t) \qquad \text{------} \qquad (6.3)$$

where the expected signs are

$$y_{P_t} > 0; \quad y_{A_{t-1}} > 0; \quad y_{H_t} > 0; \quad y_{R_T} > 0; \quad y_{K_t} > 0;$$

$$y_{S_{t-1}} < 0; \; y_{W_t} < 0; \quad \text{and} \quad y_t > 0.$$

Sales model

The factors that determine the amount of sisal sales are:

Price of sisal fibre (P_t): Marketed output is influenced by the profitability of sisal fibre. Hence the higher the price of sisal fibre, the higher the sales. However, since prices of sisal fibre are unpredictable due to constant fluctuation, producers consider both past and present prices in forming price expectations ($\overline{P}_t$) which influence their sales.

Production of sisal fibre (Y_t): It is assumed that the larger the production of sisal fibre, the larger the volume available for sale.

Price of sisal fibre substitutes (X_t): Presumably, when the price of competing fibre increases, more sisal fibre is sold because demand for sisal increases. This is because consumers are assumed to be cost minimizers and hence prefer to buy cheaper fibres. In our case the ratio of price of jute to the expected price of sisal fibre $(\frac{X_t}{\overline{P}_t})$ is considered.

Previous stock of sisal fibre (S_{t-1}): The larger the previous stock of sisal fibre, the greater should be the amount of sisal sales as this increases the quantity available for sale.

In symbols, the function for sisal sales can now be expressed as

$$Q_t = h(\overline{P}_t, P_t, Y_t, X_t, S_{t-1}) \quad \text{---------------} \quad (6.4)$$

where the expected signs are:-

$h_{\overline{P}_t} > 0$; $h_{P_t} > 0$; $h_{Y_t} > 0$; $h_{X_t} > 0$; and $h_{S_{t-1}} > 0$

Labour employment model

Labour demand is influenced by the area to be harvested and also by technological effects. The time variable is used to measure the impact of technological change on labour demand.

The labour demand model can be expressed symbolically as

$$L = m(H_t, T) \quad \text{-------------------} \quad (6.5)$$

where the expected signs are:

$$m_{H_t} > 0; \quad \text{and} \quad m_T < 0$$

Stock model

The quantity of sisal unsold is determined by the prices of sisal fibre, prices of competing fibres,and production. The factors assumed to affect stocks include:

Price of sisal fibre (P_t): The higher the price of sisal fibre, the lower should be the stock of sisal fibre. This is because producers are profit maximizers and hence prefer to sell when prices are high. Expected prices of sisal fibre ($\bar{P}_t$) are also considered important in determing the quantity of sisal unsold each year and hence will also be examined.

Production of sisal fibre (Y_t): It is expected that the larger the quantity produced each year, the more the quantity available as stock.

<u>Price of sisal fibre substitute (Y_t):</u> High prices of sisal fibre substitutes tend to lower the stock of sisal fibre through its effect on sales of sisal fibre. The ratio of price of sisal fibre substitute to expected price of sisal fibre will be considered.

In view of the above factors, the stock model is expressed as

$$\Delta S_t = i(P_t, \bar{P}_t, Y_t, X_t) \text{ ------------- } \quad (6.6)$$

where the expected signs are:-

$$i_{P_t} > 0; \quad i_{\bar{P}_t} > 0; \quad i_{Y_t} > 0; \quad \text{and} \quad i_{X_t} > 0.$$

The acreage, harvesting, production, sales labour and stock models can now be summarized as follows:

$$A_t = f(\bar{P}_t, Z_t, C_t, R_t, W_t, T) \text{ ----------- } \quad (6.1)$$

$$H_t = g(K_t, A_{t-1}, P_t, R_t, S_{t-1}, W_t) \text{ ------ } \quad (6.2)$$

$$Y_t = y(P_t, A_{t-1}, H_t, R_t, K_t, S_{t-1}, W_t, T) \text{ -- } \quad (6.3)$$

$$Q_t = h(P_t, \bar{P}_t, Y_t, X_t, S_{t-1}) \text{ ------------ } \quad (6.4)$$

$$L = m(H_t, t) \text{ --------------------------- } \quad (6.5)$$

$$\Delta S_t = i(P_t, \bar{P}_t, Y_t, X_t) \text{ -------------- } \quad (6.6)$$

The above equations depict a recursive system for sisal priduction. This implies that the equations can be estimated one at a time without running into a simultaneity bias problem. Different functional forms of the equations are estimated in the ensuing section.

6.3 Empirical results

Time series data for the period 1960 to 1985 were used to estimate the equation system. Due to data unavailability the effects of capital inputs (K_t) on area harvested and production were not estimated. Both linear and non-linear versions of the equations were estimated. Only the results of models with the best fit are presented in this section. Appendix H shows the results of other attempted regressions. All prices of commodities and inputs represent real prices. Appendix G presents correlation results, whilst the data for the estimations is contained in Appendix F. Table 6.1 shows the regression results and Table 6.3 the estimated elasticities.

Acreage model.

In the acreage model, all the correlation coefficients of the variables included in the model exhibit the anticipated signs with respect to the dependent variable, acreage under sisal. In the best acreage model, the t-statistics for the coefficients are significant at the one per cent level except for the coefficient for rainfall (see Table 6.1). The coefficient of the ratio of expected price of sisal fibre to cost of labour inputs $\frac{\overline{P}_t}{\overline{W}_t}$ is equal to 1480354.97 and the elasticity of acreage planted with respect to this ratio is 0.74[19] (see Appendix I). This means that for a one per cent change in the ratio, $\frac{\overline{P}_t}{\overline{W}_t}$, 0.74 per cent additional acreage is planted. The elasticity for the price of an alternative crop, wheat, is -1.35. Hence when the price of an alternative crop, wheat, increases by one per cent, acreage under sisal falls by 1.35 per cent. When rainfall increases by one per cent, acreage under sisal increases by 0.16 per cent.

The adjusted coefficient of multiple determination ($\overline{R}^2$) is 0.49. This implies that the variables included in the model explain 49 per cent of the variation in acreage under sisal, and 51 per cent of this is unexplained. The standard error of the regression (SER), which measures the error made in predicting the sisal acreage using this model is 43 per cent. The F statistic shows

Table 6.1 Selected Regression results

Acreage

$$A_t = 251172.43 - 2288.11Z_{1t} + 26.65R_t + 1480354.97\frac{P_t}{W_t} \quad ......(6.1)$$

(3.03)* (-3.26)* (0.82) (4.77)*

$\bar{R}^2 = 0.49$ F = 8.98 SER = 0.43 D.W = 0.73 D.F = 22

Harvesting

$$H_t = 1220.99 + 0.05A_{t-1} - 0.10S_{t-1} + 34367.52\,D1 \quad ------- \quad (6.4)$$

(0.47) (3.98)* (-0.70) (7.32)*

$\bar{R}^2 = 0.80$ F = 35.23 SER = 0.40 D.W = 1.14 D.F = 22

Production

$$\ln Y_t = 9.91 + 0.16 \ln H_t + 0.25 \ln \frac{P_t}{W_t} \quad ------------------ \quad (6.7)$$

(14.96)* (2.11)* (3.30)*

$\bar{R}^2 = 0.30$ F = 6.37 SER = 0.20 D.W = 1.16 D.F = 23

Sales

$$Q_t = 6197.77 + 0.85\,Y_t + 1442.33\frac{X_t}{P_t} \quad ------------------ \quad (6.10)$$

(1.74)** (14.80)* (0.93)

$\bar{R}^2 = 0.90$ F = 108.80 SER = 0.36 D.W. = 2.23 D.F = 23

Table 6.1 Contd...

