FACTORS DETERMINING THE ECONOMICS OF MILK PRODUCTION IN SMALLHOLDER FARMS IN KENYA HIGHLANDS

by

ANDREW CHOMBAH MWANGI

A thesis submitted in part fulfilment for the Degreee of Master of Science in Agriculture Economics in the University of Nairobi

APRIL, 1981

This thesis is my original work and has not been presented for a degree in any other University.

A. C. MWANGI

(Candidate)

This thesis has been submitted for examination with our approval as University Supervisors.

DR. A. W. MUKHEBI

DR. W.M.MWANGI

ACKNOWLEDGEMENT

Special thanks go to Dr. Doppler, Professor Dorling, Dr. Mukhebi and Dr. Mwangi of the Department of Agricultural Economics for their assistances as University Supervisors. I am particularly grateful to Dr. Doppler for providing assistances in the early stages of this work. I am also thankful to Dr. Mukhebi and Dr. Mwangi for the many hours they spared to make this work a success.

I am indebted to various people and institutions whose cooperation also made the accomplishment of this work possible. I am grateful to the Director, N.A.H.R.S. Naivasha for the conduicive environment which facilitated the write up. I am grateful to Dr. Stotz, Dr. Porschinger, Mr. Mativo and Mr. Wambugu of Livestock Recording Centre for the assitance they provided at the centre

I am indebted to Vasir for providing me all the necessary assistance at the Computer Centre. Special thanks also go to Terry and Martha for typing this work. I am grateful to Kuria and Njenga for the good job they did in drawing of figures and to all of you who assited me although time and space do not allow me to mention your names.

TABLE OF CONTENTS

ABSTRACT

Milk production from smallholder farms has gained impetus through various governmental policies. The most important measures that have been undertaken are the price incentives measures and creation of milk demand through school milk programme. On the other hand, dairy products have become the most important livestock commodities, both in terms of farm income earnings and farm family nutrition requirements.

Milk as a major commodity has been experiencing seasonal fluctuations and insufficient supply. Weather basically contributes largely to the problem, but it is necessary to be able to quantify factors within the logical manipulation of the farmer inorder to be able to plan effectively.

Data from small scale farms was subjected to production function and economic analyses to determine bottlenecks in milk production. A production model that explains the reality of milk production from small scale farms was developed by comparing several known functions. The functions that were examined included linear, square, Cobb-Douglas and quadratic functions. The quadratic function was selected as the best fit. The model was used to determine the best operating conditions, points of

milk yield maxima per cow, and to determine attributes of milk production in smallholder farms.

The findings of the analyses revealed that there is a strong relationship between feeding concentrates and milk yield, and similarly, between farm produced by-products and milk yield. Other attributes are the cow's characteristic and environmental factors. The other research findings indicate that a majority of the farms are within the profitable range. As to the consequences of increasing the herd sizes, the findings show diseconomies of herd sizes. The findings also show the need for concerted effort between the biotechnicians and the economists in farm and national planning.

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 An Overview

Issues relating to the milk production in Kenya's agricultural sector, and particularly the desirability of improving the efficiency in this field have become a source of major discussions. The need to rememdy the protein deficiency is far from settled. In 1978 the Government of Kenya decided to provide the primary schools children with free milk, creating an unanticipitated demand for milk such that the farming sector had to face unexpected changes in farm management problems in resources use and allocation in the dairy economy.

Considerable attention has been given to the dairy industry so that it has tended to overshadow other important systems in livestock development. The 'free milk to primary schools programme' will have a great impact on Kenya's milk industry, especially on the allocation of resources to milk production. Land is the most limiting resource in the high potential mixed farming areas, where the small holder milk production dominates.

The stringent governmental policy states clearly the need to satisfy our milk requirements, by either improving the existing milk production systems, or by increasing the herds sizes or both. In the high potential areas the solution seems to lie with productive resources reallocation efficiency and suitable marketing policies so as to create incentives to farmers.

In theory, there are three ways to increase total milk production:

(i) increasing the dairy herd,

(ii) increasing milk yield per cow, or

(iii) increasing both the dairy herd and milk yield per cow.

The 1974-78 and the 1979-83 development plans have adopted the third way to increase both herd size and productivity per cow. The strategies for increasing milk supply are:

a) an increase in number of grade cows,

b) a nation wide general increase in the existing small holder herds,

c) increased purchases of breeding stock from large scale farms, and

d) improvement of milk marketing (35, p 295) to act as a basis for the desired farm incentive.

Based on the experience of the last 15 years, the Development Plan 1979-83 focuses on small scale development as the main basis to achieve the set objectives of maintaining self sufficiency and rural employment. Consequently, any dairy development will be based on this sector. The milk production in small holdings accounts at present for about 40 percent of the total marketed milk. This share will increase to 50 percent and more in the very near future, taking into account the milk sold through informal channels, i.e. house to house in areas with high population densities where the actual share is estimated to be already about 50 percent mark.

As a response to the National Development Plan and the Presidential initiatives, a multimillion shilling ten year milk production programme has been launched to cover period 1980-1990("STANDARD", August 10, 1979, Nairobi). The 1979-83 Development Plan stipulates further that the farming systems in high and medium potential areas are in a transitional phase, towards more of arable land use and less grazing, and hence zero grazing will have an increased importance. Also, according to Stotz, D (41, 1978) 62 percent of the dairy herd is to be found in high potential mixed farming areas, depicting climatic zone II and III. The main concentration of dairy cows is found in Central Province, accounting for one third of the total national herd. Rift Valley, Eastern and Nyanza Provinces are rated second, third and fourth respectively, followed by the other Provinces.

1.2 Problem

As stated, the dairy production is mainly on small scale farms in the high potential Agro ecological zones II and III. The farming systems in those areas are exposed to the following main dynamic forces:

a) In all the high potential farming areas of Kenya the population growth rate are very high relative to other areas of the country.

b) There are different enterprises in a holding competing for land, the food prices in those areas are relatively high and the opportunity cost for land is high.

c) Cash crops were introduced in those areas some times back. Tea and coffee are well established and have always tended to give high return to land.

d) Price changes for coffee, tea, maize and inputs have called for changes in farm plans. The changes have been in relation to enterprises competitiveness.

e) The technological progress has been enormous in the last decade.

The results are that the farmers are not sure[1] about optimal resources use. Further more, the changes between the opportunity cost of land and labour on one hand, and the genetic potential of dairy cows have resulted in uncertainity about the optimal intensity of dairy enterprise.

An evaluation of input-output relations is necessary in order to be able to recast the farm management recommendations in these small holdings. A solution at the farm level could contribute to the national development objectives. Therefore, this study as a first step to determine the optimal input-output level will also attempt to quantify other constraints in milk production. Further investigations could then solve the problems of the whole small holdings farming systems. Recommendations derived from this study

---

1 Optimal resources use change over time due to the fact that farming is not static. (51, 1981)

could be used in other similar situations for decision making.

1.2.1 Problems in Small Scale Farming

Problems of small holder farming in developing countries are universal and have profound effects on the third world's economics. McNamara, (1973) suggested that the number of farms of less than 5 hectares are about 130 million in the LDCs, occupying a total of 20 percent of all cropland and providing livelihood for a vast population of the world (48). It is also stated that about half of the world's population is dependent on subsistence agriculture. Sixty percent of all the farmers are small holders who occupy 40 percent of arable land and produce less than 40 percent of the world's agriculture's production volume (11). Studies of small farm holdings have not yet clearly defined the bottlenecks of small scale agricultural production.

Studies in developed countries show that small farm holdings have been subjected to rigorous investigation (29) and discussions by farm management specialists, with concern over their economic. The question which arises in LDC farm management research and planning is whether the questions posed in those studies could be of any relevance to Kenyan situation, and whether recommendations prescribed in those studies can be adopted with accrueable benefits. These developed countries have a history of technological progress and experience in farming and their findings can only be adopted with a lot of reservations. But it should be clearly noted that there is also merit in these studies, and all that is required is specialized research in our circumstances.

The question as to allocations of resources in small farm holdings, within given social and economic framework, is a major issue. J.B Hardaker (11) states;

> "The role of farm management research in small farm development is related to the task of breaking constraints that inhibit increased production and income. These constraints are classified as resources constraint, lack of appropriate technologies, institutional constraints and personal and subjective constraints".

This study attempts to quantify the constraints that inhibit small farm milk production. Dairy enterprise is an integral part of the small farm holdings in the high potential farming areas, and therefore all the dynamic forces operative to the holdings also apply to the milk enterprise.

There is no borderline criteria for defining small scale farm[2] as opposed to large-scale commercial farm. It is now contended that there is a general tendency so far to have the holdings diminishing in size and increasing in numbers with intensification in farm holdings due to social and cultural changes in the rural communities. Holdings have been undergoing active subdivision upto date due to succession tradition among the African societies.

It is observed that the holdings are subdivided among the inheriting sons of the farmer and the farmer and the process is carried down into subsequent generations. The holdings have also tended to have high population densities with the rapid growth in population in the country. Sorenson (39) using 1960/61 census indicates that progressive increase in holding sizes spontaneously leads to the larger holdings supporting larger families, and therefore, the larger holdings that would be considered under economic size fail to qualify. This phenomenom is reflected in table 1.1.

---

2 The Central Bureau of Statistics defines this as holders owning less than 12 hectares.

New emphasis on small scale farming has therefore been launched to alleviate rural welfare and to reduce income disparity.

Table 1.1

Number of persons per holding by farm sizes

(Central Province, Kenya)

1960/1961 Census

	Holding	Sizes	- (Hectares)				
DISTRICT	< 1.00	1 - 1.99	2 - 2.99	3 - 3.99	4 - 4.99	5 - 5.99	> 6
KIAMBU	8.14	10.00	10.63	13.45	18.28	17.75	10.45
NYERI	5.11	4.92	6.01	8.24	18.09	23.28	6.23
MURANGA	5.25	6.21	8.91	8.62	8.62	11.09	6.39

SOURCE: Soreson, MPK "A review of some Farm Management Research Methods for smallfarm Development in LDCs" (39)

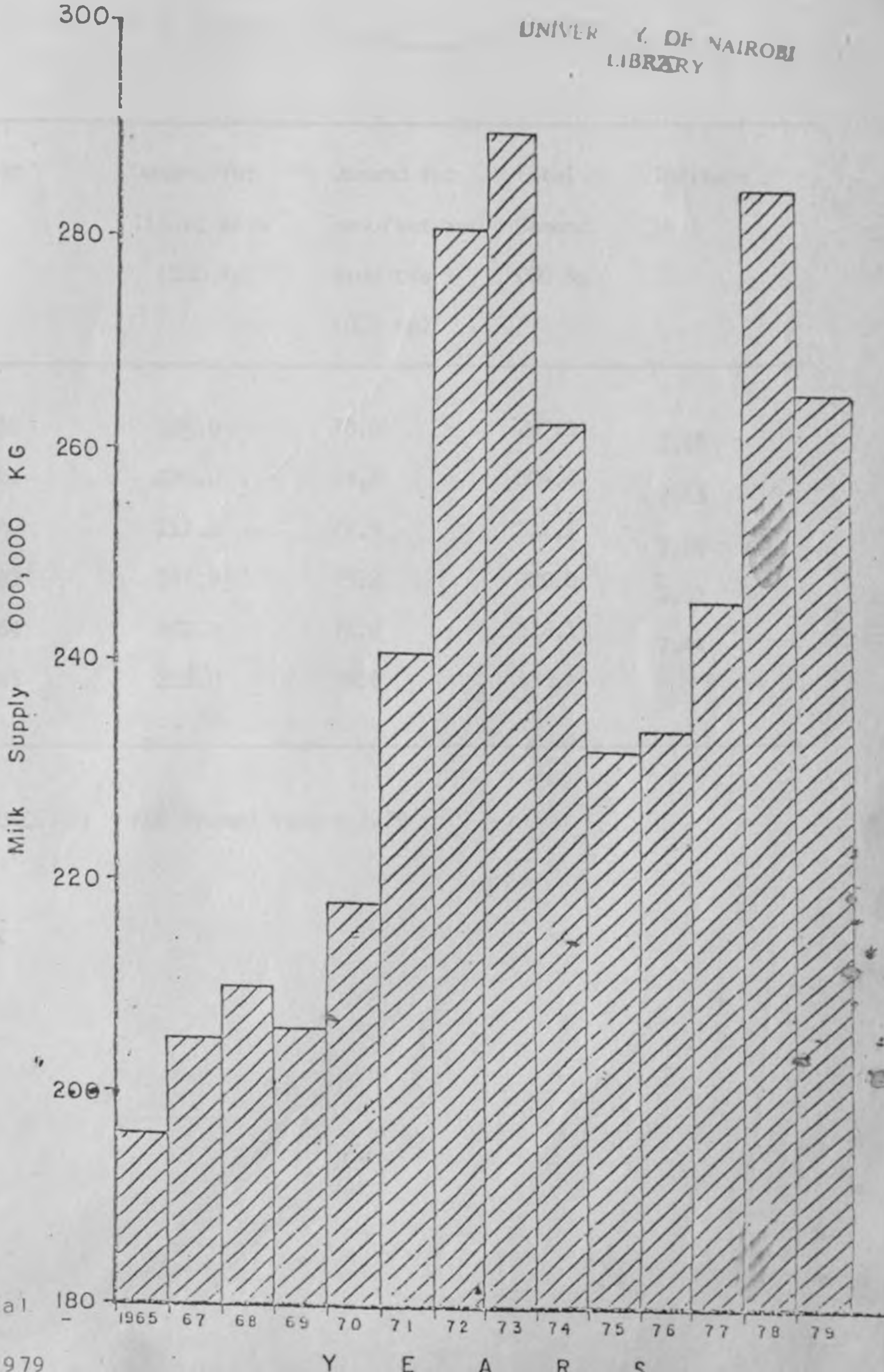
1.2.2 The Problems of the Milk Sector

It is important to realise that growth of milk sector will also enhance the general ecominc layout of the country, and even out the erratic behaviour of milk supply fluctuations presently being experienced, both annually and seasonally. Figure 1.1 illustrates the supply fluctuations realised by KCC factories in 15 years period. Without having a consistent milk supply for the ambitious school milk programme and domestic requirements, milk will always exert a perceivable impact on the economy as a whole. Annual fluctuations can be attributed to poor planning at farm and national levels.

Inorder to maintain a consistent milk supply, and at the required levels for the growing demand, a concerted effort is required between the farmer, processing industry, the government and the transportational system. Although the blame has been placed partially on the KCC and weather conditions it sho uld be realised that the impact of the programme was great enough, both to the farmers and to the KCC, to absorb immediately without short-comings and slight laggishness, i.e. a demand for milk was realised overnight.

The growth in the demand for milk and the favourably rising prices of beef leaves many livestock farmers in a dilemma. Whereas an increase in dairy herd leads to more beef being produced, this has an immediate effect on a general increment in milk production. Table 1.2 reflect the expected demand for milk and Table 1.3 reflects milk intake.

Figure 1.1 Supply fluctuations realised by KCC factories in 15 years.



s: KCC Annual Reports - 1964 - 1979

Table 1.2 Milk Demand Forecast - 1980 - 1985 by KCC

Year	Demand for liquid milk (000 Kg)	Demand for manufactured products (000 Kg)	Total Demand 000 Kg	Increase . in %
1980	224.0	73.0	297.0	2.49
1981	230.0	73.7	304.4	2.53
1982	237.6	74.5	312.1	2.53
1983	244.8	75.2	320.0	2.53
1984	252.1	76.0	328.1	2.44
1985	259.0	76.8	336.1	

SOURCE : KCC Annual Report 1979

Table 1.3 Milk Intake by KCC 1973 - 1979

Year	Butterfat	Whole	Total
1973	483,920	276,791,233	289,780,480
1974	297,470	255,473,248	263,457,846
1975	194,054	226,463,523	231,672,268
1976	143,336	230,105,765	233,953,160
1977	119,850	243,220,621	246,437,632
1978	110,136	281,927,034	284,881,284
1979	75,292	261,145,685	263,166,650

SOURCE : KCC Annual Reports 1973 - 1979

The expected impact of the newly formed Livestock Development Ministry will mainly be manifested in the dairy and beef subsectors of the livestock industry. Previous experience shows that the two subsectors could be highly competitive, or could compliment, and this will very much depend on the objectives of the Ministry and how these objectives fit in with the objectives of the farmers.

Any measure to even out month or annual fluctuations should determine constraining factors, and hence establish means and ways to overcome them. Measures to increase small scale milk production will solve milk shortage problems.

1.3 Objectives

This study attempts to establish factor product relationship in milk production on which to base decisions. The factors considered in this study are the feeds as the major production inputs. Auxiliary variables reflect the management and environmental effects to the production response.

Feeds have been categorised into three economic classes as concentrates, farm by-products and farm produced roughage. Feeds as production inputs form the biggest constituents of milk production.

Auxiliary variables cover the factors that can be manipulated by the management and those that the management has no control over them.

The auxiliaries include the herd size, lactation number or age-class of herd, and lactations lengths or mean number of days cows are in milk.

Inorder to determine the factors contributing to milk yield per cow the study has the following objectives:-

a) Select the most suitable milk production function for small scale farms.

b) Establish guidelines for increasing efficiency in milk production in small scale farms.

c) Work out the economic optimum for milk production at changing factor product prices on micro-economic level in an enterprise.

1.4 Hypotheses

The following hypotheses will be tested:-

a) Milk yield per cow as a function of feed input, other factors constant.

b) Within the given farm framework the farmers are operating below the economic optimal level of intensity.

CHAPTER 2

LITERATURE REVIEW

Milk production function studies in America and Europe give some notion of the empirical nature of the function. Important studies cited here are Heady et al (12, 27, 14), Paris (31), Carley (4), Gossling (9, 10), Keith et al (24). These studies form an important foundation in this study. Ruigu (37) used a different approach to study factors determining milk yield, as we see later, Ruigu's study is also unique in that result from parametric LP model were used to estimate a production function.

The analytical approach here attempts a method similar to Heady's (12) analysis of the economic and technical aspects of milk response surface. Madden et al (27) estimated regression equations of milk output and feed input. Heady et al (12) model included the independent variables; indexes for stage of lactation, T, coefficient of inbreeding, K, body weight, W, outside temperature, F, maturity, J, etc. With the above nine variables several different mathematical production functions were tried. The main analytical function for economic studies was the quadratic form. Other forms estimated included Cobb-Douglas

Spillman, linear and square root. The most satisfactory equation was of the form:

$$M = a + b_1G + b_2H - b_3G^2$$

$$+ b_4H^2 - b_5GH - b_6GT + b_7WG$$

$$- b_8HA + b_9A + b_{10}F + b_{11}J$$

$$- b_{12}K + b_{13}W + b_{14}T - b_{15}F^2$$

$$+ b_{16}K^{\frac{1}{2}} - b_{17}W^{\frac{1}{2}} - b_{18}AT - b_{19}AG$$

$$+ b_{20}WF - b_{21}WF + b_{22}KA + b_{23}KT$$

$$- b_{24}KF - b_{25}JT - b_{26}JF$$

Most of the t values were significant at 0.1 and 0.5 levels of significance and the variables included in the equation apparently explain.836 of the variance in milk production.

The production function upon which concentrates and roughage were analysed was a function of the form:-

$$M = a + b_1G + b_2H - b_3G^2 - b_4H^2 - b_5GH$$

Marginal physical products, marginal rates of substitution and isoquants derived from this equation served important purpose for determination of economic optimum.

Gossling (9) synthesized an annual production function of Holstein-Fresian cow using experimental data. The synthetic experimental milk production function was compared with corresponding herd average data from good dairy farms and with regression equations obtained from latter data. In his conclusion Gossling pointed out that the experimental and farm data show substantial agreement. It is therefore inorder to fit a regression equation with data from sufficient numbers of herd averages from farms. Secondly, there appears to be a range of increasing returns to grain feeding up to the level of 920 lbs (417.30Kg), followed by diminishing returns, at any fixed level of roughage. Similar results were shown by grain feeding levels equal or greater than 1,077 lbs (488.52) T.D.N. functions including paraboloid, transcendental and modified transcendental. To say the least, Gossling showed that a milk lactation function surface exists and awaits experimental verification.

Research by Carley (4) indicated that concentrates are highly significant non linear relationship to output, the output increasing at a decreasing rate. Other feeds showed a highly significant linear relationship. Carley equated marginal rate of substitution of concentrates and silage to their price ratios to show that least cost combination are at points where roughage should be fed ad libitum with concentrates playing a supplementary role.

Paris et al (31) using a second order polynomial (quadratic) in hay, concentrates, time, body weight and age to explain milk yield in a cow indicated that the R^2 values of functions explained the relationships. The hay-concentrate isoquant relationships attempts in this study indicated that the whole milk isoquant is concave to the origin

Keith Cowling et al (24) using cross sectional data collected by the National Investigation into the Economics of milk production (1960-1961) estimated the production relationships between feed input and other variables and milk output. Over 500 farms were used in the analysis. Cobb-Douglas or the power function was chosen all *a priori* as it accommodates diminishing marginal returns, and is convenient for assimilating dummy variables which were used for breed effect. Linea function could not be used as other work suggests diminishing marginal productivity of feed. The studies excluded labour input as an explanatory variable for the reason that the level of labour input is only a function of milk output, but not vice versa.

Heady (12) initiated several production functions studies in cooperation with physical scientists at Iowa State University. This cooperative work at Iowa State University reveals the true physical nature and the implications of the algebraic form of production function of crops and livestock response.

The initial work by Heady (12) covered fourteen experiments for fertilization of crops, feeding of hogs, poultry, beef cattle and dairy cows. In each case the most logical function was estimated of plants and animals response which appeared to give the most efficient estimates. The results from the experimental work defined the production functions of the various biological phenomena. For example, the fertilizer production surface has definite ridgelines, or isoclines denoting zero marginal rate of substitutions between factors, marginal rate of substitution which change along a scale line, and a point of maximum yield per acre.

Experiments in milk production by Heady show that milk production parallels the technological conditions of crops. Similar to crops, the ridgelines with $dG/dH = 0$, where G and H refer to concentrates and forage consumed respectively, defined by the limit of the cows stomach capacity to consume the bulky hay and still allow attainment of a given milk yield, and $dH/dG = 0$ defined by the physiological minimum forage for a ruminant animal. The function selected as the most appropriate for milk is:-

$$M = a + b_1H + b_2G + b_3A + b_4T - b_5H^2$$
$$- b_6G - b_7T^2 - b_8HG - b_9GT - b_{10}HT$$

$R^2 = .9016.$

M denotes milk production per cow per month, H pound of forage, G pounds of concentrates, A is ability of cows measured as milk per cow in a preliminary production period of one month and T refers to time in months during the six months experimental period.

From Heady's equation it is possible to get least cost feed combinations for particular level of milk and the most profitable point. Economic variables could be worked from above relationship. This work provides insights into the technical production functions and into economic decisions which are to be found in algebraic form of relationships. Brokken et al, 1976 (13) assessed the technical and the economic relationships of cattle feeding. He empirically derived suitable isoquant relationships and compared this with the traditional methods of deriving the same. He derived a sigmoid shaped grain roughage isoquant for beef production.

Previous research relating to the nature of milk isoquant and surface has differed a bit in functional forms and in methods used. Huffman and Duncan (19) found that the milk isoquant is linear. Jansen et al (21) also predicted the non-linearity of input -output curve. Ashe (2) using a sample of dairy farms found that non-linearity exists up to 4000 lbs (181.437Kg) of grain per cow and above that point is linear and above 6000 lbs (2721.55Kg) increases only slightly, Yate (49) postulates there is diminishing marginal rate of substitution.

Hamilton and Swift explain the nonlinearity phenomena by the fact that the ruminants microflora and fauna require certain combination of roughage and concentrate to stimulate or depress microbiological activity.

Variation in the quality of feed affects milk productivity directly. Roughage and grains are of different nutrients levels and hence a combination of the two affect the shape of the milk response. Work in New Zealand by Rogers, 1979, (36) indicates that dairy cows fed on pasture and unwilted silage, and formaldehyde treated silage gave significance in diet and level of feeding.

Recent work in plant and animal sciences indicates, that the basic agriculture production response relationships are rectlinear. The use of LP is now quite reserved especially for determination of feed mix for dairy cows, and hence search for suitable nonlinear algoriths continues. Heady et al (16) used a logarithmic quadratic and square root functions and found the logarithmic form the best fit on basis of t values, although the R value was slightly lower. Madden et al (27) used the quadratic function after experimenting with Cobb-Douglas, Spillman, linear and square root functions. So far there is no clear cut criterion for chosing a production function in relation to others.

Technical production functions derived through these studies have been used widely. Gossling (9) attempts to produce the "The Ontorios Shortrun Milk Supply" is a quite creditable study in milk production functions. He made the assumptions below:-

1) "Producers will produce up tothe point where marginal cost is rising, *ceteris paribus*,
2) For the farm firm's technical unit, a cow of a particular breed, its production function is known."

Using cross sectional data, he produced a transcendental function and a paraboloid. His independent variables were feed inputs of grain and concentrates. Studies by Gossling (9) clearly indicate that a sample of 170 farms is suitable to derive a milk production functions, suitable for deriving a shortrun supply relationship. This method is quite instructive because the function is derived from actual field survey without cross reference to experimental data.

Keith (24) also derived a supply response of each breed of dairy cows from the breeds production functions. This was important in the management of national herds and predicting the average estimated yield at various milk feed price ratios.

Ruigu (37) used parametric linear programming to study milk response in small holdings of Central Kenya . The basis of his initial data was a survey of small holdings by the Central Bureau of Statistics and IADP of Ministry of Agriculture. Ruigu's regression model denotes five factors influencing milk supply. The general function is given as:-

$$Qs = f(N_i, Pm_i, Pc_i, Ci, T)$$

Where:-

Qs = Supply of milk

N = number of cows and heifers two years old and over

Pm = past and present price of milk

Ci = cost of inputs (feed, labour and capital)

T = level of technology.

Using results from a parametric linear programming model, Ruigu concluded that milk prices and input prices are significant in determining milk production. Ruigu's postulations are that the level of milk supply can therefore be managed by the manupulation of price mix of input and output. This is an important theoretical approach, but just like other methods it should be treated with caution, Ruigu postulates.

Stotz (41) studied the whole of Kenyan dairy industry. He indicated that milk yield per cow varies with the agroecological zones, level of animal husbandry and the feeding system being practiced i.e. zero; grazing or semi grazing are the common systems in small holdings of Kenya.

CHAPTER 3

METHODOLOGY

3.1 Introduction

To a great extent the data for the analysis has been obtained from the records of Small holder Dairy Enterprises Recording Scheme of the Ministry of Livestock Development. Basically, data from farm record books and questionnaires and annual reports supplied primarily the analytical data upon which this work is based.

The deliberate use of this data arose from the following grounds:

i) The author was involved in its collection.

ii) This exercise of the small scale farm recording has now undergone a long period of experience, as the history of the scheme will show. Such experience is accrued with obvious accuracy and reliability of data source for technical analyses.

iii) The use of available data in this country has been very much limited, and totally not properly utilized.

iv) Deliberate use of this data has a long term effect on cost saving at national level, since further costs associated with surveys are avoided.

The details of the scheme's farm recording will support this fact.

3.2 Smallholder Dairy Enterprise Recording Scheme: An Overview

The Smallholder Dairy Enterprise Recording Scheme is a concerted effort between the extension staff of the Ministry of Livestock Development and the officers of Livestock Recording Centre. The actual recordings for the purpose of dairy farm management was initiated in 1974 with funds from Germany and the then, Ministry of Agriculture's Animal Production Division. It was then hoped that with this recording it will be possible to monitor the small holdings dairy enterprises into more profitable venture.

Apart from advising farmers the scheme gives guidelines to the Livestock Development extension officers as to the strategies for alleviating the bottlenecks of milk production in the Districts. This is normally provided for in the district reports and annual reports. The farmer also gets a report on the overall picture of the whole farm. In addition this section provides the farmers with lactation certificates and herd reports, at the end of the recording period.

The recording exercise is carried out for each individual cow by the farmer himself, or one of the agricultural livestock development officers attached to the extension service of that division. The amount of milk produced by each cow in the herd is weighed in the morning and evening. This is done once per month. The daily milk yield sheets are then sent to Livestock Recording Centre, at Naivasha.

At the centre they are computed into monthly milk yield. A measure of butterfat content is not considered unless the farm is located near butterfat laboratories.

The farmer's benefits include the advisory service rendered by the scheme and also the fact that he is in close touch with the extension staff for any problems arising in his farm. In the long run the farmer benefits by having been trained in the art of record

Similar records to those of the scheme are those of the Kenya Milk Records (KMR). With the KMR, the milk yield per cow is weighed each morning and evening for 365/6 days a year. This would be rather tedious for small scale farmers, but the KMR specializes on the large scale farms where the labour for recording is not a major problem. Daily milk yield recording in large scale farms is a routine procedure.

3.3 Selection of Sample Farms

The selection of the sample farm originates from the initial enrollment of member farms into the scheme. Basically, the Small holder Dairy Enterprise Recording Scheme selects its members farms on the basis of the following criteria:-

i) Member farm is a small scale holding.

ii) Dairy is one of the enterprises in the farm.

iii) The willingness of the farmer to be a member is also crucial.

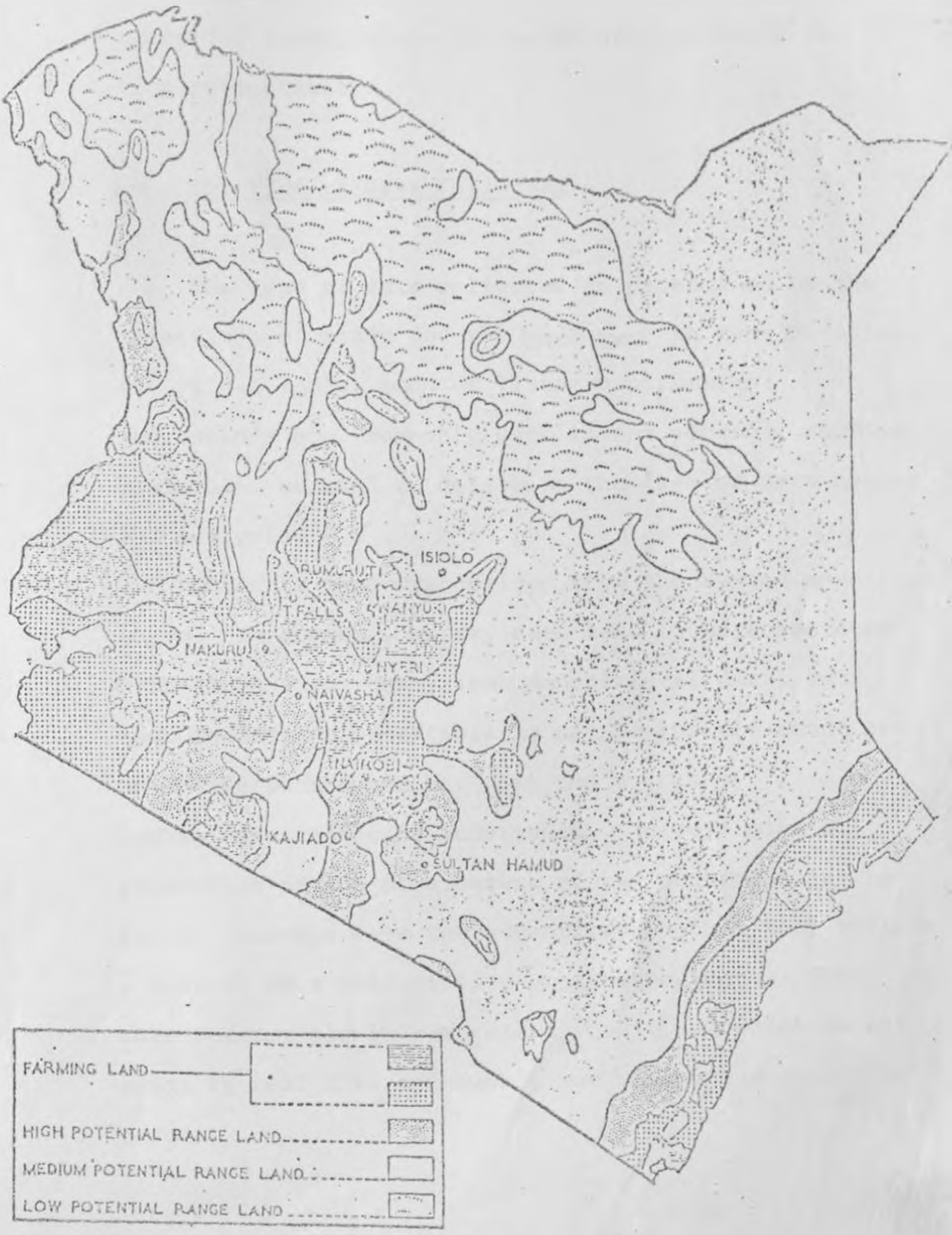
iv) Be in the specified district and agro-ecological zone.

Over 200 farms are members of the Small holder Dairy Enterprise Recording Scheme, scattered in 11 districts, and arrangements are in the pipeline to extend the recording into the other Agricultural Districts. Within the sample stratum 185 farms were considered for the purpose of this analysis.