Labour	$L = 8835.45 + 0.53\ H_t$ --------------------	(6.12)
	(3.57)* (2.62)*	
	$\bar{R}^2 = 0.20$ F = 6.85 SER = 0.51 D.W = 0.61 D.F = 23	
Stock	$\Delta S_t = -4879.71 + 0.13\ Y_t - 1609.65\ \frac{X_t}{\bar{P}_t}$ --------------	(6.15)
	(-1.33) (2.27)* (-1.01)	
	$\bar{R}^2 = 0.15$ F = 3.19 SER = 0.38 D.W = 2.18 D.F = 23	

NB: * = Significant at one or five per cent level

** = Significant at ten per cent level.

The t - values are in parentheses.

Table 6.2 A comparison of actual and estimated values of sisal acreage for the period 1960-1985

Year	Actual value of dependent variable	Estimated value of dependent variable
1960	255377	271839
1961	272206	209838
1962	257116	236801
1963	258147	268680
1964	268852	246657
1965	266941	226077
1966	252980	226488
1967	248809	173360
1968	239331	180526
1969	191457	134122
1970	178009	182624
1971	161544	149550
1972	152902	152396
1973	136006	175296
1974	130653	197601
1975	126779	174678
1976	134118	169601
1977	133919	206667
1978	122891	154125
1979	100263	148962
1980	122090	118948
1981	138028	151973
1982	143733	166423
1983	139199	139268
1984	139417	107988
1985	137625	137502

Table 6.3 Estimated elasticity values

Dependent variable	Explantory variable	Elasticity value	Equation
Acreage:	Z_{1t}	1.35	(6.1)
	R_t	0.16	
	$\frac{\overline{P}_t}{W_t}$	0.74	
Harvesting:	A_{t-1}	0.74	(6.4)
	S_{t-1}	-0.00039	
Production:	H_t	0.16	(6.7)
	$\frac{P_t}{W_t}$	0.25	
Sales:	Y_t	0.85	(6.10)
	$\frac{X_t}{P_t}$	0.03	
Labour:	H_t	0.40	(6.12)
Stock:	Y_t	52.23	(6.15)
	$\frac{X_t}{\overline{P}_t}$	14.08	

that the overall regression is significant. That is all the explanatory variables as a group significantly influence the dependent variable.

The Durbin - Watson statistic is 0.73 reflecting positive serial correlation of the error term. An important consequence is that "the predictions based on estimates obtained from OLS (ordinary least squares) applied to a model with autocorrelated U's are not efficient" (Koutsoyiannis 1977:227)[21]. It is necessary to determine the source of autocorrelation in order to correct the incidence of serial correlation of the residuals. A more efficient estimate of the regression coefficients, free from autocorrelation bias, would enable the model to predict sisal acreage more effectively.

The acreage model (6.1) does not have a high predictive power since the values of estimated and observed dependent variables are not very close (see Table 6.2). However, this model provides a fair explanation of the total variation in acreage under sisal in Kenya.

Equation 6.1 was preferred because all the coefficients representing the explanatory variables exhibit the correct signs. The equations 6.2 and

6.3 explain more of the variation in acreage under sisal and would have been presented if the time-variable were a good measure of declining soil fertility and increasing productivity. But since it was not possible to measure and observe that soil fertility was actually declining, the results of equation 6. have to be considered still as an hypothesis and hence cannot be considered as the best.

Harvesting model

All the correlation coefficients in this model exhibit the correct signs. A dummy variable was included in the model to represent factors influencing abnormal harvests in 1969. A dummy variable equal to one for 1969 represents the year of abnormal harvest where all other years are considered normal and are represented by a dummy variable equal to zero. It is highly suspected that data for 1969 is inaccurate. For example, the year 1969 shows area harvested equal to 49925 acres whereas all other years harvests fall below 15,000 acres. Production in the same year did not increase proportionally (see Appendix F).

In this model, all the regression coefficients exhibit the correct signs. The dummy variable (Dl) included in the model to represent factors influencing abnormal harvests in the year 1969, has the correct sign. However, only the previous acreage and the dummy variable are statistically significant in explaining variation in acreage harvested at the one per cent level.

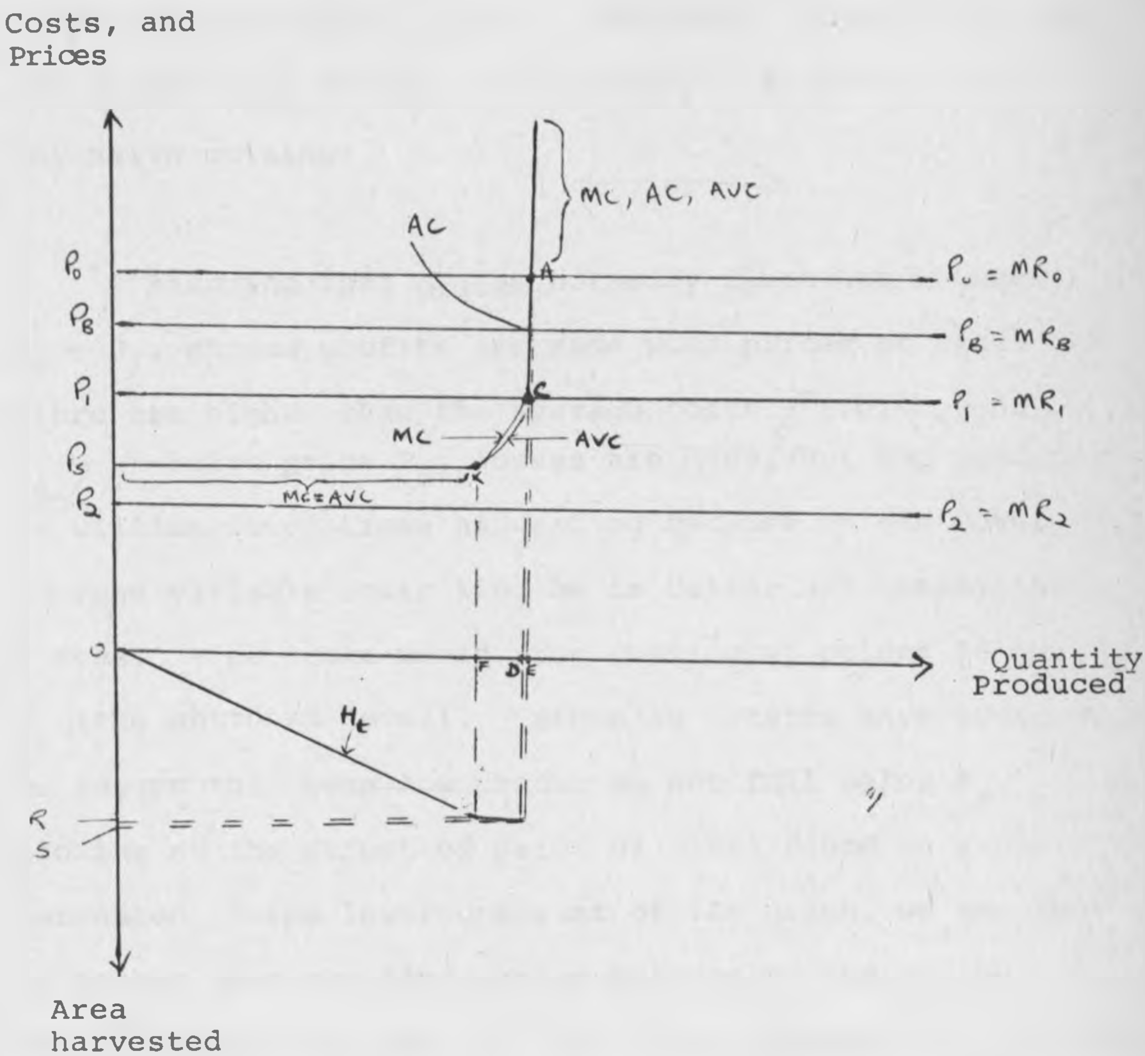
The elasticity of area harvested with respect to previous acreage is 0.74. Thus when previous acreage increases by one per cent, area harvested increases by 0.74 per cent. Estimated elasticity of area harvested with respect to previous stocks is -0.00039. This elasticity is close to zero, and hence previous stocks have little influence on acreage harvested.