There is no obvious technical criteria used in the selection of the 185 farms. Farms were either dropped on the basis of missing data, premature retirement of the farm from the scheme, or on some extreme data situation, such as the presence of zebus breed for dairy purpose, or the farm being in slightly different agro-ecological zone.

The recording districts are distributed throughout the country in the high potential areas as per figures 3.1 & 3.2

FIG 3.1 MAP OF KENYA SHOWING LIVESTOCK PRODUCTION POTENTIAL.



Source: Ministry of Livestock Development, Cartographic Section

The districts covered are namely Baringo, Kericho, Nandi, Kisii, Nyandarua, Meru, Embu, Kirinyaga, Murang'a, Nyeri and Kiambu.

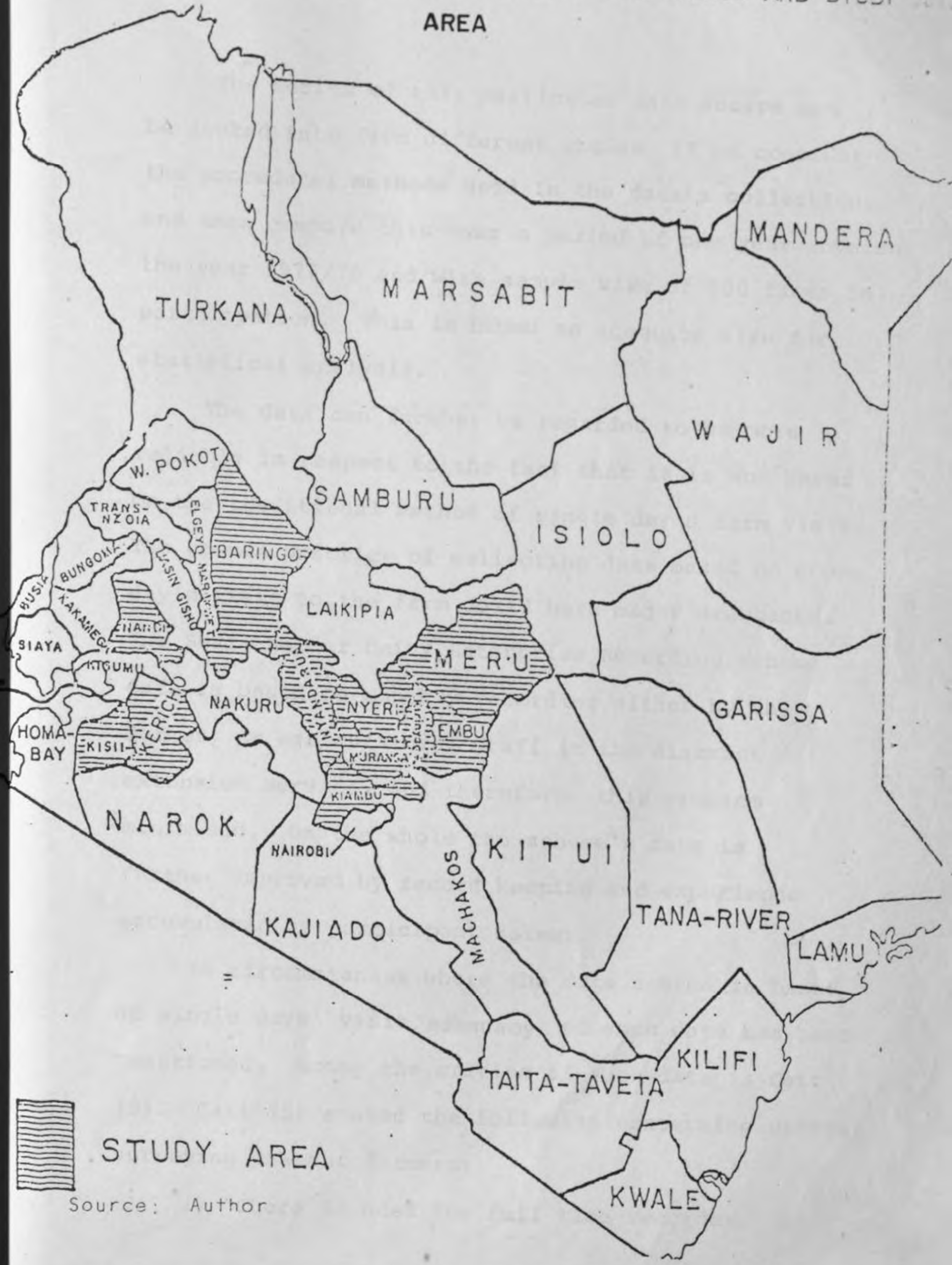
These 11 districts are located in the high potential areas, where the holdings also major in crop productivity.

3.4 The Type of Data Collected

The type of data collected is determined by the objectives of study and the hypotheses in consideration. Analytical tools, such as linear programming, regressions etc, commonly used in the economic studies could also be used to determine the type of data needed for analysis.

The data used was derived from the survey mentioned above. In general, survey data tend to be associated with large error term, than experimental data, such that regression co-efficients may be insignificant even when they should not be. But the merits of survey data cannot be underrated. Surveys give a reflection of the true nature of the phenomena in the field. Surveys have the advantages in that they reflect a natural farm condition, whereas experimental data only reflect highly controlled conditions which do not exist in real life and hence, low random and measuring errors.

FIG. 3·2 MAP OF KENYA SHOWING DISTRICT BOUNDARIES AND STUDY AREA



Source: Author

The merits of this particular data source can be looked into from different angles, if we consider the procedural methods used in the data's collection and then compare this over a period of one year covering the year 1977/78 and with sample size of 200 farms in participation. This is indeed an adequate size for statistical analysis.

The data can further be regarded to be more reliable in respect to the fact that it is not based on the traditional method of single day's farm visit. The common practice of collecting data based on a one day's visit to the farm could have major drawbacks. The Small holder Dairy Enterprise Recording Scheme data is based on monthly recording either by the farmer, or agriculatural staff in the district extension service, and therefore, this problem minimised. On the whole the scheme's data is further improved by record keeping and experience accumulated by participant farmer.

In circumstances where the data source is based on single days' visit adequacy of such data has been questioned. Among the critics of such data is Catt (5). Catt (5) stated the following concerning general surveying peasant farmers:

i) "There is need for full time recorder.

ii) There is need for adequate personal supervision and checking for gaps and inconsistence on the spot.

iii) It is better to underestimate the number of farmers that can be covered than to overestimate them and end up with a lot of inadequate data.

iv) The one day - visit technique is adequate for records of acreage, family size, etc and of yields if done directly after harvest. If different crops are harvested at different times it may be necessary to make several visits to coincide with the harvest of each.

v) The weekly visit method is probably necessary if accurate labour records and certain other classes of data are required. It is important to maintain the level of supervision throughout the year otherwise gaps occur."

The major limitations for data is therefore very much dependent on the method employed during the survey. The restrictions of the analyses as a whole have been due to the data available.

3.5 Growth and activity requirements of a cow

A lactating cow requires energy for growth and activities. This means that the requirements for maintenance, foetus and foetus membrane development and growth requirements must be met. Similarly, the requirements for walking in pasture to graze and walking to water must be met. And hence, the requirements of zero grazers is not the same as for grazing cows. It is estimated that 48 Kcal/100Kg liveweight per Km walked and 0.68 Kcal/metre vertical ascent are required (20). This factor has not been emphasised in this study due to the limitations of the available data.

3.6 Stage of lactation and lactation number

The milk yield per cow varies along the lactation curve. The lactation curve can be subdivided into three parts as:

i) early lactation

ii) mid lactation

iii) late lactation, or dry period.

The milk yield along the lactation curve is partially influenced by the feeding patterns but strictly the shape of the lactation curve is physiologically controlled, increases and then reaches a peak and thereafter decreases continuously until the cow dries out.

The recording practice does not fully incorporate the properties of the lactation curve. The records are strictly taken once a month and therefore not adequate to derive a lactation curve, as milk recorded at the peak day of milk yield will tend to bias the results upwards, and similarly, it cannot be the same as the milk yield a few days later or earlier.

For the purpose of deriving milk production function the mean lactation number in the herd has been used. This too has its own drawbacks in that the large variations could reduce the accuracy of the data. The lactation yield per cow was also computed by this once a month milk recorded, which was multiplied by number of days the cow is in milk. The error in time of milk recording could then be carried forward.

3.7 Butterfat content

The recording does not take into consideration the differences in milk butterfat despite the variation in energy requirement for milk production varies with the butterfat content.

3.8 Forage

The production of forage has been measured in hectarage areas. Similarly, the quantity of by-products used by the dairy herd was also measured in hectares. This is not a good measure because milk yield is a function of energy inputs. There is therefore discrepancy in such measures owing to variation in grass species, and season and soil types will always introduce differences in nutritional status of such feed.

3.9 Breed effect

The major limitation in livestock productivity in the tropics is nutrition and management, and not so much the genetic potential. This assumption has been taken to hold in this study data, and hence, all breeds have been pooled so as to have no effects. If milk production has to be improved the nutritional level should be the strategy so far. It is possible that this assumption does not always hold, but is reasonably justified.

3.10 Interaction with other enterprises

Dairy enterprise has been considered in isolation in this study and the only interaction with the whole farm system is only with regards to the use of farm by-products. Crops by-products form a major part of the livestock feeds, and therefore it would be erroneous not to consider them in milk enterprise.

In the small holdings of the high and medium potential areas dairy is an integral part of whole farming system. It is therefore prejudicial to consider dairy enterprise in isolation of the whole farm. Figure 4.1 shows the interacting factors in milk production.

The use of farm by-products has been incorporated and will partially reflect the influence of the rest of farm system. Crops residue in the farm have been found to substitute costly feeds at very beneficial rates.

A study therefore covering the whole farm as an entity is the ultimate goal. It is important to note that the money ploughed into dairy in the farm is in the form of concentrates, or drugs bought as a result of profits in other enterprises. The scope of this study does not encompass the whole farm as a single system.

3.11 Resources level

Management, land, buildings and other investiments have been assumed fixed and therefore not measured in the study. The interaction of management and capital have been left out in the production function.

CHAPTER 4

DESCRIPTIVE ANALYSIS

4.1 A model of milk production

Milk production per cow involves a complex interaction of several variables. These variables and their conceptual relationships are depicted in a model of milk production in figure 4.1. Variables considered in the quantitative determination of the mathematical production function model are shown by the asterisk in figure 4.1. The six variables selected from the schematic model depend on the data available (see section 2.4). These variables are assumed to adequately explain the milk production process.

4.2 Variable description

The technical analysis model includes the following six variables: farm forage, farm by-products, concentrates, herd size or the number of cows in the farm, average number of days in milk in the herd in the year and the mean lactation number. The first three variables can be valued at market prices, but the other three of the explanatory variables cannot be similary valued.

The dependent variable is the milk yield per cow per year, measured in kilogrammes of whole milk. It can also be easily valued by a market price. The following sections describe the six variables.

a) Farm grown forage

Forage or roughage may be viewed as that part of roughage or pasture or ley grown deliberately for feeding livestock. Thus, as opposed to farm by-products, which include a great deal of roughage, forage is purposely for feeding farm animals.

Farm forage in this study measured in hectare units alloted to each dairy cow per year. This amount is derived directly by asking the farmer, or by enumerat doing an estimation during his visits.

The average amount of forage per cow is the total farm gown forage area in hectares divided by the total number of cows. This is therefore specified in the production model as ha/cow.

The cost of producing farm forage per hectare, or per cow is relevant, in this study to work factor cost. The costs considered are[3]:

1) variable costs as:[4]

Machinery use costs; fuel, repairs seeds, fertilizer and transport of fertilizer

2) Fixed costs as:

fences, interest at 11% on borrowed capital, land and farm machinery costs: e.g. chopcutter.

Farm grown forage is defined as that part of forage produced either as ley or fodder and fed directly to the dairy cows, unlike farm by-products which is derived either from crops or other sources.

Farm forage is not a good variable to explain milk yield per cow per year because milk is/function /a of energy input, derived from feeds, and not so much from forage. Energy measurements were not possible within the scope and time of this study.

b) <u>Farm by-products</u>

Farm by-products constitute that part of animal feeds derived from crops residues, such as maize stover, banana leaves, sweet potatoes etc. This is an important constituent in farm animal

---

[4]The procedure used on these calculations is as given in Ministry of Agriculture, Land and Farm Management Division handbook, "Yields costs-prices 1980, Nairobi, March, 1980."

feeds because all the farms were mixed farms in the high potential areas, where crops and livestocks compete for land. It was measured in hectare areas alloted to each dairy cow per year.

When considering factor cost of by-products there is no direct price to consider. Various methods have been suggested which either assume farm by-products to have zero factor cost, or which consider the cost of substituted feeds which could have otherwise biological significance of the feed in starch equivalents, or other nutritional units.

The nutritional value of the by-products is technically the most logical approach but quite complex in its method of opportunity cost consideration. Wen Yuen Huang (17) conceptual model on farm by-products used the total net benefit of use of by-products as the yardstick for considering the value of farm by-products.

Appraising the feed value on pineapple green chop Gullison (10) used total digestible nutrients (T.D.N.) values. The amount of T.D.N. contained in the pineapple green chop is used as basis for evaluating its economic feed value. This method would not work in Kenya where even the commercial feeds are not valued on their biological potential.

This study assumes farm trash to have a production cost as per appendix VIII. A zero factor cost would definitely bias the result.

The nutritional value of the by-products and farm grown roughage vary with agro-ecological zones. The farms considered were located in the five agro-ecological zones shown in table 4.1 as defined by the Central Bureau of Statistics .

Table 4.1

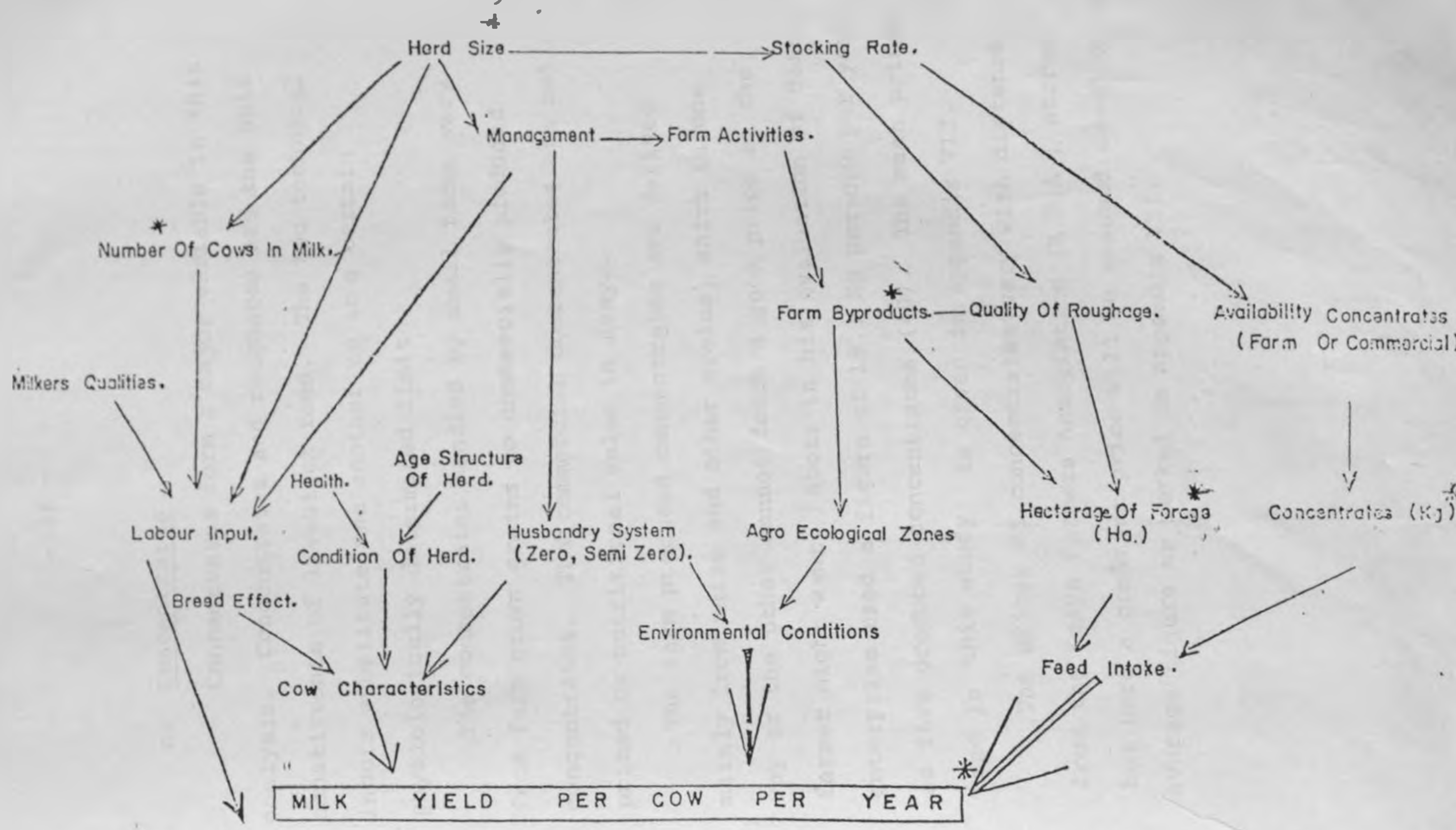
Number of the Sample Farms by Agro-Ecological Zones

ZONE	I	II	III	IV	V
Dominant Crops or grass species	tea maize pyrethrum	maize tea	maize tea coffee	maize coffee bananas	maize beans
number of farms	24	61	24	40	25
percentage of farms	13.79	35.06	13.79	22.99	14.37

Source_ Survey Data

Figure 4.1

A MODEL OF MILK PRODUCTION



* Variables considered in the estimation of production function of milk.