The adjusted coefficient of multiple determination ($\bar{R}^2$) indicates that 80 per cent of the variation in area harvested is explained by the model. Forty per cent error is made in predicting the area harvested using this model. The F statistic indicates overall significance of the explanatory variables. The value of the Durbin-Watson statistic is 1.4 reflecting some positive serial correlation of the residuals (see note 21).

The estimated model appears to provide a good explanation for the variation in area harvested since the variables included in the model, except previous stocks, are statistically significant at the one per cent level and their coefficients exhibit the correct signs. Although insignificant at the one per cent level, the coefficient representing previous stock of sisal fibre was included in the equation because the negative direction of its effect is correct as expected in theory. The price of sisal fibre was omitted from the selected equation 6.7, because the direction of its effect is incorrect (see equations 6.5 and 6.6. Appendix H)[20]. One might expect a positive relationship between area harve and price of sisal fibre. But in practice, producers are willing to cut sisal fibre whether prices are high or low in the short-run. Figure 6.1 illustrates this.

Prices do not have a large influence on area harvested and hence can be excluded from the function. For the short-run, the marginal cost curves, the average cost curve, and the average variable costs curves are shown in figure 6.1. Initially, the margina cost (MC) and the average variable cost (AVC) curves

Figure 6.1 Short-term Costs and Production Decisions



coincide in a horizontal straight line (between points Ps and X) and then change direction upwards after X. Between Ps and X, the curves respond to an increase in area harvested which increases as one moves from O to E. But the maximum area of mature leaves for harvesting is limited (i.e O-S). Afterwards the producer may increase the quantity of fibre for processing if leaves are cut more intensively in the area harvested. But, this lowers future profits because the plant's growth is retarded. Lost future revenue has to be discounted and considered as a component of marginal costs. Therefore, after X, MC and AVC curves rise steeply reflecting losses due to too intensive cutting.

Assuming that prices normally fluctuate between P_o - P_1, excess profits are made when prices of sisal fibre are higher than the average costs [i.e. beyond P_B]. Below price P_B, losses are made, but the producer is willing to continue harvesting because he can cover average variable costs i.e. he is better off minimizing losses. A producer would stop cutting at prices below P_s (the shutdown level). Since no estates have shutdown, we assume that even low prices do not fall below P_s. Looking at the effect of price of sisal fibre on area harvested in the lower quadrant of the graph, we see that no matter what the fluctuation between P_o and P_s the area harvested changes by a very small amount (i.e. R - S). Even when prices are low say P_1, the producer can continue to cut since average variable costs are covered. Thus, it is not suprising that area harvested is not positively correlated with price of sisal fibre (see equations 6.5 and 6.6 Appendix H): Hence, the negative relationship was rejected.

Production Model

The variables that affect production are previous acreage, price of sisal fibre, and cost of labour inputs. The variables in the best equation have the correct sign and are statistically significant at the one per cent level. The values of the coefficients given by the logarithmic regression equation are elasticity values. Thus the elasticity of area harvested with respect to production is 0.16. A change in area harvested by one per cent would increase production by 0.16 per cent. This elasticity is low. The elasticity of production with respect to the ratio of the price of sisal fibre to the cost of labour inputs is plausible and indicates that an increase by one per cent in this ratio would increase production by 0.25 per cent.

The value of the adjusted coefficient of multiple determination indicates that 30 per cent of the variation in production is explained by the variables included in the model. This is not a good-fit. The F statistic is significant. That is, together, all the explanatory variables significantly influence the dependent variable. The standard error of the regression is 0.20 which means that in predicting production by using this model, we make only 20 per cent error. The Durbin-Watson statistic is 1.16 indicating some positive serial correlation of the residuals again posing a problem for predictions made using this model.

A higher percentage of the total variation in production is explained by the variables included in equation 6.8. But the rainfall variable does not exhibit the correct sign. All the variables included in equation 6.9 have the correct signs and their coefficients are statistically significant at the one per cent level. A higher variation is explained by this equation (see equation 6.9, Appendix H). This equation is unacceptable because it overlooks harvesting practices. In practice, production is closely related to area harvested.

Sales Model

Both the coefficients of production variable and the ratio of the price of jute to the price of sisal fibre have the expected signs in the best equation. But only the coefficient of the production variable is significant at one per cent level. In fact, as anticipated, the production variable alone explains 90 per cent of the variation in sales (see equation 6.11). The coefficient of the production variable (0.85) implies that an increase of production by one metric ton would increase the quantity sold by 0.85 metric tons. The elasticity of quantity produced with respect to sales of sisal fibre is also equal to 0.85.

The standard error of the regression is 36 per cent, and the F statistic is statistically significant. The Durbin-Watson statistic of 2.2 indicates absence of serial correlation in the residuals and implies that predictions made using this model are efficient.

Labour model

Labour employed was expected to be a function of area harvested and of technological changes. On apriori grounds, labour employed should be positively related to area harvested and negatively related to time, a proxy for technological change. Thus, we would expect labour employed to fall with increased technological change and to rise the higher the area harvested. In equation 6.13, the two variables explained 70 per cent of the variation in labour employed. The standard error of the regression and the Durbin-Watson statistic were satisfactory. Nevertheless, this equation was not acceptable because in theory we would not expect a negative correlation between labour employed and area harvested. Suspicion of the data for 1969, the year of abnormal harvests, led to exclusion of that data from the time series in equation 6.14. The equation 6.14 still did not improve; the coefficient of area harvested maintained a negative sign. Exclusion of both the time variable and data for 1969 gave the expected positive correlation between labour employed and area harvested.

The best equation explains only 20 per cent of the variation in labour employed. We make 51 per cent error in predicting labour employment using this equation. The F statistic is significant at the five per cent level. The Durbin-Watson statistic is 0.61 indicating positive serial correlation of the residual. This equation (6.12) though explaining a small variation in labour employed was preferred on the strength of its correct signs.

Stock model.

The factors considered to influence stock of sisal fibre were production, the price of substitute fibre (i.e. jute), and the price of sisal fibre. But these account for only 15 per cent of the variation. The error made in predicting stock of sisal fibre using this equation is 38 per cent. Thus it was not possible to determine the factors that cause variation in stocks. Although the F statistic is not significant at both one and five per cent, the Durbin-Watson statistic indicates absence of serial correlation in the residuals.

All the equations, except the stock model, offer a good explanation of the variation in the dependent variable as discussed. However, in all equations except the sales and stock models, the presence of serial correlation of the residuals poses a problem because predictions made using these models are not efficient. It would be necessary to eliminate the serial correlation for the models to predict better. Though this was not done by the author, future studies should consider this bias.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

This study focussed on the economics of sisal production in Kenya. In particular, the key factors of the sisal production system were identified and used to model an integrated system of sisal production consisting of acreage, harvesting, labour employment, production, sales, and stock models. These models are considered to represent the sisal system in Kenya. In the acreage model, the price of an alternative crop (wheat),and the ratio of price of sisal fibre to cost of labour inputs (i.e. the ratio $\frac{P_t}{W_t}$) statistically influence variation in acreage. Previous acreage under sisal influences the area harvested and the area harvested influences production of sisal fibre. In the production model, the ratio of the price of sisal fibre to the cost of labour inputs significantly influences production. Production of sisal fibre on the other hand influences variation in sales of sisal fibre. Though only significant at the fifteen per cent level, the ratio of price of jute to the expected price of sisal fibre exhibits the correct sign and the magnitude of its effect is plausable. In all but the stock equation, the model explains a good variation of the sisal production system. Some coefficients in the sisal equation system did not have the expected signs. This is perhaps due to omitted explanatory variables or to other specification errors.