Source: Author

c) Concentrates

Concentrates form a major variable in this analysis. Concentrates and roughages are the bulk constituents of livestock feed. The two technical inputs substitute one another up to a certain physiologically determined limit:.

The concentrates handled by small farms vary from farm grown grains to commercially produced concentrates. The commercial concentrates are not priced on nutritional value in Kenya.

The farm produced concentrates are derived mainly from maize and other grains, which in one way or the other cannot fetch a good price as the farmer might want. Stotz in his evaluation of dairy enterprise used a figure of 18.1 Kg per cow per year as farm produced concentrates (40). The mean prices used in this study is given in appendix VII.

The prices of concentrates vary with distance from the Kenya Farmers Association (K.F.A.) stores, but here a constant price will be assumed based on an average figure as worked in appendix VII.

4.3 Auxiliary Variables

From the foregoing section and the schematic model in figure 4.1 it can be seen that one could expect other variables to influence milk yield. Since quantification of all these variables is not feasible some proxies will be used.

Therefore the model includes three other explantory variables termed as auxiliary variables. They cover the cow's characteristics and environmental effects. These variables can successfully be influenced and manipulated by man, or specifically, the farmer.

The three auxiliary variables are days in milk, number of cows and lactation number. These are defined below:-

a) Days in milk is a mean value of the farm's herd. The total number of days in a year cows are in the herd is divided by dairy cow herd size.

b) Number of cows stands for the herd size and is assumed to reflect the efficiency or the inefficiency associated with increasing or decreasing the herd size. The unit of measurement is the number of cows in the herd per year.

c) Similarly, the lactation number is a mean value taken from the farm herd. The herd's mean lactation number depended on the number of cows and their age structure. A value for the mean lactation number in the farm herd was calculated and assumed to reflect the herd's mean age, represented by lactation. The behaviour of a cow's lactation curve and lactation number is discussed in chapter 2.

There is no direct factor cost for evaluating these variables, but they play a significant role in the determination of milk production.

These variables varied over the range of data as shown on Table 4.2.

4.4 Mean Values

The first attempt on analysis is done using mean values. The mean values and their respective standard deviations reflect that small holdings show quite a wide range in inputs levels.
Tables 4.2 depicts the means of the farm inputs and auxiliary variables. These values are the means of the six explanatory variables considered in different regression analyses.

Table 4.2

Mean Values and Standard Deviations of The Data Set

Variables	Milk yield Kg per cow (Kg) M	Farm grown forage per cow (Ha) F	Farm by-products per cow (Ha) B	Concentrates per cow per year (Kg) C	Number of cows in herd or herd size (cows) N	Days cows are in milk per year D	Lacta tion numbe in th herd L
Average	2173.79	0.4738	0.2206	328.74	4.5380	294.53	3.9756
Standard Deviation	870	0.3221	0.21	355.75	3.99	40.99	1.54

SOURCE: Survey Data

Other variables influencing the milk yield per cow, not considered in the production function analyses, are time or season of calving and breed effects. The reasons behind their exclusion in the technical model are given in Chapter 2.

4.5 Scattergraph Analysis

Scattergraph method provides a useful analytical tool for portraying a general functional relationship between any two variables. This involves a visual scanning of the observations set out in graphical form which can suggest likely form of the production function. For this purpose, a production function can be illustrated geometrically in two dimensions only, and, practically more than three variables relationships is not easily representable. There are six relationships considered i.e. each independent variable against the milk yield per cow component. Figure 4.2 to 4.7 represent these relationships as reflected by the sample data.

a) Milk-farm grown forage relationship

A visual look at the computer plotting relationship scattergraph figure 4.2 indicates that there is a general inverse relationship between milk yield and forage hectares per cow beyond the .2070 ha/cow level. This is a reasonable forage stocking rate in the high potential agro-ecological zones where forage is supplemented by other feeds. The relationship implies that there is an optimal forage stocking rate beyond which it does not pay to provide more forage to the cow. This can only be determined from a knowledge of more exact functional relationship and input - output prices. This is the subject of a later chapter.

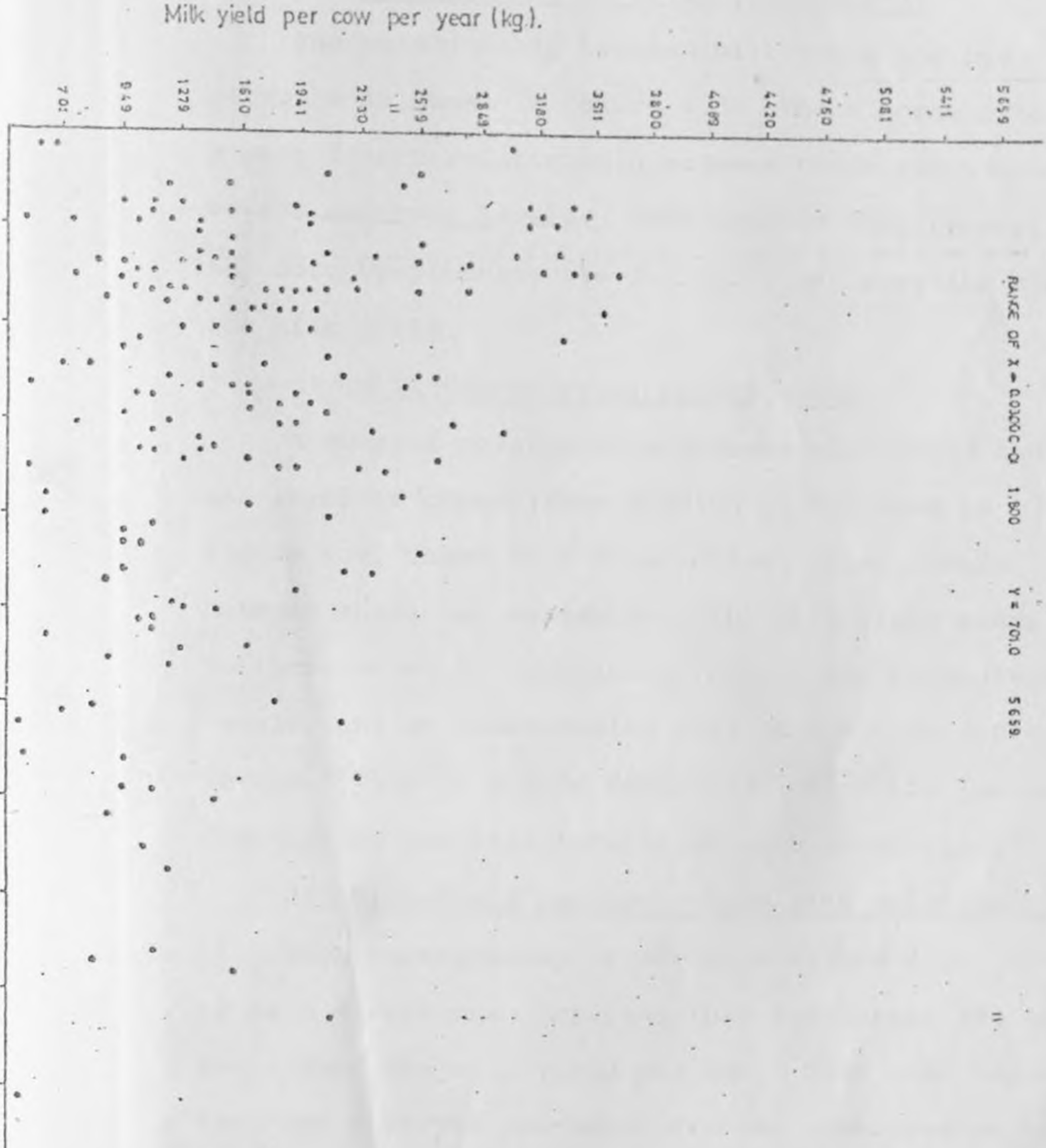


FIG. 4.2 Milk – farm forage relationship.

b) <u>Milk-Farm by products relationship</u>

The relationship between milk yield and by-products is shown in figure 4.3. There appears to be a weak direct relationship between these two variables at the observed levels. This implies that generally the more by-products are available per cow, the higher the milk yield.

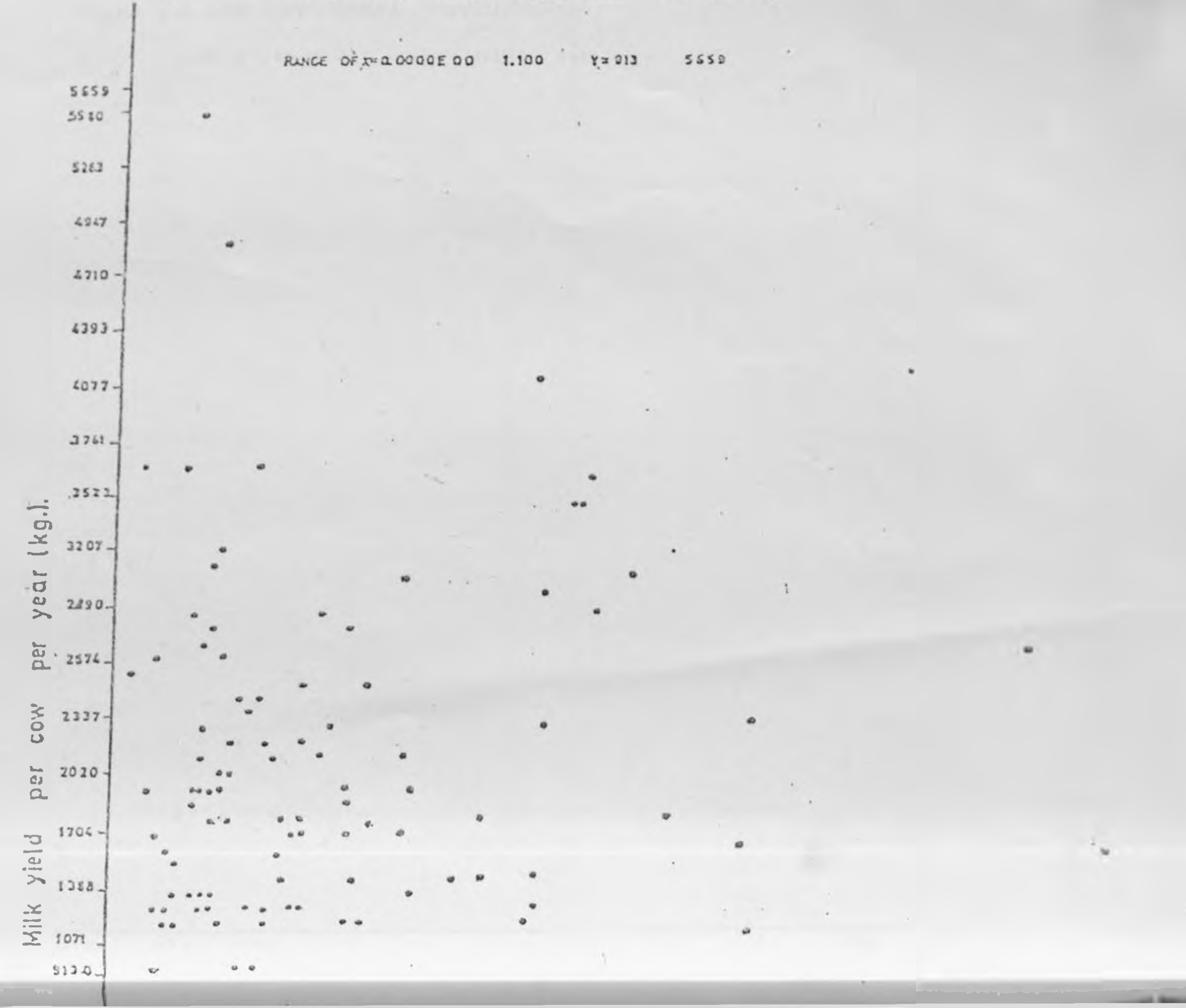
c) <u>Milk-Concentrates relationship</u>

A general relationship between milk yield and the level of concentrate feeding is depicted in figure 4.4. There is a clear direct relationship between these two variables. The milk yield seems to increase at an increasing rate at low concentrate levels, and at a decreasing rate at the high concentrate levels. This is a good demonstration of the law of diminishing marginal returns in milk production.

d) <u>Milk-Yield per cow - herd size relationship</u>

This relationship is shown in figure 4.5. It appear to be a direct one, implying that the larger the cow-herd, the higher the milk yield per cow. This also means that the observed cow-herds are not too large as to effect the law of diminishing returns. However, one would expect diminishing returns at relatively large cow-herd sizes when cows compete for available feeds, managerial attention and other inputs. Such large

Fig. 4.3 — Milk yield — farm byproducts relationship



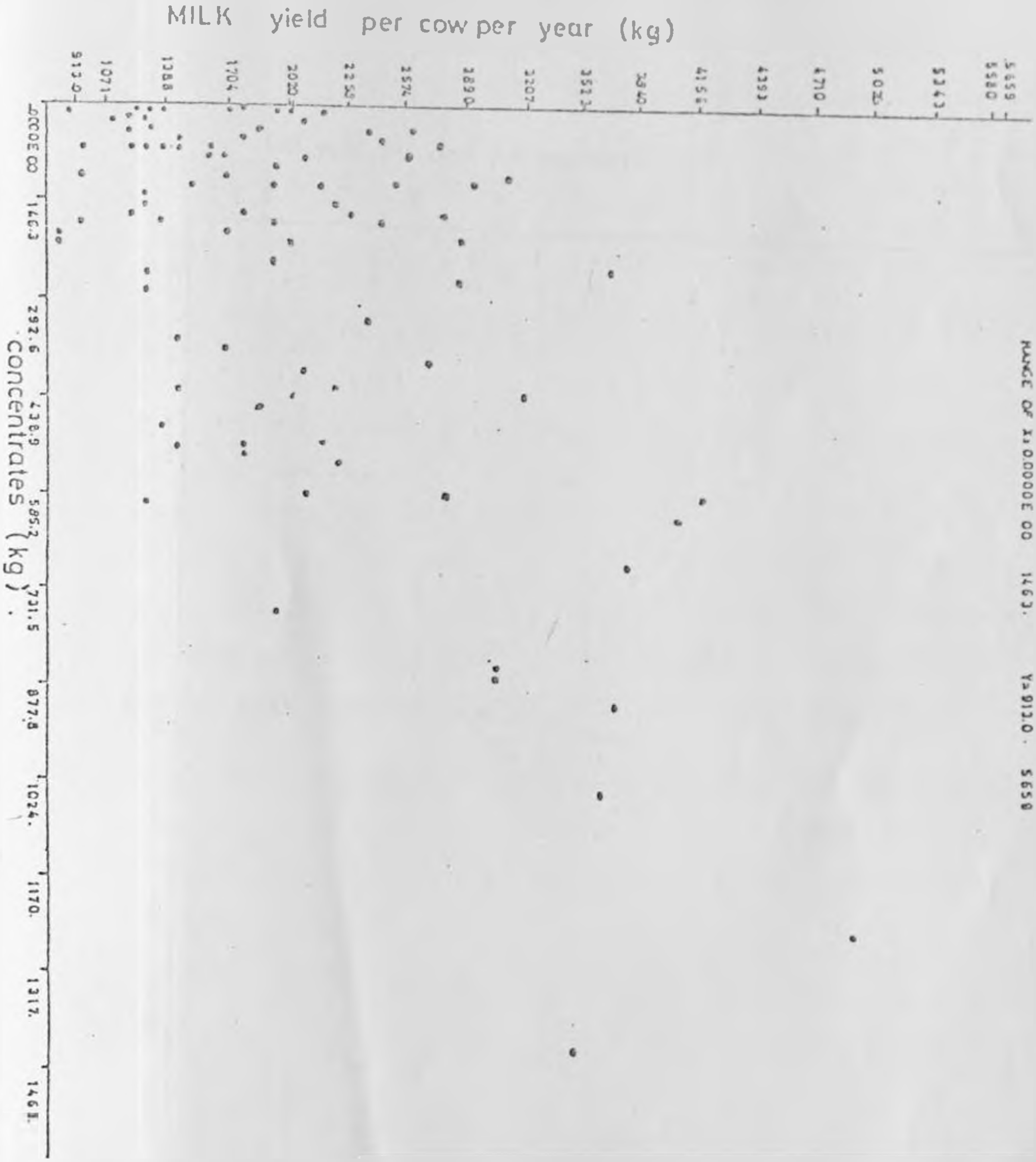
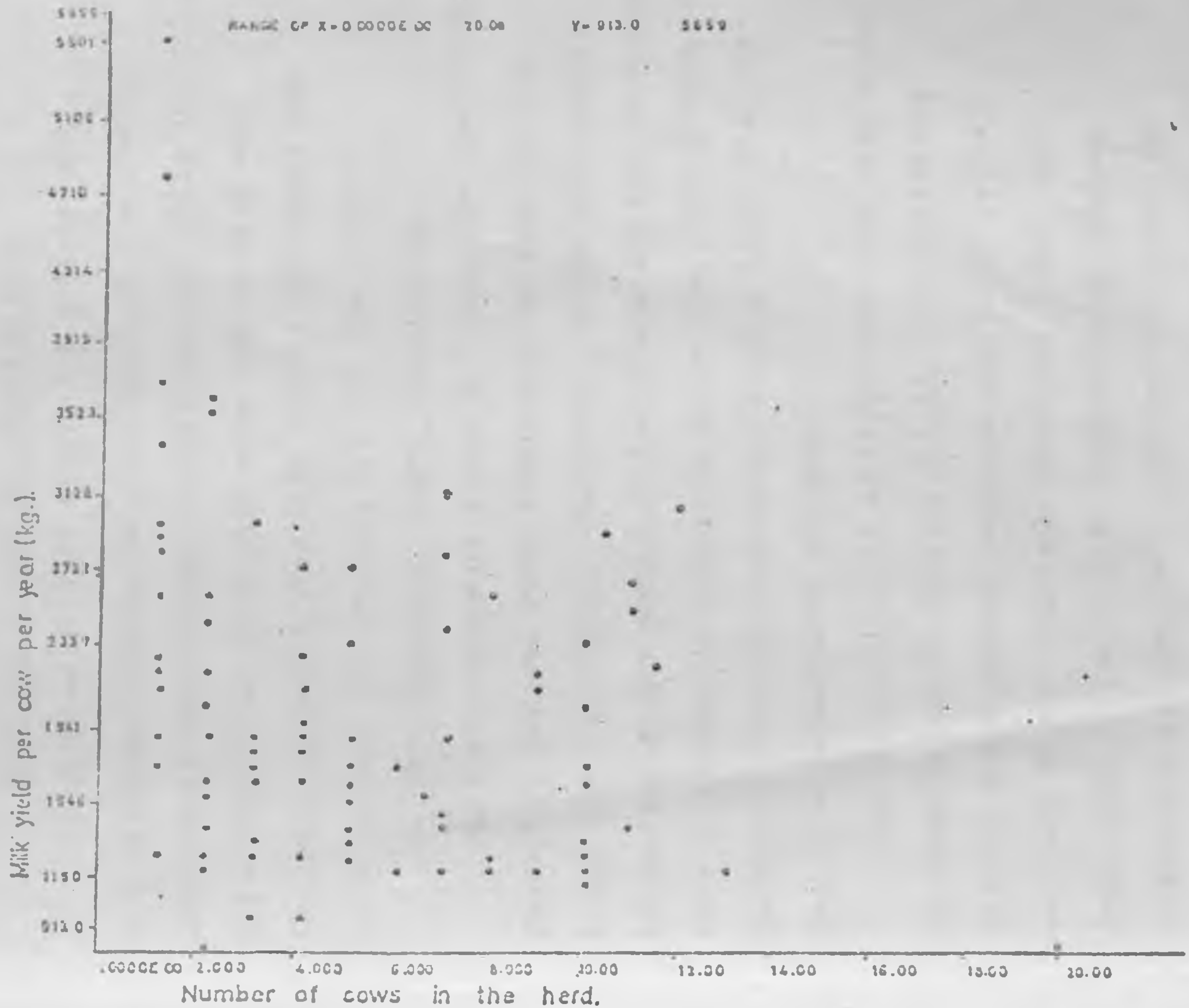


Figure 4.4 milk-concentrates relationship


RANGE OF X=0.0000E 00 20.00 Y= 913.0 5659
Milk yield per cow per year (kg.).
Number of cows in the herd.

cows-herd sizes are beyond the limits of plotted or observed data.

e) Milk-yield per cow - mean number of days cows are in milk in the farm herd

The observation from figure 4.6 reveals that milk yield per cow per year increases with a general increase in mean number of days in milk. This is quite logical as herds with more cows in milk will logically achieve higher milk returns per annum than herds inwhich the cows are dry for long periods.

f) Milk-Lactation number relationship

The scattergraph in figure 4.7 indicates that milk production per cow stays relatively the same for the first four lactations. Thereafter, production appears to decline as the number of lactations per cow increases. This is reasonable because as a cow ages, its productive potential naturally diminishes up to a point where it has to be culled from the herd.

The above series of scattergraphs have only helped in identifying the general functional relationship between the dependent variable milk yield per cow and each of the independe variables. More exact relationships can only be determined by running regression analysis and examining the effect of each independent variable upon the dependent variable. This is the subject of the next chapter.

Fig. 4.6 Milk - mean number of days in milk per year relationship.

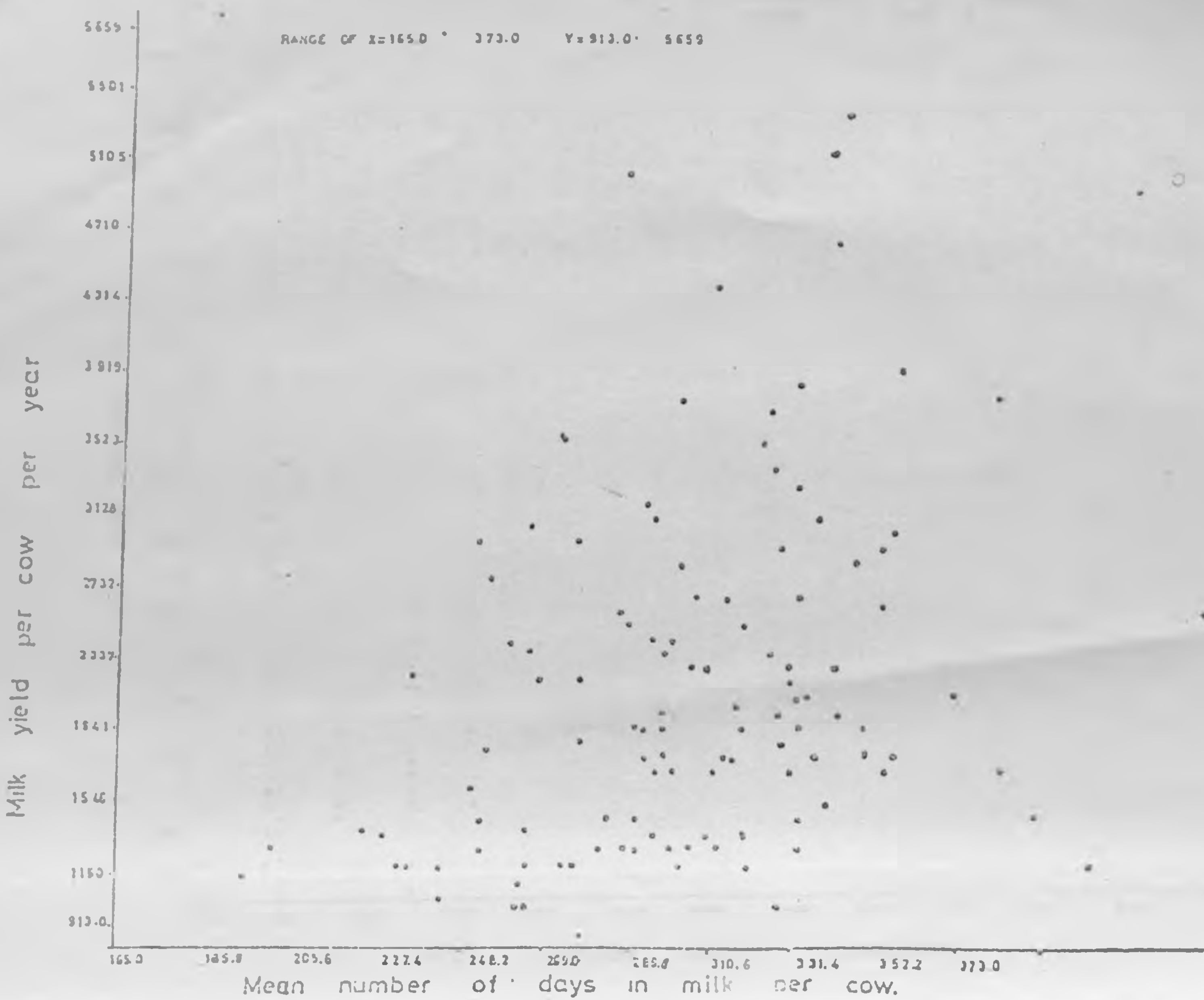
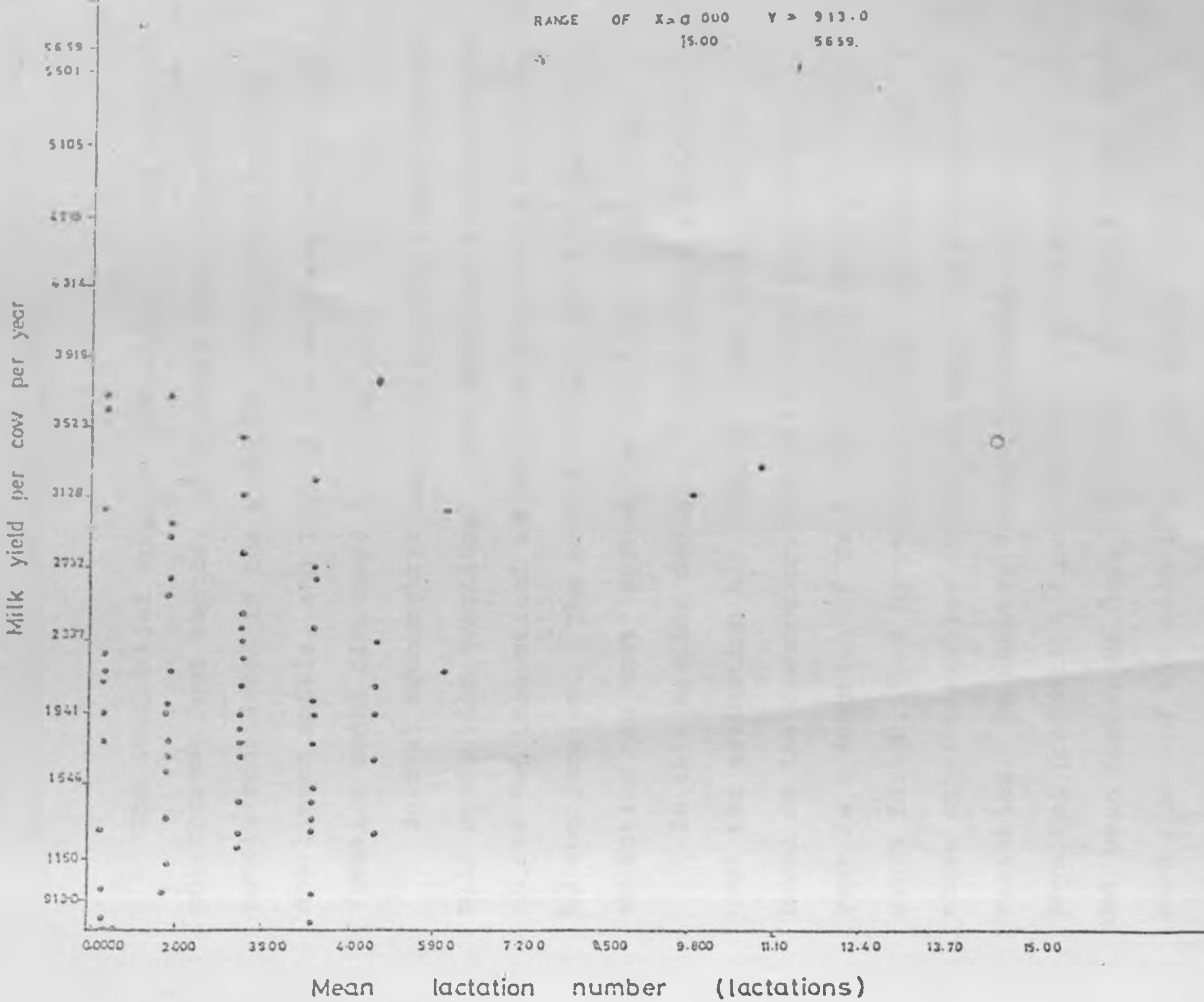


Fig. 4.7 Milk - lactation number relationship



CHAPTER 5

MILK PRODUCTION FUNCTIONS ANALYSIS

The statistical analysis presented in this section encompasses four topics, as follows; the regression models considered in the analysis, the linear and the non-linear models, and finally the selected production function model discussed in details.

Several econometric models were used for estimating milk production functions. Each function was considered on its own theoretical assumptions and merits as reflected by the data set. The most difficult problem was that of selecting the most appropriate function among them.

In this section ordinary least squares, method is used for estimation all through. The model used is based on the assumption that milk yield per cow per year is a function of feed inputs, comprising of farm grown forage, farm by-products and concentrates and three other variables formed as auxiliary explanatory variables. In Chapter 4 these variables in the physical production function model were discussed and included mean number of days the cows are in milk, the mean herd size and the mean lactation number in the herd.

This section discusses various relationships as below:-

5.1 Bivariate regression analysis

The initial estimation included linear, quadratic, square and Cobb-Douglas functions. Each variable was tested in a simple regression analysis and by scattergraph method, figure 4.2 through 4.7

The simple regression analysis considered in each case of milk yield as a function of feed inputs, as on table 5.1.

Simple linear regression equations showed that concentrates was the most important variable. Equation 3 table 5.1. shows that the relationship is statistically significant at 0.05 level of significance.

$$M = 1737.53 + \underset{(8.47)}{1.33C} \text{ and } R^2 = 0.55$$

Both the t values, bracketed, and the R^2 value were significant[5]. The equation is consistent with expected result in feeding concentrates. Milk yield increases with feeding concentrates, other variables held constant. The other two relationships shown in table 5.1 are also statistically significant with respect to the R^2 and t tests, at the .05 level of significance, except the by-products influence on milk yield per cow per year relationship which is insignificant, possibly due to the limitations of the method used to measure it as described in Page 37

Table 5.1

Bivariate Regressions of Milk and Feed Components

(Simple Regression)[4]

DEPENDENT b COEFFICIENTS AND t VALUES OF DEPENDENT VARIABLES

MILK(M) \ VARIABLES		INTERCEPT (Q)	FORAGE (F)	BYPRODUCTS (B)	CONCENTRATES (C)	TOTAL FORAGE(Z) (F + B)	F
1. M	=	2618.92	-939.47F (4.87)**				.0.
2. M	=	2180.17		-28.67B (0.09)			0.
3. M	=	1737.53			1.33C (8.47)**		0.
4. M	=	2568.47				-568.34Z (3.71)**	0.

[5] Results from Stepwise regression programme. Stepwise regression analys. programme introduces regressors in several ways. The way the regressors are introduced may depend on the statistician *a priori* specification of the order required, as in above case. In other production function models the regressórs were introduced on the bases of statistical impor tance of the regressors' data. The computer therefore chose the order in the latter case.

* Depicts 0.05 level of statistical signif ance

** D icts 0.10 level of statistical signif nce

5.2 Multiple linear regression analysis with two and three independent variable relationships

The second set of models considered two factors independent variables in regression analysis. The results are presented in table 5.2

Table 5.2

Multiple Linear Regressions

No of Equation	DEPENDENT VARIABLE	Intercept	Forage (F)	By-products (B)	Concentrates (C)	Total Forage (Z)	R^2
			b COEFFICIENTS AND t VALUES OF INDEPENDENT VARIABLES				
1.	M	2577.57	-971.39 (4.93)**	256.00 (0.85)			0.35
2.	M	1937.00			1.24 (7.58)**	245.60 (1.76)*	0.56
3.	M	1945.43	-340.94 (1.76)*		1.19 (6.78)**		0.55
4.	M	1787.19		-245.78 (0.92)	1.34 (8.52)**		0.55
5.	M	1956.45	-315.58 (1.57)	-131.07 (0.48)	1.20 (6.71)**		0.56

* See page 62

** See page 62

The coefficients of multiple determination, R^2s, were sufficiently high , so that the equations in table 5.2 can be said to explain the linear relationship of the factor and their products. Nevertheless, only the t values of concentrates were actually significant in all the equations. The positive coefficient sign of the concentrates is biotechnically logical.