Nonetheless, the models are useful for predictive purposes.

A recent innovation in sisal decorticating, the mobile-field decorticator, is unlikely to take root in well equipped and well managed estates with adequate water supplies, machinery, and infrastructure.

The reduced production costs from using the field decorticator are more than offset by revenues lost from the production of inferior fibres. Thus, net profitability from using the field decorticator is lower than that from using the existing factory decorticators. This makes the net profits from using the field decorticator unattractive to producers.

The field decorticator is suitable for small producers and for decorticating very old sisal especially hedge row sisal, neglected sisal, and sisal grown in arid areas where water for washing fibres is unavailable. In small estates, the cost of setting up a factory and other infrastructure would be too costly for a small producer. Field decorticating reduces production costs because most factory-related expenses are eliminated, for instance, for factory pumps, washing, and power plants. Maintenance expenses are low because the decorticator is fairly new and hence requires little maintenance. Field costs of transporting fibres to the factory are also low because much of the waste from leaves is left in the field. Moreover the factory decorticator can even be superior in the well managed estates.

The sisal industry suffers from an inadequately organized and inefficient marketing system. The sisal producers totally rely on agents to look for the market, organize shipping and insurance, and negotiate sisal fibre prices on their behalf. This is not effective in stimulating the sisal industry because of the lack of competition amongst too few agents.

The producers totally rely on agents who have a monopoly over marketing of sisal fibre. The government should evaluate the feasibility of nationalizing the marketing institution to control marketing of sisal fibre. The nationalized institute could also initiate a feasibility study for a buffer stock system. This would control sales of sisal fibre coupled with contraction and expansion of export licences to increase or reduce the volume of sales. To do this requires good forecasting tools and information regarding international market prices. Therefore, the marketing institution should rely on a variety of information sources.

The Sisal Board is unable to regulate the sisal industry effectively because of insufficient manpower, information, and finances. Financial constraints hinder it from implementing some of its projects. For example, a lack of funds has delayed the construction of sisal collection centres in small-scale sisal producing areas. The Board is also currently unable to aggressively promote the sale of sisal fibre and products in overseas countries through exhibitions, trade shows, and trade fairs as was done previously.

To improve the sisal industry, the constraints facing it should be tackled. For example, the industry faces a shortage of labour for cutting leaves. Without adequate labour for cutting leaves, production is constrained and leaves are lost due to natural decay. This leads to a loss of profits. Wage incentives are necessary in order to increase labour employed. But, with increased labour costs, production may fall and hence reduce profits made by producers. A study to determine the effects of increased wages on production and profits is necessary to formulate a proper policy.

The government should also design policies based on controllable variables included in the sisal production system. For example, the government should raise the duty on imported fibres thus raising the domestic price of these fibres to make them unattractive to local consumers. This would induce increased local consumption of sisal fibre and give local sisal an edge over imported fibres.

The following actions are necessary in order to improve the sisal industry's processing and marketing of sisal fibre. With regard to the sisal Board, the following actions should be taken.

Firstly, the manpower requirements of the sisal Board should be reviewed to ascertain the additional personnel that should be recruited.

Secondly, the sisal Board should look for ways to get additional revenue needed for prgrammes and projects for prmoting and developing the sisal industry. For example, additional revenue can be collected through increased cess charges. Therefore a study needs to be carried out to determine the appropriate percentage increase in cess charges that will not affect production.

Thirdly, the Sisal Board should maintain a good data system to enable it regulate and control the sisal industry effectively. Proper records and filing reduce the possibility of errors in decision making. With information about the international market prices for fibre it could ensure that producers get the best obtainable prices. Accurate information about prices, the world market, potential consumers, and world output of sisal is needed by the Board in order to regulate sales of sisal fibre.

The government together with the Sisal Board should emphasize research on plant breeding, planting, weeding, and new uses of sisal fibre. Producers lack the scientific knowhow and funds to carry out such research Research on breeding to produce high quality fibre plants, and high fibre per plant is necessary. Estates previously producing the disposal-of-sisal-sludge (D.S.S) powder from the sisal juice, for export, have been discouraged from doing so due to high costs of extracting. Research on more economic ways of extracting the "disposal of sisal sludge" will encourage sisal estates to earn revenue from this additional source.

Lastly, transfer pricing on sisal may well be occurring in Kenya. At times, prices quoted on export application forms do not reflect the international market prices. The officials of the Sisal Board should detect underpricing of sisal fibre. But since the Board relies on information about the market from the agents, it is entirely possible that transfer pricing occurs in Kenya. This issue should be investigated and all loopholes closed. Profits made in Kenya should be used for development projects and ivestments.

NOTES

1. Daily Nation, "Sisal Output declines," 3rd April, 1987. P.-1.

2. This list is contained in Table 3.1 of chapter three. The estates under survey are located in different parts of the country.

3. A manual prepared by Deloitee, Haskins, and Sells (1986) on behalf of Kenebco Ltd, owners of several estates and promoters of the "crane", was provided for this study (see reference citation).

4. Gross Domestic Product (GDP) deflators for the period 1964-1982 were obtained from a memiograph by Vandemoortele, J.,"Kenya Data Compedium 1964-1982," March 1984, Table 3. Deflators for 1960-1963 and 1983-1985 were computed using the formula given below:

$$\frac{\text{G.D.P. at factor cost at current prices}}{\text{G.D.P. at factor cost at constant prices}} \quad (1)$$

Additional deflators for 1983-1985 were calculated easily using the formula given above, because both GDP values are provided in the Statistical Abstract.

In computing the deflators for the years 1960 to 1963 two problems were encountered. Firstly, in the year 1968, better methods of estimation together with new industrial classifications were introduced and these necessitated revision of GDP at current and constant prices in that year's Statistical Abstract and in later years. The 1968 Statistical Abstract covers the years 1963 to 1967 and hence excludes the years prior to 1963. It was not possible to trace old files in order to revise GDP values at current prices for the years 1960 to 1962. Yet, time series data for estimation purposes stretch back to 1960. For conformity, data for 1960-1962 needed to be revised. Thus GDP at current prices for 1960-1962 have been revised upwards by 17.57 per cent, the average percentage increase for the revised data between 1963-1967. Since data for 1963-1967 increased by about 15 to 19 per cent, an average increase for these years (17.57%) is a good estimate for revising data prior to 1963.

Secondly, it was necessary to compute GDP at constant (1976) prices for the period 1960-1962. This was done using the formula provided by the officials of Central Bureau of Statistics.

$$Z_{t-1} = \left[\frac{Z_t(X_{t-1})}{X_t}\right]\left[1+\frac{Y_t}{100}\right] \quad \text{-----------} \quad (2)$$

where Z_t = real values for the current year i.e GDP at constant prices

Z_{t-1} = Previous GDP values at constant prices

X_t = Nominal values of GDP in the current year.

X_{t-1} = Previous nominal values of GDP

Y_t = Change in inflation rate, calculated from the consumer price index.

Using the formula above, and given the values of the variables in the formula except Z_{t-1}, we can compute Z_{t-1} at constant (1976) prices. Thus we can work backwards to derive values of GDP at constant (1976) prices for the other years, 1960 to 1962. That is since Z_t for 1964 is known, we compute Z_{t-1} 1963, etc. Once having all GDP values, the deflators can be calculated using formula (1).

5. This plant was developed by Lock at Mlingano Research Station (Tanzania) through back-crossing of A. Amaniensis and A. Angustifolia (Lock, 1962).

6. Thinner leaves in drier coast areas are found around Voi, Teita, and Taveta areas.

7. Experiments carried out by Lock (1962:200) and Osborne (Kenya Sisal Board Bulletin, 1967:12) show that use of beans and Kudzu cover crops between sisal rows increases sisal fibre per leaf.