By inclusion of more variables in the equation sets as in table 5.2, the intercept changes, i.e. compare table 5.2 and 5.1. Mathematically this is also possible and logical.

All the above relationships in table 5.1 and table 5.2 show that concentrates are the most important attribute to milk yield per cow per year. Thus the amount of milk a farmer gets per year is mainly a function of concentrates feeding, *ceteris paribus*. We can assert with confidence that concentrates as major components of animal feeds contribute significantly to the amount of milk produced by a given herd in a given period.

It is also possible that milk production function could be determined by considering feed factors alone, especially when the data source indicates high level of precision, such as that from experimental stations.

Due to lack of precision with survey data, auxiliary variables are included to account for cow charactaristics and environmental influences that are not specified in the functions.

The functions in table 5.1. and 5.2. are linear relationships, but *a priori* knowledge indicates that milk function is never linear. Then what is the explanation for the significant R^2 values and t statistics in the linear functions? The explanations may be that farmers are operating within the linear range. A step ahead with non linear fucntion will assist in choosing the best fit for the data set.

Since, farm grown forage and by-products as explanatory variables yielded a non significant b coefficient, we can speculate that they do not follow a linear relationship. At this point it is logical to start advocating a non-linear relationship. Literature, such as work by Huffman and Duncan (12) reveals that linearity exists within certain levels of feeding. Is this the range local farmers are operating in?

Work in this study indicates farmers operate within a mean 328.74 Kg and ∓ 355.75Kg standard deviation concentrates feeding per cow. This is quite a low regime of feeding concentrates in an intensive system of zero and semi zero grazing. Chances are, farmers are operating within the linear range of concentrate feeding. This point stands to be verified by comparison with non-linear functions.

The negative signs in farm grown forage and farm by-products can be explained by the role of concentrates by substituting these two. The two also substitute one another. This fact follows from the observation that farms with high level of roughage feed less concentrates and vice versa.

Biotechnically also, there is a negative relationship between concentrates and roughage. Controlled experimental work by Heady (14) showed that substitution occurs in grain and hay. The substitution effect of grain for roughage and vice versa might be the reason for the negative signs. Other explanations are as stated in Chapter 2 on quality of the data. Measuring farm forage and farm by-products in hectares could yield misleading coefficients on these variables. A more reliable unit of measurement would have been units of starch equivalent which would hold constant the variation of pasture quality. But it is important to note the influence of variable total forage[6], Z, on the linear function relationship, equation 2 of table 5.2. The coeffcient is both statistically significant and biotechnically logical. It is therefore important to note that milk yield per cow is a function of total forage in the farm. For physical production function analysis total forage could have been a more appropriate variable to consider instead of farm forage and by-products separately. The latter would have been appropriate but would impair economic analysis owing to our earlier assumption that the production cost of by-products and farm forage are different.

5.3. Multiple regression analysis with six independent variables

In an attempt to choose the best estimator of milk production relationship a linear function, a quadratic function, a modified quadratic function, squared function and power function were all examined using the data. Extra explanatory variables were also included.

Among the functions tested a most suitable

---

6 Z represents the amount of total roughage available to the milk herd in hectares. This is also the sum of farm by-products and farm grown roughage.

function was selected on statistical and theoretical superiority. *A priori* information and literature were also further criteria for the selection of the function.

Investigations for the most suitable function included considering a total of six variables, namely the farm grown forage, the farm produced by-products, concentrates and the three auxiliary variables specified in Chapter 3. The means of these variables were incorporated into the production function analysis to represent the farm level of operation. The means and the standard deviations are given in table 4.2 for the whole data set.

A quadratic function was selected in the final analysis, but the Cobb-Douglas and the linear functions compared favourably with it. In general terms, this form fitted adequately with the general background of the data and biotechnical logics of milk production. The function was then used for deriving economic interpretations of the data and recommendations. The function can also serve important purposes, such as, factor-product relationship prediction.

The sections that follow here below describe each function as analysed:-

a) <u>Multiple linear regression</u>

The first function to be estimated using the data set was a multiple linear regression of the form:-

$$M = a + b_1F + b_2B + b_3C + b_4N + b_5D + b_6L$$

The results are depicted in table 5.3. The table includes the standard errors and the t statistics. Significant coefficients are shown by asterisk markings on corresponding t values.

The linear function states that milk yield per cow per year is a function of concentrates feeding, farm grown forage available to dairy cows, farm by-products used for feeding dairy cows, the herd size, days cows are in milk and the lactation number (These variables are described in Chapter 3). By mere consideration of statistical significance milk yield per cow per year turns out that it could be regarded to be a linear function of concentrates feeding, days in milk and lactation number, i.e.

$$M = a + b_3C + b_5D + b_6L$$

Table 5.3

Multiple Linear Regression With

Auxiliary Variables

FUNCTION: MULTIPLE LINEAR REGRESSION

INDEPENDENT VARIABLE	SYMBOL	b Coefficient	Standard error	t Statistics
Intercept	a	-283.73		
Farm forage	F	-198.98	206.51	0.96
By-products	B	76.10	264.17	0.30
Concentrates	C	1.00	.16	5.91**
Number of Cows	N	-15.53	15.32	1.01
Days in Milk	D	6.73	1.37	4.88**
Lactation No.	L	73.30	33.57	2.18*
R^2		.653		

SOURCE: Computer printout

* See Page 62

* See Page 62

At ten percent level of significance, the herd size, N, becomes a significant attribute.

Concentrates as a major attribute determining amount of milk a cow produces is consistent with equation 2 in table 5.2, and the equations in table 5.1. and 5.3. This further supports the hypothesis that milk yield is largely a function of concentrates feeding, with or without other variables being held constant.

On the other hand, among the auxiliary variables days in milk proved a significant attribute to the amount of milk a cow gives out in a specified period.

The positive b coefficient of days in milk indicates that farms where cows are longest in milk produce much more milk per annum than farms where most cows are dry a great period of the year. In a farm herd yield maximization process, dry periods are significantly short and therefore cows are much more productive throughout the year.

The second auxiliary variable in consideration was the lactation number. Lactation number can be regarded synonymous with cow's age. The first lactation signifies the start of the productive life of the dairy cow. The statistical and mathematical significance of coefficient days in milk reflected in table 5.3 for L variable depict that a general increase in lactation number is correlated with increase in milk yield of the cows. A look at the scattergraph 4.7 further supports the same fact. The relationship in scattergrap however is not easily identifiable. The results of the production function analysis portray a linear trend of the lactation numbers. This fact can be interpreted to reflect that small holdings of surveyed farms appear to be operating within the linear section of the production function of the cow's age. The possible explanation is that cows are never milked to very old age where diminishing returns exist. Other explanations exist such as the fact that old herds could be fed more feeds in order to sustain high milk yields.

Examining the herd size as an attribute to milk yield indicates that an increase in number of cows has a negative effect on milk yield per cow. The negative sign is an indication that a general increase in cows number has detrimental effect on milk yield per cow, and hence, diseconomies of size exist in dairy farming.

If inefficiency increases with herd size, then the strategies taken in Development Plan[7] are not practically viable to some extent. On the same issue, Matulich (28) investigated the efficiencies in large scale dairying and found significant economies of size were evident up to 750 cow herds. Operations above this mark has a consequential effect on efficiency of the herd size. In comparison, the research here covered farms operating within a mean of 4.54 cows, with a standard deviation of 3.99 cows. Owing to the fact that most of the farms were small scale mixed farms, management and labour inputs could have acted indirectly as bottlenecks, and hence, diseconomies of size suggested by the results.
In the linear function farm by-products and the farm grown forage turned out statistically insignificant variables. If the criteria for determining the model is based on statistical analysis alone, these two explanatory variables would be excluded from the production function model.
In the final analysis multiple linear regression was dropped owing to *a priori* evidence elsewhere[8] which suggests diminishing marginal productivity of feed inputs and non-linearity of other variables.

---

7 Kenya Government Development Plan 1979-83 (Section 100) Government Printers, Nairobi, 1979.

8 See under literature review Page 18

b) Cobb-Douglas Function

The other function that the data was fitted was Cobb-Douglas function. This function has a mathematical relationship of the form:

$$M = aF^{b1} B^{b2} C^{b3} N^{b4} D^{b5} L^{b6}$$

Where,

M is milk yield per cow per year is the dependent variable, and F, B, C, N, D and L are defined in table 5.3., and b_1, b_2, b_3, b_4, b_5, b_6, and a are structural parameters of the production function being estimated.

The physical properties of the Cobb-Douglas power function have limited its usefulness in analysing crop and livestock responses e.g. the biological phenomena of fertilizer response in crops indicate Cobb-Douglas function is not suitable function (29). However, the function accommodates diminishing marginal returns and is suitable for assimilating dummy variables. Its disadvantages include the following when used for milk response.

i) does not allow the milk function to reach a maximum,

ii) does not allow both increasing and decreasing returns and hence,

iii) does not allow negative and positive marginal productivities

iv) gives statistical significance where conventional equations do not at the same level of degree of freedom and,

v) gives a symptotic isoquant.

The practical significance of these points as seen from the analysis carried out in this research are discussed and commented on as follows. Firstly, the theoretical disadvantages i to v reduce its usefulness in estimating milk production function. Points i and ii are theoretical points which have little practical relevance as far as surveys collected data is concerned where the range of data source is outside the researcher's control i.e. the exemplified example here reflects that the range of data is not quite sufficient to establish a complete production function of milk[9]. Logically therefore, it is only correct to say we are dealing with only a portion of the true production function. For this reason the Cobb-Douglas function might be more adequate than the quadratic or the transcendental function for practical purposes.

The other points. ii, iv, and v could be ignored on practical basis. As far as point v is concerned the study does not extend to isoquant analysis.

The survey data were fitted into the function and yielded the mathematical relationship given in

9 See the standard deviations and mean of data table 4.2

table 5.4[10]. Other parameters given to explain the goodness of fit for the function are the t values and R^2.

The statistical analysis of the Cobb-Douglas function indicates that this is a suitable fit. The t statistics indicate that the coefficients of F, B, C and D are statistically acceptable at 0.05 level of significance. The lactation number and farm by-products are the least significant in terms of t statistics.

Table 5.4.

Cobb-Douglas Function

Interdependent Variable	Symbol	b Coefficients	Standard Error	t Statistics
Intercept term	a	1.3485139		
Farm grown forage	F	-0.1063568	0.0396781	2.68**
Farm by-products	B	0.1792558	0.170492	1.05
Concentrates	C	0.0356006	0.0135031	2.64**
Number of Cows	N	-0.0720727	0.0392169	1.84*
Days in Milk	D	1.0424737	0.161862	6.44**
Lactation Number	L	0.1088280	0.0722981	1.51
Mult. Corr	R^2	o.625		

10 The function could be algebraically be written as

$$M = 1.35 F^{-0.11^{**}} B^{0.18} C^{0.04^{**}} N^{-0.07^{*}} D^{1.04^{**}} L^{0.11}$$

(2.68) (1.05) (2.64) (.84) (6.44) (1.51)

R^2 = o.625

* See page 62

** See page 62

The coefficients were all positive except N and F. The coefficient of multiple correlation, R^2, was statistically significant at 99% confidence level. The multiple correlation coefficient value indicates that 62.5 percent of the total variance in milk production is explained by the Cobb-Douglas relationship. A multiple correlation coefficient of 0.625 sufficiently justify the use of Cobb-Douglas relationship to study milk yield per cow.

Other evidences in support of Cobb-Douglas regression analysis are found in literature such as, Keith Cowling et al (23) used and recommended Cobb-Douglas mathematical form for explaining milk production. Keith (23) also adopted this form because it accommodates diminishing marginal return and dummy variables. The milk production relationship in this study does not incorporate dummy variables whatsoever.

The power function in this study was rejected and all *a priori* in favour of quadratic function discussed later, but due to strong evidence in favour of Cobb-Douglas reflected by our data the two functions are compared in the technical analysis.

c) Square function

The linear function, the square and the quadratic function have similarities in that the six variables are linearly represented in all the three functions, and additionally, in squared and quadratic functions some of the variables are squared. Table 5.5. is the regression analysis of milk using square function. The main difference between the two is that the quadratic form incorporates the interaction influence of the variables by cross-products of the variables[11]. The squared function analysis in this study therefore is a step into deriving the best quadratic function for milk.

The resulting squared function proved inferior to all the other functions fitted in this study by the virtue of t statistics values. For functions see appendix V.

The results on the table 5.5 also reflect that the squared function has also disadvantage in that some of the coefficients signs were misleading. The concentrates coefficients' signs in the function are harmonious with the established theoretical phenomena of livestock and crop responses relationship.

The function in table 5.5 can also be represented as below:-

$$M = -73.02\ F - 835.72\ B + 1.32\ C + 15.60N + 6.37\ D + 12.70\ L - 53.21\ F^2 + 965.15\ B^2 - 0.000211\ C^2 + 4.49L^2$$

$$R^2 = .960.$$

It is important to note from the above function that only

---

11 See aprendix iv, terms FB, FC and BC are the Cross-products of F and C and B and C, respectively.

Table 5.5. Square Regression Function

Independent Variable	Symbol	b Coefficient	Standard Error	t Statistics
Constant	a	-	-	0.16
Farm forage	F	-73.02	552.51	0.13
Farm by-products	B	-835.72	686.98	1.22
Concentrates	C	1.32	0.39	3.33**
Number of cows	N	15.60	15.32	1.02
Days in milk	D	6.37	.85	7.49**
Lactation number	L	12.70	84.66	0.15
Square Terms	F^2	-53.21	345.95	0.15
	B^2	965.15	712.52	1.35
	C^2	-0.0002	0.003	0.83
	L^2	4.49	6.72	0.67
Multiple Corr	R^2	.960		

SOURCE: Computer Printout

F. B. C. and L have been squared in the algebraic form. The other variables are not squared as they were either, assumed to follow a linear form, or from the scattergraph showed a linear trend. The four variables which were squared follow a non-linear form i.e. either from biotechnical point of view or scattergraph[12].

d) <u>Appropriate quadratic function</u>

The last part of statistical analysis looks into appropriate quadratic function for milk production analysis. In the preliminary work several forms of quadratic equations were used in the milk production function determination. Three of the most suitable equations are presented in appendix IV.

A quadratic function takes the form of:-

$Y = a + bX - cX_i^2$ [13]

---

12 See scattergraph 4.1 to 4.6. Same arguments used for the quadratic functions.

13 The theoretical background of quadratic form require that the function is of the following nature and properties:-

(i) The functional form permits both positive and negative marginal products of the total production function: And hence a quadratic form is capable of explaining the decline in total product as a result of high input levels.

(ii) Does not allow both increasing and decreasing marginal products.

(iii) The maximum of the total output curve can be determined by

$$\frac{dY}{dX} = 0$$

Quadratic analysis is used widely for livestock and crops responses. It was used at Katumani in 1978, by Feldman (7) to analyse fertilizer response. Its popularity in crop and livestock responses can be attributed to its capacity to amendments to accommodate different biotechnical relationships.

Different quadratic functional forms, such as those in appendix V, were analysed. Results in appendix V and a statistical comparison of the two final quadratic functions quadratic 11 and 111, and a linear form is included in the table for comparative purposes. Also included in the appendix V are the results of a quadratic function ran with a homogenous source of data from a sample that was exclusively zero grazing. The sample size was however, much smaller than the rest i.e. 65 zero grazing.

The functional results in table 5.6 present the most suitable form for the data used. The criteria used in its final selection are disccussed later. The function is later subjected to the relevant economic analysis which follows in Chaper 6.

Statistical analysis and biotechnical logics were used for determining the best fit among the possible quadratic regressions. The statistical approach is based on least square estimation's t and R^2 values.