8. Exports of sisal fibre from these plantations paved way for the sisal processing industry and encouraged neighbouring areas in Kenya to grow sisal.

9. The East African Bag and Cordage Company is the present name of the sisal processing company established in 1934.

10. The sisal grades are explained in Appendix D.

11. A Raspador is a hand-operated leaf decorticator for sisal leaves.

12. For a discussion on the history, type, production and growth of these fibres, refer to Barclays Bank, Dominion, Colonial and overseas,(1963:8-11),and to Berger (1969:187).

13. A trading table shows monthly prices of sisal fibre based on information extracted from the export application forms.

14. Assuming a life of 10 years and using straight-line depreciation for the crane, valued at Ksh 1.5 million, gives depreciation costs equal to Ksh 112,500. Approximately 1,825.3 metric tons of fibre are produced per year. Depreciation per ton of fibre is Ksh 61.6.

15. Data used as case 1 was obtained from Deloitte, Haskins, and sells (1986), Appendix 2, sheet 2.

16. The data used as case 2 was obtained from one estate in the Rift Valley Province.

17. High ranking estates are highly productive and well managed with maximum use of land under sisal. Medium ranking estates have lower total production of sisal fibre and a diversified farm practice. Low ranking estates have a large acreage under sisal that is often not harvested. Low ranking estates are not properly managed and produce the smallest volume of production.

18. F.O.B. value of U.H.D.S. grade is Ksh 5,520 per ton. We assume that waste fibres collected from the decorticating drums could be sold as unwashed Hand Decorticated Sisal (U.H.D.S). In the experiments, the decorticators are run dry and hence waste fibres are not washed.

19. The formula for estimating elasticity values for the variables in the linear regression is given by Koutsoyiannis (1977:66). The elasticities for non-linear regressions equalled the regression coefficients.

20. The significance of new regressors may be judged using t-statistics for these coefficients. Alternatively, the analysis of variance and the F statistic may be applied (see Koutsoyiannis, 1977: 158-164).

21. The Durbin-Watson Statistic was used in testing serial correlation in the functions. The critical value for serial correlation corresponds to the amended Durbin-Watson test where d<-du or d >(4-du) to reflect positive serial correlation, and du< d< (4-du) for absence of serial correlation. Alternative techniques to handle serial correlation together with shortcomings of using the Durbin-Watson test are discussed by Koutsoyiannis (1977: 203-227).

Significance points of d_u at one per cent level

Number of Observations (n)	Number of Parameter excluding the constant									
	K=1		K=2		K=3		K=4		K=5	
	du	(4-du)	du	(4-du)	du	(4-du)	du	(4-du)	du	(4-du)
25	1.21	2.79	1.30	2.7	1.41	2.59	1.52	2.48	1.65	2.35
26	1.22	2.78	1.31	2.69	1.41	2.59	1.52	2.48	1.64	2.36

Derived from (Koutsoyiannis 1977:666)

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Appendix A. Quantities of Sisal sold both locally and overseas: 1960 - 1985

Year	Exports			Local sales	Total sales
	Volume metric ton	Value (Millions Ksh)	Average (Ksh Per ton	Volume (Metric ton)	Volume (Metric tons)
1960	51,824	91.320	1762.0	4,920	56,744
1961	57,956	83.840	1447.0	4,213	61,169
1962	55,981	86.497	1545.0	4,868	60,849
1963	63,821	150.661	2360.6	4,277	68,098
1964	56,976	120.561	2100.0	4,800	61,776
1965	57,329	77.038	1346.0	6,257	63,586
1966	54,473	66.802	1218.0	6,222	61,095
1967	40,790	41.287	1012.0	7,502	48,292
1968	41,251	36.654	888.0	9,783	51,034
1969	35,837	34.475	962.0	7,837	43,674
1970	44,291	37.295	824.0	7,124	51,415
1971	34,714	30.302	872.0	10,137	44,851
1972	37,885	41.354	1092.0	8,953	46,838
1973	44,801	95.516	2132.0	12,351	57,152
1974	72,073	339.132	4705.0	10,208	82,281
1975	43,950	150.133	3416.0	6,269	50,219
1976	29,363	83.781	2853.0	7,288	36,651
1977	29,167	71.789	2461.0	10,092	39,253
1978	27,057	79.145	2925.0	6,292	33,349
1979	26,043	98.467	3781.0	5,033	31,076
1980	39,152	178.205	4552.0	6,858	46,010
1981	38,421	178.358	4640.6	7,434	45,865
1982	40,808	212.898	5217.0	8,838	49,646
1983	38,486	234.600	6095.0	9.030	47,516
1984	39,505	253.097	6404.0	7,592	47,077
1985	38,345	273.300	7111.0	6,969	45,314

Source: Republic of Kenya, Statistical Abstract, 1960-1985, (Government Printer, Nairobi.)
Kenya Sisal Board, Annual Reports 1960-1985

NB: Average price of sisal fibre is given to the nearest Kenya shilling.

Appendix B

Output of Sisal fibre per grade for the period 1960-1985

METRIC TONNES ($M/_T$)

	NO1	A	2	3L	3	UG	SCWF	JI	T.2	FLUME	others	UHDS	Total
960	5517	2,045	7213	1,3149	11,835	126	15,921	2797	537	2994			62620
1961	5404	1948	5359	12926	10645	18697	143	2545	662	2580	1420	-	62,329
1962	5994	1301	8107	10550	12030	13836	131	2395	749	2627	913	-	58631
1963	5882	1121	6010	11134	11942	27527	58	2464	1116	2604	295	-	70,154
1964	6702	1025	5836	12344	10846	22238	423	2765	1102	3478	200	-	66,959
1965	5174	1041	6265	12889	13236	17031	305	2710	550	3554	221	-	65,975
1966	5372	702	5421	12062	11,155	15,606	182	2592	287	2834	154	-	56,366
1967	5416	293	4172	9232	10175	15790	36	2272	272	3036	171	-	50,864
1968	5070	320	3591	11090	9122	14019	-	2192	127	3628	233	-	49,390
1969	4580	475	3119	12220	10,053	12,976	4	2686	92	3378	150	-	49,834
1970	4484	361	3320	13,104	7277	11,194	10	2146	66	1559	411	-	43,931
1971	3027	340	2162	12085	8211	12,930	-	2206	57	3296	517	-	44,826
1972	3051	307	1485	8949	6249	15,932	-	2277	71	2502	388	-	41,211
1973	1940	25	852	9650	4729	31,414	-	2608	162	2592	4083	-	58,045
1974	1466	14	840	9710	3366	29070	-	3537	563	2026	2811	32,570	85,973
1975	1775	28	1198	10,713	2346	19686	-	2874	156	1200	369	3296	43,639
1976	1043	-	764	8465	2154	17190	-	2075	133	1044	131	557	33,555
1977	571	-	429	10,263	2772	15192	-	2004	30	1059	33	1110	33,462

Appendix B contd...

	NOI	A	2	3L	3	UG	SCWF	JI	T.2	FLUML	others	UHDS	Total
1978	474	-	83	10661	2943	14,078	233	1676	15	745	35	511	31,445
1979	730	3	162	10346	1114	15,763	1751	1748	21	879	3	4338	36,858
1980	1306	-	235	13897	1331	17601	1356	2078	63	663	5	8378	46,910
1981	690	-	487	10384	1964	17319	740	1596	98	240	5	7803	41,325
1982	514	-	270	10758	940	20403	549	1687	478	479	-	13,950	50,029
1983	780	-	404	11,986	1181	21,578	495	1919	491	621		10,273	49,728
1984	886	-	564	11118	1812	19705	214	2065	649	264	-	14162	51,439
1985	550	-	654	12333	1836	20402	298	2030	293	12	-	6507	44,915

SOURCE: SISAL BOARD Annual Production Statistics

NB: FIGURES GIVEN TO THE NEAREST POINT

Appendix C NET IMPORTS OF SISAL FIBRE SUBSTITUTES

	Jute including Jute Cuttings and waste			Synthetic Fibres			Jute Bags and sacks	
	Quantity Kg '000	Value Ksh '000	Price Ksh Per 100 kg	Quantity Kg '000	Value Ksh '000	Price Ksh per 100 kg	Quantity kg '000	Value Ksh '000
1960	1,521	2,100	140	.336	11,00	327	3,738	7,180
1961	2,059	4,800	230	814	2080	255	6,478	16,220
1962	2,251	2,920	130	1045	2,920	279	5,142	10,040
1963	1,933	2,420	125	1427	3,960	278	5,493	10,720
1964	3,374	4,380	130	2198	4,600	209	3,825	7,760
1965	2,439	4,020	165	3632	12,180	335	4,794	11,720
1966	2,854	4,700	165	5283	16,460	312	6,603	16,700
1967	2,983	4,340	145	5107	16,080	315	6,941	13,660
1968	3,251	4,180	130	5344	16,940	317	2,714	4,840
1969	3,611	5,480	150	5801	19,860	342	4,110	7,740
1970	3,405	5,300	155	3867	14,600	378	322	660
1971	10,951	17,480	160	5035	21,080	419	112	440
1972	7,193	15,420	215	5426	22,880	422	2,107	6,340
1973	8,297	15,460	190	4516	19,640	435	-	-

Appendix C contd...

	Jute including Jute Cuttings and waste			Synthetic Fibres			Jute Bags and sacks	
	Quantity kg '000	Value Ksh '000	Price Ksh Per 100 kg	Quantity Kg'000	Value Kg '000	Price Ksh per 100 kg	Quantity kg '000	Value Ksh '000
1974	8,416	16,600	200	5884	34,380	584	586	1700
1975	7,857	19,380	245	3940	24,240	615	-	-
1976	9,111	21,720	240	3710	38,220	103	2,020	7,140
1977	11,803	27,620	235	6442	64,820	1,066	14	2,200
1978	10,372	28,000	270	6634	70,900	1,068	-	-
1979	8,549	16,860	210	6273	80,140	1,278	23	1,880
1980	12,383	32,020	260	6010	105,080	1,748	-	-
1981	12,206	35,240	290	7970	153,880	1,931	-	-
1982	8,185	26,660	330	6967	146,800	2,107	-	-
1983	11,114	43,040	390	6164	153,680	2,493	-	-
1984	7,520	46,420	620	9823	234,900	2,391	-	-

Source: Republic of Kenya, Statistical Abstract. (various issues) 1960 - 1984, (Government Printer, Nairobi,)

Appendix D

REWORDED SISAL GRADING DEFINITIONS AS AGREED BY ALL SECTIONS OF THE EAST AFRICAN SISAL TRADE

SISAL

Grade 1 Length from 3 feet upwards. Free of defective decortication. Properly brushed, free of tow, tousled and bunchy ends, knots and harshness. Colour creamy white to cream.

Grade A Length from 3 feet upwards. Free of defective decortication. Properly brushed, free of Tow, tousled and bunchy ends, knots and harshness. Colour yellowish, slightly spotted or slightly discoloured.

Grade 2 Length from 2 feet 6 inches upwards. Free of defective decortication. Properly brushed, free of Tow, tousled and bunchy ends, knots and harshness. Colour creamy white to cream.

Grade 3L Length from 3 feet upwards. Brushed fibre with minor defects in cleaning permissible but it must be free of tow, knots, back or undecorticated fibre. Colour may vary from creamy white to yellowish but a higher proportion of spotted or discoloured fibre is permissible than for Grade A.

Grade 3 Length from 2 feet upwards. Brushed fibre within minor defects cleaning permissible but it must be free of tow, knots, bark or undecorticated fibre. Colour vary from creamy white to yellowish but a higher proportion of spotted or discoloured fibre is permissible as for Grade 3L.

APPENDIX D contd....

Grade R or UG Fibre that does not conform to the above-mentioned grades as regards colour. Although defects in cleaning are allowable and some imperfectly decorticated fibre or barky runners are permissible, it must be free of undecorticated leaf and knots. Length to be not less than 2 feet.

S.C.W.F. Length from 18 inches upwards. Short Clean White Fibre. Free of defective decortication. Properly brushed, free of tow, tousled and bunchy ends, knots and harshness. Colour creamy white to cream.

Note No. 1 All grades to be of parallel packing, no ties or knots, free from dampness and excessive baling pressure. Where reference is made in the above definitions to tousled and bunchy ends it refers to faulty packing and not to anything caused through handling or stowage in transit.

Note No.2 Harshness. The word "harshness" included in the definitions refers to fibre from which the gum has not been sufficiently extracted by cleaning and does not apply to fibre which is coarse in texture due to soil or climatic conditions.

Note No.3 Slight Sunburning- meaning over-exposure of the fibre to sunlight - is permitted in Grades A, 3L and 3.

APPENDIX D contd....

Note No. 4 Premium marks are marks which from the point of view of length and/or texture, and/or colour, and/or cleaning, and/or packing are in request by manufacturers for special purposes.

TOW 1 Proper Tow from the brushing machine. Free of line fibre, cuttings and reasonably free of dust but entirely free of sweepings, knots, bark and undercorticated fibre. Colour creamy white to cream.

TOW 2 Darker colour allowed. Small percentage of line fibre, long white cuttings, and not entirely free of dust but entirely free of sweepings and knots.

Note The term 'line fibre' included in the definitions of Nos. 1 and 2 tow indicates "pieces of sisal" not tow.

Source: Patel H.D and E.B. Riordar, East Africa Journal of Rural Development, Vol. 1, No 1, 1969, Appendix II.

Average current prices to producers: 1960 - 1985

Appendix E.

Ksh Per 100 kg

Year	Wheat	Maize	Coffee	Sisal
1960	42	36	718	146
1961	52	39	660	132
1962	52	32	670	140
1963	53	33	572	223
1964	52	36	700	198
1965	52	36	669	122
1966	54	40	654	108
1967	57	35	583	108
1968	56	31	640	93
1969	56	30	630	90
1970	45	28	747	78
1971	51	33	636	68
1972	51	39	779	90
1973	57	39	921	243
1974	80	46	1008	424
1975	105	70	1069	323
1976	120	77	2524	234
1977	133	89	3975	298
1978	133	89	2818	272
1979	144	77	2835	361
1980	164	95	2635	414
1981	167	100	2258	412
1982	188	107	2780	503
1983	222	154	3488	625
1984	269	175	3844	674
1985	271	187	3972	707

Source: Kenya Sisal Board, Annual Reports, 1960-1985
Republic of Kenya, Statistical Abstracts, 1960-1985
(Government Printer, Nairobi.)
Republic of Kenya, Economic Survey, 1960-1985
(Government Printer, Nairobi.)

Appendix F

DEFINITIONS

A_t = acreage under sisal in time t

Z_{1t} = price of alternative annual crop (wheat) in Kenya shillings

Z_{2t} = price of alternative annual crop (maize) in Kenya shillings

C_t = price of alternative perennial crop(coffee) in Kenya shillings

P_t = current price of sisal fibre in Kenya shillings

$\bar{P}_t$ = Expected price of sisal fibre in Kenya shillings

R_t = rainfall in sisal growing areas in millimetres

W_t = cost of inputs)labour) in Kenya shillings

H_t = area harvested at time t in acres

A_{t-1} = previous acreage under sisal in acreas

S_{t-1} = previous stock of sisal fibre in tonnes

Y_t = production of sisal fibre sold each year in tonnes

X_t = price of sisal fibre substitute (jute) in Kenya shillings

T = time

L = labour demand (in numbers)

ΔS_T = change in stocks in metric tonnes

Appendix F. Time series data:undeflated prices and inputs:

Contd....