---

13 Continued

Where:

$\frac{dY}{dx}$ is the rate of change of the tota products curve defined by the first deriva

(iv) Intercept, a, defines the output at zero factors le

Table 5.6 Quadratic Regression Function of Milk

Independent Variable	Symbol	b Coefficient	Standard Error	t Statistics
Intercept		-278.86		
Farm forage	F	-44.11	329.14	0.13
Farm by-products	B	-36.94	882.94	0.04
Concentrates	C	1.24	0.26	4.76**
Number of cows	N	-14.22	15.59	0.91
Days in milk	D	6.87	1.40	4.92**
Lactation number	L	22.49	97.28	0.23
Square terms	B^2	1279.93	782.21	1.64
	L^2	4.15	7.37	0.56
Interaction terms, or Crossproducts	FB	-872.04	1021.73	0.85
	FC	0.39	0.81	0.49
	BC	-1.36	0.73	1.85
Multiple correlation	R^2	0.667		**

SOURCE : Computer Printout

* See Page 62

** See Page 62

A comparison of coefficients of multiple correlations, R^2s, values show that quadratic II has 0.96 and quadratic III has 0.67[14]. Statistically both of the coefficients are highly significant, i.e. at 0.01 and 0.05 (6) levels of significance. It is therefore not possible to reject anyone of the quadratic functions on those bases. Quadratic II may appear a statistical fit in that it explains 96% of the variance, whereas quadratic III explains 67% of the variance, but these differences are not adequate for crucial decisions, and hence, move to the t statistics values.

The 'students' t statistics of the two functions tie-up by number of statistically acceptable coefficients at 0.05 level of significance. Quadratic III had a slightly higher means of t statistics i,e, quadratic III mean t statistics was 1.49 and quadratic II has a mean of 1.48 values.

The decision criteria were therefore coupled with the basic biotechnical logics of the mathematical regression functions; i.e.

i) The coefficient signs

The coefficient signs in the two quadratic functions were not different and therefore this

---

14 See appendix V for quadratic II and III.

criterion could not be used as a basis of selecting the best functional form.

ii) Interaction terms

An interaction term is incorporated as a cross-product of variables. The variables cross multiplied were B, C and F which were assumed to interact in milk productivity. This phenomenum is discussed in the previous chapters.

The only statistically acceptable interaction coefficient was that of BC i.e. the interaction of by-products and concentrates. These were significant at 0.05 levels.

Quite unexpected, quadratic II's FC coefficient indicates there is 0.00 interaction between farm forage and concentrates. There is a proven[15] interaction between the roughage and concentrates in ruminants' nutrition.

e) Intercept coefficient

Quadratic III has an intercept of -278.86, whereas quadratic II has no intercept. Biotechnically, in the milk production function the constant depends on the number of variables

---

[15] Proven here means, elsewhere in other biotechnical work or experiments. such as, Madden, J.P. et al (27).

and undetermined levels of unaccounted for variables. The intercept for this matter is not a suitable criterion for determining appropriate algebraic function.

In the final analysis, the quadratic III is therefore selected for the purpose of all the discussions hereafter, including economic analysis.

f) Correlation among explanatory variables

Attempts to estimate meaningful multivariate production function is frequently impaired by occurrences of high correlations among explanatory variables. Situations whereby such high correlations adversely effect both the statistical and the technological interpretations of the function are termed as multicollinearity problem. The precision of the parameters are significantly reduced by multicollinearity.

The magnitude of this problem is tested in this study by zero order correlation, directly available from XDS3 computer statistical programme; results of which are presented in appendix III. The variable correlation matrix for explanatory variables range from 0.012 to 0.458 for linear variables the squared and the cross-products had expectedly higher variables due to mathematical interaction. The results can therefore be accepted as unbiased estimate of the biotechnical condition. Reservations to this only go to F parameter which has two of its correlations with C and N slightly higher i.e. 0.458 and 0.456.

This explains the reason for the F parameter being unexpectedly statistically insignificant. Non conformity with research expectations regarding the parameter significances is not a sufficient criterion for rejecting such a variable from the function. The bounds of acceptance depend on the structure of problem under consideration and the magnitude of the multicollinearity problems, and thus a general bound is not stated here.

The function therefore determined, namely the quadratic function, is deemed to adequately represent milk production condition. There is also sufficient justification for relying on the methodology used which demonstrates that alternatives have been systematically examined. Equally true, there have been substantial changes in milk production functions analysis, in which all the time have entailed new approaches.

CHAPTER 6

ECONOMIC ANALYSIS

For decision making at farm level and at national level an economic assessment is important. The grassroot of the national objectives is basically the farm and therefore the method employed here is that of farm enterprise profit maximization.

Viable development of the farm is necessarily based on the farm's economic achievements, not merely on physical productivity. And hence, for a sound economic analytical framework a production function was derived *vis-a-vis* Chapter 5, which also provided means and ways for technical analysis. The technical analysis comprised statistical analysis, the schematic presentation of the milk production model, and a comparision of different types of known milk production functions. The functions considered included, the linear, the Cobb-Douglas and the quadratic relationships. One of the quadratic functions was adopted on its own merit over other functions.

The technical analysis gave the tendency for the economic to be able to concentrate on popular problems and issues of farming. Thus, the ultimate aim in estimating the appropriate milk production function being to set up some bases for econ appraisal for small scale farms milk enterprise. The economic relevance of the function is reflected in this section.

The function is in this section utilized beneficially to determine economic parameters, such as best operating conditions, least cost feed combinations and points of profit maximization by method of marginal analysis. The principle of marginal analysis is discussed later. Other production function parameters worked in this section are the physical maxima of milk yield per cow.

The marginality principle is applied under some stipulated assumptions of this economic model. This is also covered in this section.

The section is subdivided under four subsections described as the economic model, marginal analysis, hypothesis testing and the economic analysis with linear and Cobb-Douglas[16] - functions.

6.1 The economic model

The economic model makes it feasible to analyse sets of choices within a framework of limited resources. The economic model that concerns us is that which maximises profits by the method of the mathematical production function.

---

16 A comparison with Cobb-Douglas economic model was attempted but dropped. The function gave unrealistic figures in the marginal analysis and therefore its rejection was further justified.

The algebraic technical production function model selected for economic analysis is given as 6.1.1.

$$M = -278.86 - 44.11F - 36.94B + 1.24 - 14.22N + 6.87D + 22.49L$$

$$\qquad (329.14) \quad (882.94) \quad (0.26)^{**} \quad (15.59)^{**} \quad (1.40) \quad (97.28)$$ [17]

$$+ 1279.93B^2 + 4.15L^2$$

$$(782.21)^{**} \quad (7.37)$$

$$- 872.04FB + 0.39FC - 1.36BC$$

$$(1021.73) \quad (0.81) \quad (0.73)^{*}$$

$R^2 = 0.67$

Where

M = Milk yield per cow per year in Kgs.

F = Farm grown forage in hectares.

B = Farm by-products available to the dairy cows in hectares per year.

C = Kilogrammes of concentrates.

N = Number of cows in the herd per year or the herd size

D = Mean number of days in milk per cow in the herd.

L = Mean lactation number of the herd.

This subsection looks into the assumptions applicable in the economic analysis of milk yield. The assumptions are stipulated as follows:

---

17 Figures in the paranthesis are standard errors of the b coefficients above them.

i) Dairy farmers are cash oriented.

ii) Maximization of farm family welfare is a function of economic returns, and not necessarily the functior of physical output. Thus, profit maximization is a more relevant parameter than the yield maximization.

iii) The applied model is comparable with other attempts to explain resources allocation in livestock sector.

iv) Land size and labour are important indicators, which are conveniently reflected in herd size and farm by-products available to dairy cows here.

6.2 Marginal analysis

Marginal analysis is an economist's method for economic optimization of the use of the limited resources. By definition the marginal physical product is the physical amount by which the yield, or total product, is changed by single unit change in factor input. For economic optimizat prices and costs are included, so that it is required tha farms operate in the range where marginal products is positive but decreasing.

The total production function equation estimated i table 5.6 is given below. Only three of the variables considered in the main analysis. The main reasons bein to simplify the calculus of optimization but other reasons included parameters statistical biotechnical importance. The other three variables were fixed at their mean values. These three are the herd size or the number of cows in the farm herd, N, average number of days cows are in milk, D, and the mean lactation number, L.

Total product equation is given as:-

$M = f(F,C,B)/N,D,L$[18]

The mean values that these variables are held constant are given as:-

$\bar{N} = 4.54$

$\bar{D} = 294.53$

$\bar{L} = 3.98$

Whereas the total production regression is depicted as:-

6.2.1 $$M = 1769.51 - 44.11F - 36.94B + 1.24C + 1279.93B^2 - 872.04FB + 0.39FC - 1.36BC \qquad 6.2.1$$

The highest milk yield could be specified for the variables farm forage, farm by-products and concentrates by setting the partial derivatives, or the marginal productivities of these inputs to equal zero. At this point it was found that farm forage is not an important variable as its b parameters were

---

18 N,D,L, held constant at their mean values. The actual function applied has the general form as:-

$$M = a + b_1F + b_2C + b_3B + b_4\bar{N} + b_5\bar{D} + b_6\bar{L} + b_7B^2 + b_7\bar{L}^2 + b_8FB + b_9FC + b_{10}BC$$

all insignificant, and that it gives a negative value at the optimum milk yield. For this reason and statistical significances lead to dropping F, farm forage, and setting its level at its means. Hence equation 6.2.2 replaces 6.2.1, thus:-

$$M = 1755.30 - 317.82B + 1.37C + 1279.93B^2 - 1.36BC \qquad 6.2.2$$

The first differentials, marginal productivities of farm forage and concentrates are obtained, thus:-

$$MP_B = \frac{dM}{dB} = -317.82 + 2559.86B - 1.36C = 0$$

$$MP_C = \frac{dM}{dC} = 1.37 - 1.36B = 0$$

By simultaneously solving for B and C the feeding levels for by-products was obtained as 1.1411 hectares, and for concentrates was obtained as 1662.40 kgs per year. At these levels of feeding a milk yield of 2756.86 Kgs of milk obtained per cow per year.

This milk yield obtained at feeding 1662.40 Kgs of concentrates and 1.1411 hectares of by-products and setting all the other variables at their means as table 4.2 gives the technical maximum milk yield per cow obtainable in production function analysis of the sample farms.

For economic optimization price consideration plays an important role. This involves maximization of profits with respect to input variables, i.e.

$$\frac{d\Pi}{dX_i} = 0$$

Where II is the profit function given by $\Pi = p_yY - p_iX_i$

Where py is the price of product, and Y is the yield

Xi is the factor input and

pi is the factor cost.

Economic optima give the best operating conditions. Our function being unconstrained, best operating conditions are obtained by setting marginal productivities to their inverse price ratios.

$$\frac{dM}{dB} = \frac{Pb}{Pm},$$ [19]

and,

$$\frac{dM}{dC} = \frac{Pc}{Pm}$$ [20]

---

19 $\frac{dM}{dB}$ is the partial derivative of by-products with respect to milk yield, or MP_b

Pb is the factor cost of by-products per unit

20 Pc is the factor cost of concentrates per Kg. And $\frac{dM}{dC}$ is the partial derivative of concentratrs with respect to milk yields, or MPc

Pm is the price of milk per Kg.

Therefore, by simultaneously[21] solving for B and C levels of by-products and concentrates, the economic optimum is obtained. B at this point equals to 0.375 ha. of farm grown by-products and C is equal to 365.60 Kg of concentrates per cow.

At this input level there is economic optimization, from our unconstrained production function. Similarly a milk yield of 2130.52 Kgs[22] is obtained under the best operating conditions.

Thus, farmers feeding their animals at this levels maximize profits, *ceteris paribus*.

---

21 Hence, for by-products: $\frac{dM}{dB} = \frac{Pb}{Pm}$

$$- 317.82 + 2559.86B - 1.36C = \frac{509^{*}}{1.0g}$$

* See appendix VII, VIII and IX. For concentrates therefore, $\frac{dM}{dC} = \frac{Pc}{Pm}$, $1.37 - 1.36B = \frac{.95}{1.10}$

22 Best operating condition is obtained by substituting the values of B and C into equation 6.2.2

Thus, 6.2.3

$$M = 1755.30 - 317.82\ (0.375) + 1.37\ (365.60) + 1279.93\ (.375^2) - 1.36\ (.375)\ (365.60)$$

$$= 2130.52 \text{ Kg.}$$

6.3 The economic analysis with linear function model

The resulting linear model 5.1.2 showed a high level of statistical significance, the b coefficients signs were biotechnically logical.

Subjecting the function to marginal analysis reveals the following:-

i) the partial differential of B with respect to M yield.

$$\frac{dM}{dC} = 1.24$$

ii) the partial differential of C with respect to M gives

$$\frac{dM}{dB} = 245.80$$

The best operating condition for C and B is obtained where their marginal productivities equal to their inverse price ratios, i.e.

$$\frac{dM}{dB} = \frac{P_B}{Pm}\text{, and}$$

$$\frac{dM}{dC} = \frac{Pc}{Pm}\text{ and therefore,}$$

$$\frac{dM}{dC} = 1.24 = \frac{Pc}{Pm}$$

$$1.24 = \frac{Pc}{Pm}$$

If we take the price of concentrates to equal Shs. 0.95[23] per Kg., the price of milk has to be Pm per kg inorder for the farmer to operate at the economic optimum.

$$\frac{Pc}{Pm} = 1.24$$

$$Pm = \frac{0.95}{1.24} = 0.76$$

The price worked at economic optimum is Shs. 0.76 per kg, but the price given by the Kenya Co-operative Creameries is at a mean of Shs. 1.10 per kg, and therefore profitable to the farmer.

Suppose, at this price given by KCC we want to find out the most favourable price for concentrates for dairy farmers. Once again, we use the principle of marginality i.e. by setting the MPs to equal to inverse price ratios.

$$\frac{dM}{dC} = \frac{Pc}{Pm}$$

and therefore,

$$1.24 = \frac{Pc}{1.10}$$

$$Pc = 1.36$$

We can state that farmers are buying concentrates at a

....

23 See appendix VIII, and appendix VI

lower price ratio than the optimal price might dictate.

We can therefore say that the use of concentrates in milk productivity is justifiable so long as the prices do not exceed Shs. 1.36 for concentrates and that of milk does not go below Shs. 0.76.

6.4 Hypotheses testing

a) The hypothesis that milk yield per cow is a function of feed input, other factors held constant, has been clearly established in production function analysis Chapter 5. The scattergraph section 4.5 further supported this point. In all the analyses carried out, concentrates turned out to have been the most significant attribute.

It is therefore stated with confidence that milk yield per cow in small holder farms is a function of feed inputs, other factors held constant.

b) The second hypothesis postulated that farmers operate below the economic optimum level of intensity. This can be rejected in view of the fact that the farm's feeding levels are within the economic optimum point of the production function *vis-a-vis* table 6.4.

Table 6.4

A Comparison of Economic Optimum with Technical Optimum (Maximum) and the Farm's Average

	Technical Optimum	Economic Optimum	Farm Average
By-products ha	1.141	0.375	0.221
Concentrates Kg	1662.40	365.60	328.74
Variable costs of feeds (Shs)	2160.10	538.00	424
Milk Yield per cow (Kg)	2756.86	2130.57	2146.88
Gross return (Shs)	3032.55	2344.00	2361.55
Return to by-products and Concentrates	872.45	1806.00	1937.55 [24]

Source: Author

24 The discrepancy revealed here by higher mean values than the economic optimum is due to the fact that the computer programme used missing figures to work the regression. The means in table 4.2 were worked with zero values instead of missing figure value in the independent variable. In simple non-statistical analysis this difference is not warrantable.

It is particularly interesting to note the farmers' means and the economic optimum. The disparity revealed is not sufficient to justify accepting the hypothesis that farmers are not rational. This is true to some limits as the farms' minimum and maximum levels give wide range. Thus, we can say a majority of the farmers are rational entrepreneurs[25].

At this juncture, it is worthwhile to note the magnitudinal difference in profits between the technical optimum and the economic optimum. Whereas it can be said that a majority of the farmers are rational so as not to operate outside this optimum region, others do so to their disadvantage to get sub-optimal profits. See appendix X.

On the other hand, too often the technical optimum is recommended by animal husbandry and agricultural extension services. And too frequently, planners base the programme on technical assumptions, and only rarely on economic optimum and therefore, rendering national objectives infeasible. Basically, it is important to realise that farmers act rationally from a micro-economic point of view, and therefore Government plans should bare this in consideration.

---

25 See appendix IX

CHAPTER 7

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The basic concept underlying the investigation of milk production with some emphasis on the economics of small holder production has been attempted. This study is a pre-requisite for quantifying the empirical nature of milk production function, of smallholder farms of Kenya Highlands.

The study is based on high potential farming areas of Kenya Highlands where it is estimated most of the grade dairy farming occurs. The analytical data is exclusively from the survey carried out in 11 districts.

The data were subjected to the economic and statistical analyses with the view of determing main factors which influence the economics of milk production in small holder farms in Kenya. The final chapter is broken down into summ conclusion and policy recommedations.