Year	Pt	$\bar{F}_t$	Z_{1t}	Z_{2t}	C_t	X_t	W_t
1960	146	119.7	42	36	718	140	900
1961	132	122.7	52	39	660	230	976
1962	140	131.10	52	32	670	130	946
1963	223	160.5	53	33	572	125	1094
1964	198	173.2	52	36	700	130	1234
1965	122	170.1	52	36	669	165	1294
1966	108	162.7	54	40	654	165	1372
1967	108	134.0	57	35	583	145	1354
1968	93	107.7	56	31	640	130	1422
1969	90	99.8	56	30	630	150	1454
1970	78	92.2	45	28	747	155	1492
1971	68	82.2	51	33	636	160	1568
1972	90	81.50	51	39	779	215	1880
1973	243	119.7	57	39	921	190	1868
1974	424	206.2	80	42	1008	200	1918
1975	323	270.0	105	70	1069	245	2312
1976	234	306.0	120	77	2524	240	2700
1977	298	319.8	133	89	3975	235	2694
1978	278	281.8	133	89	2818	270	3196
1979	361	291.3	144	77	2835	210	3506
1980	414	336.3	164	95	2635	260	4428
1981	412	364.8	167	100	2258	290	4548
1982	503	422.5	188	107	2780	330	4572
1983	625	488.5	222	154	3488	390	5271
1984	674	553.5	269	175	3844	620	5988
1985	707	627.3	271	187	3972	820	6618

Source: Republic of Kenya, Statistical Abstract, 1960-1985.

Appendix F. Time series data used to estimate regression equations:
Contd... In hundreds (Deflators, real prices and inputs: 1960-1985)
(Base Year 1976)

Year	P_t	$\bar{P}_t$	Z_{1t}	Z_{2t}	C_t	X_t	W_t	GDP deflato
1960	309.45	253.71	89.02	76.30	1521.83	296.74	1907.59	47.18
1961	273.52	254.25	107.75	80.81	1367.59	476.59	2022.38	48.26
1962	275.37	257.87	102.28	62.94	1317.86	255.70	1860.74	50.84
1963	435.89	313.72	103.60	64.50	1118.06	244.33	2138.39	51.16
1964	454.45	352.97	105.97	73.36	1426.53	264.93	2514.77	49.07
1965	250.15	350.01	106.62	73.82	1371.74	338.32	2653.27	48.77
1966	217.83	328.16	108.91	80.68	1319.08	332.80	2767.24	49.88
1967	212.85	264.09	112.34	68.98	1148.99	285.77	2668.51	50.74
1968	161.60	187.14	97.31	53.87	1112.08	225.89	2470.89	57.55
1969	172.61	191.41	107.40	57.54	1208.29	287.69	2788.65	52.14
1970	145.69	172.21	84.05	52.30	1395.22	289.50	2786.70	53.54
1971	121.26	146.58	90.94	58.84	1134.09	285.31	2796.01	56.08
1972	149.03	134.96	84.45	64.58	1289.95	356.02	3113.10	60.39
1973	367.96	181.25	86.31	59.06	1394.61	287.70	2828.59	66.04
1974	544.50	264.80	102.74	53.94	1294.47	256.84	2463.08	77.87
1975	375.71	314.06	122.14	81.42	1243.46	284.98	2689.31	85.97
1976	234.00	306.00	120.00	77.00	2524.00	240.00	2700.00	100.00
1977	252.48	270.95	112.68	75.40	3367.79	199.10	2282.47	118.03
1978	223.13	231.17	109.11	73.01	2311.73	221.49	2621.82	121.90
1979	281.86	227.44	112.43	60.12	2213.46	163.96	2737.35	128.08
1920	294.64	239.34	116.72	67.61	1875.31	185.04	3151.38	140.51
1981	266.32	235.81	107.95	64.64	1459.60	187.46	2939.88	154.70
1982	299.16	251.28	111.81	63.64	1653.38	196.27	2719.16	168.14
1983	339.99	265.73	120.76	83.77	1897.41	212.15	2867.32	183.83
1984	335.84	275.80	134.04	87.20	1915.39	308.93	2983.71	200.69
1985	324.92	288.29	124.55	85.94	1825.45	1825.45	3041.50	217.59

Appendix F

Year	R_t	Q_t	L	t	D1	$\frac{P_t}{\bar{P}_t}$	$\frac{P_t}{W_t}$
1960	1031.0	56744	24277	1	0	1.220	0.162
1961	701.4	61169	23610	2	0	1.076	0.135
1962	521.2	60849	23425	3	0	1.068	0.148
1963	1385.9	68098	23644	4	0	1.389	0.204
1964	1152.4	61776	27046	5	0	1.143	0.160
1965	880.4	63586	20698	6	0	0.715	0.094
1966	1813.8	61095	18542	7	0	0.664	0.079
1967	1225.9	48292	14951	8	0	0.806	0.080
1968	1481.6	51034	13838	9	0	0.864	0.065
1969	995.5	43674	10489	10	1	0.902	0.062
1970	1200.4	51415	8214	11	0	0.846	0.052
1971	1105.9	44851	9347	12	0	0.827	0.043
1972	1193.0	46838	1006.4	13	0	1.104	0.048
1973	1007.6	57152	10328	14	0	2.030	0.130
1974	789.1	82281	11377	15	0	2.056	0.221
1975	1117.4	50219	13638	16	0	1.196	0.140
1976	965.1	36651	14459	17	0	0.765	0.087
1977	1393.8	39257	11010	18	0	0.932	0.111
1978	1998.8	33349	8814	19	0	0.965	0.085
1979	1206.8	31076	10884	20	0	1.239	0.103
1980	837.5	46010	11093	21	0	1.231	0.093
1981	1102.4	45865	10146	22	0	1.129	0.091
1982	1309.4	49646	11117	23	0	1.191	0.111
1983	1003.1	47516	12305	24	0	1.279	0.119
1984	1025.2	47097	12738	25	0	1.218	0.113
1985	1150.6	45315	12915	26	0	1.127	0.107

Source: Republic of Kenya Statistical Abstracts, 1960-1985, Government Printer, Nairobi.

Kenya Sisal Board, Annual Reports 1960-1985

Appendix F

Contd.....

Year	$\frac{P_t}{W_t}$	$\frac{X_t}{P_t}$	Y_t	A_t	H_t	ΔS_t	S_{t-1}	GDP deflators
1959	-	-	-	253648	-	-	-	-
1960	0.133	1.170	62620	255377	20152	5379	-4219	47.18
1961	0.126	1.874	62329	272206	17547	1160	-3378	48.26
1962	0.139	0.992	58631	257116	19957	-2218	4274	50.84
1963	0.147	0.779	70154	258147	16276	2056	3127	51.16
1964	0.140	0.751	66959	268852	10944	5183	-2794	49.07
1965	0.132	0.967	65975	266941	17489	2389	-7118	48.77
1966	0.119	1.014	56365	252980	5620	-4729	7301	49.58
1967	0.099	1.082	50864	248809	11575	2572	-4216	50.79
1968	0.076	1.207	49390	23331	13075	-1644	-7804	57.55
1969	0.069	1.503	49834	191457	49925	6160	-13644	52.14
1970	0.062	1.681	43931	178009	14404	-7484	7509	53.54
1971	0.052	1.946	44826	161544	18710	-25	-5602	56.08
1972	0.043	2.638	41211	152902	13394	-5627	6520	60.39
1973	0.064	1.587	58045	136006	6645	893	2199	66.04
1974	0.108	0.970	85973	130653	630	3692	-10272	77.87
1975	0.117	0.907	43639	126779	8873	-6580	3484	85.97
1976	0.113	0.784	33555	134118	5652	-3096	-2699	100.00
1977	0.119	0.735	33468	133919	9780	-5795	3891	118.03
1978	0.088	0.958	31445	122891	13335	1904	7686	121.90
1979	0.083	0.721	36858	100263	9252	5782	-4882	128.08
1980	0.076	0.773	46910	122090	7452	900	-5440	140.51
1981	0.080	0.795	41325	138028	5652	-4540	4923	154.70
1982	0.092	0.781	50029	143733	4714	383	1829	168.14
1983	0.093	0.798	49728	139199	3859	2212	2151	183.83
1984	0.092	1.120	51439	139417	6077	4342	-4741	200.69
1985	0.095	1.307	44915	137625	7227	-399	6969	217.59

Source: Republic of Kenya, Statistical Abstracts 1960-1985, Government Printer, Nairobi.

Source: Kenya Sisal Board, Annual Reports 1960-1985

Appendix G Correlation results

Dependent variable		Explanatory variables			
Acreage		A_t	Z_{1t}	R_t	$\overline{P}_t/W_t$
	A_t	1.000			
	Z_{1t}	-0.286	1.000		
	R_t	0.078	-0.048	1.000	
	$\frac{\overline{P}_t}{W_t}$	0.563	-0.145	-0.089	1.000
Harvesting		H_t	A_{t-1}	S_{t-1}	D1
	H_t	1.000			
	A_{t-1}	0.498	1.000		
	S_{t-1}	-0.438	-0.082	1.000	
	D1	0.836	0.181	-0.458	1.000
Production		Y_t	H_t	P_t/W_t	
	Y_t	1.000			
	H_t	0.185	1.000		
	P_t/W_t	0.482	-0.311	1.000	

Appendix G. Contd...

Sales		Q_t	Y_t	$X_t/\overline{P}_t$
	Q_t	1.000		
	Y_t	0.949	1.000	
	$X_t/\overline{P}_t$	0.017	-0.045	1.000

Labour		L	H_t
	L	1.000	
	H_t	0.479	1.000

Stock		ΔS_t	Y_t	$\frac{X_t}{\overline{P}_t}$
	ΔS_t	1.000		
	Y_t	0.428	1.000	
	$\frac{X_t}{\overline{P}_t}$	-0.205	-0.048	1.000

Appendix H

Regression results

Equation	Dependent variable, explanatory variables, estimated coefficients and other regression statistics. (The t-values are in parenthesis).
Acreage	$A_t = 251172.43 - 2288.11\ Z_{1t} + 26.65\ R_t + 1480354.97\ \frac{P_t}{W_t}$ --- (6.1)
	(3.03)* (-3.26)* (0.82) (4.77)*
	$\bar{R}^2 = 0.49$ F = 8.98 SER = 0.43 D.W = 0.73 D.F = 22
	$A_t = 168078.37 + 240.96\ \bar{P}_t - 7045.50T + 17.61\ R_t + 10.66\ W_t$ ..(6.2)
	(2.82)* (2.57)* (-7.30) (0.86) (0.48)
	$\bar{R}^2 = 0.81$ F = 27.37 SER = 0.26 D.W = 0.52 D.F = 21
	$A_t = 122346.31 + 904.31Z_{1t} + 642.95\ Z_{2t} - 21.20C_t - 6878.60T$
	(2.38)* (1.24) (0.94) (-1.77)** (-5.00)*
	$+26.86R_t + 150906.41\ \frac{\bar{P}_t}{W_t}$ ------------------------------ (6.3)
	(1.46)** (0.52)
	$\bar{R}^2 = 0.84$ F = 22.39 SER = 0.24 D.W = 1.11 D.F = 19

Appendix H continued.

Harvesting $H_t = 1220.99 + 0.05\ A_{t-1}$

$(0.47) \quad (3.98)^*$

$\bar{R}^2 = 0.80 \qquad F = 35.23$

$H_t = 5627.15 + 0.05A_{t-1}$ -

$(1.48)^{**} \quad (3.87)$

$\bar{R}^2 = 0.81 \qquad F = 28.53$

$H_t = 2104.50 + 0.05\ A_{t-1}$

$(0.65) \quad (3.94)^*$

$\bar{R}^2 = 0.80 \qquad F = 25.62$

$- 0.10S_{t-1} + 34367.52\ D1$ .... (6.4)

(-0.70) (7.32)

SER = 0.40 D.W = 1.14 D.F = 22

$13.58P_t - 0.19S_{t-1} + 31814.84D1$ .... (6.5)

(1.55)** (-1.22) (6.58)*

SER = 0.39 D.W = 1.13 D.F = 21

$- 9462.81 \frac{P_t}{W_t} - 0.13\ S_{t-1} + 33497.11\ D1$ ....(6.6)

(-0.47) (-0.80) (6.54)*

SER = 0.41 D.W = 1.16 D.F = 21

Appendix H contd...

Production $\ln Y_t = 9.91 + 0.16 \ln H_t + 0.25 \ln \frac{P_t}{W_t}$ .... (6.7)

(14.96)* (3.30)*

$\bar{R}^2 = 0.30$ F = 6.37 SER = 0.20 D.W = 1.16 D.F = 23

$\ln Y_t = 12.62 + 0.13 H_t + 0.25 \frac{P_t}{W_t} - 0.35 R_t$ .... (6.8)

(10.48)* (1.87)** (3.78)* (-2.59)*

$\bar{R}^2 = 0.44$ F = 7.54 SER = 0.18 D.W = 1.19 D.F = 22

$\ln Y_t = 6.85 + 0.36 \ln A_{t-1} + 0.16 \ln \frac{P_t}{W_t}$ .... (6.9)

(4.67)* (3.02)* (2.38)*

$\bar{R}^2 = 0.40$ F = 9.42 SER = 0.19 D.W = 1.37 D.F = 23

Sales $Q_t = 6197.77 + 0.85 Y_t + 442.33 \frac{X_t}{\bar{P}_t}$ .... (6.10)

(1.74)** (14.80)* (0.93)

$\bar{R}^2 = 0.90$ F = 108.80 SER = 0.36 D.W = 2.23 D.F = 23

Appendix H contd...

$$Q_t = 7975.4 + 0.8 \quad Y_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6.11)$$

(2.66)* (14.81)*

$\bar{R}^2 = 0.90$ F =217.45 SER = 0.36 D.W = 2.20 D.F = 24

Labour

$$L = 8835.45 + 0.53 \quad H_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6.12)$$

(3.57)* (2.62)*

$\bar{R}^2 = 0.20$ F = 6.85 SER = 0.51 D.W = 0.61 D.F = 23

$$InL = 12.82 - 0.25 \; In \; H_t - 0.43 \; In \; T \quad \ldots\ldots\ldots \quad (6.13)$$

(14.80)* (-2.92)* (-7.54)*

$\bar{R}^2 = 0.70$ F = 30.20 SER = 0.19 D.W = 0.88 D.F = 23

$$L = 26958.13 - 0.25 \; H_t - 677.12T \quad \ldots\ldots\ldots\ldots\ldots \quad (6.14)$$

(5.96)* (-1.07) (-4.38)*

$\bar{R}^2 = 0.53$ F = 15.72 SER = 0.38 D.W = 0.32 D.F = 22

Appendix H contd.....

$$\text{Stock} \quad \Delta S_t = -4879.11 + 0.13\, Y_t - 1609.65 \frac{X_t}{\bar{P}_t} \quad \ldots\ldots\ldots\ldots \quad (6.15)$$

$$(-1.33) \qquad (2.27)^{*} \qquad (-1.01)$$

$$\bar{R}^2 = 0.15 \quad F = 3.19 \quad SER = 0.38 \quad D.W = 2.18 \quad D.F = 23$$

NB * = Significant at one or five per cent level

** = Significant at ten per cent level