7.1 Summary

The Government's strategy in dealing with the increase in national milk demand being increasing milk production volume through smallscale farms, an enterprise constraints determination study is of great relevance. Profit maximization form the basis of small scale farm viability. The basic requirements for small scale farm developments and incentives are therefore based on profit maximization. The study therefore, has a primary objective of increasing small scale farm profits through an enterprise model analysis.

The objectives of this study had the *a priori* objective of determining the factors contributing to milk yield per cow by:-

a) Selecting the most suitable milk production function for small scale farms.

b) Establishing guidelines for increasing efficiency in milk production in small scale farms.

c) Work out the economic optimum for milk production at changing factor - product prices.

Two hypotheses were tested. These were analysed under the following working hypotheses.

a. Milk yield per cow is a function of feed input, other factors constant.

b. Within the given farm framework the farmers are operating below the economic optimal level of intensity.

These hypotheses were formulated as *a priori* postulations suggested that milk yield per cow is determin by a set of six variables. These included farm grown forage, farm by products utlizable by livestock as feeds, concentrates produced in the farm and those that are bought and three other auxiliary variables stated as herd size, mean number of days in milk and the lactation number which can be said to reflect the age factors of milking herd.

The methodology that was followed scrutinized all these variables statistically in different production function analysis. The statistical analysis and the biotechnical relationships revealed the algebraic of the function applicable in small holdings of high potential farms of Kenya Highlands. The data for analysis was from a survey carried out by Smallholder Dairy Enterprise Recording scheme, Naivasha.

After systematically trying various forms, a quadratic form was found/the best fit for the data. This form was subjected to the economic analyses with the view of determining the main factors which influence the economics of milk production.

/to be

The research yielded several important findings:-

a) That milk production is mainly a function of concentrates, other variables such as farm grown forage were also postulated to influence milk production but their impact was not found to be significant at 0.05 level of significance.

b) The model also established that milk yield in small scale farms is a non linear function of concentrates inputs, average number of days cows are milked in a year, farm by products and concentrates - byproducts interaction. Thus, farms feeding substantial amounts of concentrates derive higher milk yields from their dairy stocks than farmers purely grazing_cows, or depending entirely on roughage.

The second major result pertained to the economics of small holder milk production. The economic analysis of milk production revealed in general;

a) That the farmers are economically rational in decision making process and

b) that dairy enterprise is a profit oriented agribusiness whereby profits are maximised.

Generally, these facts are revealed by subjecting the various functions to the marginal analysis procedure. The principle establishes that farms are on average operating within the economic limits, and that both the producers prices of milk and the cost of concentrates are justifiably in favour of the dairy farmer. These benefits could only be disrupted by a drastic rise in price of inputs, without a corresponding rise in milk price, *ceters paribus*. The range limits of the prices of the model are quite wide, and hence a stable system.

The formulated model also indicated that the management of mean number of cows in milk is important. It showed that milk yield per cow in the farm firm is a linear function of the mean number of cows in milk. Thus, herds with cows dry for long periods reduce the income accrued to dairy herd. It was also found that farms with large herds exhibit diseconomies of size as far as milk yield per cow is concerned. Thus, the coefficient of herd size, N. reflected negative sign and downwards trend in scattergragh figures 4.5

7.2. CONCLUSION AND POLICY RECOMMENDATIONS

In any strategy for economic development, the performance of the agricultural sector is crucial for LDC states like Kenya where over 80% of the population is rural. In the past, LDC's agricultural production was generalised as peasantry and subsistent. Today, the greater emphasis is placed on social objectives, such as equity, reduction in unemployment and elavated rural welfare. These objectives cannot be achieved unless the small holding production is oriented towards profit maximization.

Improving agriculture involves being in a position to define the constraints that impede productivity. For instance, this study attempted to identify the major factors influencing small holder milk production. These factors were empirically determined.

The problem in milk production seems to lie with the feeding management of the dairy cows. The single most important factor is the level of feeding concentrates. Concentrates as major source of energy input carry the biggest share in cost of milk production.

A focus on small holder milk production reflects that specialization is on semi-zero, and also that concentrates form the bulk of energy source. This is the reverse of large scale dairy ranches[26]. It can therefore be said that in milk production the management of costs should centre on the cost of concentrates.

Varying the feeding regimes in dairy herd is reflected in the profit function. The farms were found to operate within a wide range of feeding and other aspects of dairy stock, which contributed to establishing a response surface. On this surface lie the economic optimum and a technical maximum.

The mean farms lie within the economic optimum. But, since the data showed large standard deviations we should not assume that a majority of the farms are definitely at best operating condition. The recommendations, therefore should be treated with care.

The marginal analysis method employed to calculate optimal operating conditions require that farms operate to the point where marginal revenue equals marginal costs. Thus, also, the marginal productivities set to equal the inverse price ratios. The findings here dictate that farms should operate at a feeding rate of 0.375 hectares of by-products source per cow and 365.60 Kg of concentrates

---

26 See map figure 2.1

per cow per year, and supplemented with some farm produced roughage[27]. Deviations from this level reduce incomes.

It was also found out that the prevailing factor product prices of milk, concentrates and roughage are favourable to the producer. The milk prices set at a price greater than or equal to Shs. .80 and concentrates set below or equal to Shs. 1.35 is on the profit end[28]. Thus, unless there is a drastic rise in prices of concentrates, without a proportionate rise in price of milk, the dairy farmer should continue to produce milk. Remarkably though, a rise in producer price of milk will only serve as an incentive to the farmer, but will not boost milk productivity greatly

The other aspect on the economics of dairy is the nature of the availability of concentrates throughout the year. The fluctuations realised in milk supply cannot be alleviated unless concentrates are in constant supply in the farms.

The concurrent shortage of concentrates in shops and lack of pastures during dry seasons need to be investigated in later works.

It was also established that the management of the mean lactation number is an important aspect. In its own context

---

27 This parameter proved statistically insignignificant, but its importance is established in other studies.(27)

28 See appendix VI and VII.

refers to the mean herd age. It is also recommended that old cows should be culled and replaced with younger stocks. Other management features of a productive dairy herd is the steaming up aspect and quality of feeds.

The research here dwelt on semi-zero system of high potential mixed farming areas, and therefore, the interacive effects of the system should be investigated to establish the whole farm constraints and their direct effects on dairy. It is also recommended that other milk functions should be established so that each could be applied in a specific area. Other studies should include functions covering large scale farms, ranches and grazing farms.

The policy implications of the findings are quite relevant as a guideline to increased small holder milk production. The findings also suggested that increasing dairy herd will reduce the efficiency in milk production sector in contradiction with the strategy taken by the Development Plan (35), which suggests increasing milk production by increasing small holder herd sizes. If this plan's strategy is to be adopted, other constraints, such as labour, will have to be increased simultaneously as they limit the efficiency in small scale farms. This study further emphasizes the need for more studies to guide national planning policies.

Also, as a matter of policy implications, it is important to note the discrepancy which could arise while basing ambitious Governmental Plans on technical optimum instead of basing on micro-economic optimum. The findings indicate that farmers act rationally from micro-economic point of view, and therefore, too often farmers are blamed for production volume below Government plans - for no good a reason!

BIBLIOGRAPHY

1. Anderson, J.R. and Dhillon, J.L
   "Economic Consideration in Response Research".
   American Journal of Agric Econ, Vol 50
   No 1, February 1968.

2. Ashe, A.J.
   "Response of Milk Production to Increased Grain
   Feeding" Farm Econcmic, No. 174, Cornell
   University, 1950.

3. Brokken, R.F. et al
   "Framework for Economic Analysis of Grain Versus
   Harvested Roughage for Feedlot".
   American Journal of Agricultural Economics
   Vol. 58 No 2, May 1976.

4. Carley, D.H.
   "Silage - concentrates substitution: Effects
   on Milk Production and Income Over Feed Cost in
   D.H.I.A. Herds",
   American Journal of Agricultural Economics
   Vol. 55 No 4, 1973.

5. Catt, D.C.

"Surveying Peasant Farmers - Some Experiences".

Journal of Agricultural Economics Vol. XVIII No. 1, 1966.

6. Doran, M.H. Et al

"Cattle as a Store of Wealth in Swaziland : Implications for Livestock Development and Overgrazing in Eastern and Southern Africa".

American Journal of Agirultural Economics Vol. 61 No. 1 Feb. 1979.

7. Feldman, D.

"The Economic Analysis of Production Response".

Farm Systems Training Workshop, Ministry of Agriculture (SRD), Kenya, October, 1979.

8. Gossling, W.F.

"The Economics of the Holstein Friesian Cow".

Journal of Agricultural Economics XV, No. 4.

9. Gossling, W.F.

"The Ontorio Shortrun Milk Supply Curve".

Canadian Jouranl of Agricultural Economics Vol. XII No.1, June, 1964.

10. Gullison, A.E.

"Feeds and Feeding".

Va Reston Publishing Co., 1975

11. Hardaker, J.B.

"A Review of some Farm Management Research Methods for Small Farm Development in LDCs".

Journal of Agricultural Economics Vol. XXX, No. 3, 1978.

12. Heady, E.O.

"An Econometric Investigation of the Technology of Agricultural Production Functions".

Econometrica, Journal of the Econometric Society, Vol. 25 No. 2, 1957. North Western University, Illinois, U.S.A.

13. Heady, E.O.

"Elementary Models in Farm Production Economics Research".

Journal of Farm Economics, Vol. XXX No. 2, May 1948.

14. Heady, E.O.

"Organization Activities and Criteria in Obtaining and Fitting Technical Production Function".

Journal of Farm Economics, Vol. XXXIX, No. 2, May 1957.

15. Heady, E.O.

"Production Function from a Random Sample of Farms".

Journal of Farm Economics, Vol. 28 1948.

16. Heady, E.O. and Dhillon, J.L.

Agricultural Production Functions Iowa State University Press, Ames Iowa, 1961.

17. Huang, W.Y.

"A Framework for Economic Analysis of Livestock and Crop By-products Utilization".

American Journal of Agric. Economics, Vol. 61 No. 1, February, 1979.

18. Hock, I.

"Returns to Scale in Farming: Further

18. contd.

Evidence Cobb Douglas used".

American Journal of Agricultural Economics, Vol. 58 No. 4 Nov. 1976 Part 1

19. Huffman, C.F. and Dancan, C.W.

"The Nutritive Value of Alfalfa Hay".

Journal of Dairy Science, 32, 1949

20. Irungu, K.R.

"The Feeding of Lactating Dairy Cows"

N.A.H.R.S. Naivasha, 1979.

21. Jensen, E. et al

"Input-output Relations in Milk Production".

Technical Bulletin 815, USDA Washington D.C., 1942.

22 Just, R.E. and Pope, R.D.

"Production Function Estimation and Related Risk Consideration".

American Journal of Agricultural Economics Vol. 61, 1979 May.

23. Keith, Cowling and Gardner, T.W.

"Milk Supply Response : An Interbreed Analysis".

The Statistician, Vol. 14 No. 3, 1957

24. Keith, Cowling.

"Labour input in Milk Production. An Analysis of Qualatative and Quantatative Determinants"

Farm Economist, Vol X No. 4, 1963.

25. Kenya Cooperative Creameries.

Annual Reports 1964/1979

K.C.C. NAIROBI, 1980.

26. Linle, C.H. and Dockson, G.A.

"Measurement of Kakage by use of an Input-Output Model".

American Journal of Agric. Econ., Vol. 50 No. 4 Nov. 1968.

27. Madden, J.P. et al.

"Milk Production Functions in Relation to Feed Inputs, Cow Characteristics and Environmental Conditons".

Agricultural and Home Economics Station, Iowa State University of Science and Technology Research Bulletin 529, July 1964, Ames, Iowa.

28. Matulich, Scott C.

"Efficiencies in Large Scale Dairying Incentives for Future Structural Change". American Journal of Agricultural Economics, Vol. 60 No. 1 Nov. 1978.

29. McInerney.

"Towards a New Emphasis on Management, An Approach through Small-holding Reform". Journal of Agricultural Economics Vol. XVII No. 1, May 1966.

30. Ministry of Agriculture,

Annual Report 1977/77. Dairy Enterprise Recording Scheme, Naivasha, Nov. 1977.

31. Paris, Q. et al.

"A Note on Milk Production Function" American Journal of Agricultural Economics, 52 : 594-598, Nov., 1970.

32. Paulsen A. and Koldor, R.D.

"Evaluation and Planning of Research in Experimental Station". American Journal of Agriculture Economics, Vol. 58 No. 1, February, 1976.

33. Paulsen A, et al.

"Economic Impact of Restricting Feed additives in Livestock and Poultry Production".

American Jouranl of Agriculture Economics, Vol. 58 No. 1, February, 1976.

34. Per-Pinstrup - Andersen et al.

"Impact of Increasing Food Supply on Human Nutrition. Implications for Commodity Priorities in Agricultural Research and Policy".

American Journal of Agricultural Economics, Vol 58 No. 1, November, 1976.

35. Republic of Kenya.

Development Plan 1979-83 (Section 6.100)

Government Printers, Nairobi, 1979.

36. Rogers, G.L. et al.

"For Economic Optima on Rations".

N.Z. Journal of Agricultural Research No. 22, 1979.

37. Ruigu, G.M.

An Economic Analysis of the Kenya Milk

37. contd.

Subsystem.

PH.D. Thesis, Michigan State University, 1978.

38. Shashanka, Heady, Meton.

"Direct Estimation of Gain Isoquant. An Application to Beef Production".

Journal of Agricultural Economics, Vol. XXX No. 3.

39. Sorenson, M.P.K.

"A Review of Some Farm Management Research Methods for Smallffarm Development in LDCs".

Journal of Agricultural Economics, Vol. XXX No. 3.

40. Stotz, D.

"A Guide to How to Evaluate Dairy Enterprise Records for Small-scale Farms."

Dairy Farm Management, Handout, Nairobi, Dec., 1976.

41. Stotz, D.

Development of Dairy Industry in Kenya.

(Unpublished Ph.D. Thesis),

Stuttgart University, February, 1979.

42. Stotz, D.

Development of Small-holder Dairy in

Kenya.

Livestock Development Project Course

(ILCA), March, 1978.

43.

Implications of Assuming Log-linear

Disturbance. Fertilizer Response

Experimental Data.

American Journal of Agricultural Economics,

58 No. 1, February, 1976.

44. Tesfaye, Cebremeskel et al.

"Farm Planning and Calf Marketing

Strategies for Risk Management. An appli-

cation of L.P and statistical Decision

Theory".

American Journal of Agricultural Economics

Vol. 61, No. 2, May, 1979.

45. Upton, M. and Dalton G.

"Linear Production Response".

Journal of Agricultural Economics,

Vol. XXVII, No. 2, May 1976.

46. Wannacott, T.H. and Wannacott, R.J.

Introductory Statistics.

John Wiley and Sons, New York, Hamilton

Publication.

47. Wannacott, T.H. and Wannacott, R.J.

Econometrics

John Wiley and Sons, N.Y., Hamilton

Publication.

48. World Bank/IDA

Annual Report 1973.

Washington, D.C., 1973.

49. Yates, F., et al.

"Influence of Changes in Level of Feeding on Milk Production".

Journal of Agricultural Science, No. 32, 1942.

50. Young, D.L.

"Resources Allocation and Risk. A Case Study of Small-holder Agriculture in Kenya, Comment".

American Journal of Agricultural Economics. Vol. 61 No. 1 February, 1979.

51. Kenneth E. B.

Agricultural Economics in an Evolutionary Perspective.

Journal of Agricultural Economics Vol. 63

Number 5. December 1981. Proceeding issue.

Appendix II

Abbreviations Meaning or Descriptions

Symbol or Abbreviation	Description or Meaning of Symbol or Abbreviation used
M	Milk yield per cow in Kgs.
F	Farm grown forage in ha. per cow.
B	Farm by-products derived from crops per cow.
C	Concentrates in Kg. fed per cow.
N	Mean number cows in the herd.
D	Mean number of days in milk per cow.
L	Mean lactation number in the herd.
*	Depicts 0.05 level of statistical significance.
**	Depicts 0.10 level of statistical significance.
R^2	Coefficient of multiple determination.

ZERO ORDER MATRIX

VARIABLES	M	F	B	C	N	D	L	F^2	B^2	C^2	L^2	FB	BC	CF
MILK	1.000	-.3478	0.0070	0.5426	-.3024	.4558	.0944	-.2794	.0348	.4719	.1075	-.1614	.2671	.239
F	-0.3478	1.0000	0.1912	.4569	.4585	-.1949	.0336	.9431	0.1575	-.3568	.0138	.6098	-.1765	.162
B	-0.0070	..1912	1.000	.0954	.05428	-.1200	-.1290	.1724	0.9333	.0744	-.0410	.7873	.5908	.2938
C	0.5426	-.4569	.0955	1.0000	.2244	.26686	-.0309	-3273	0.0946	.9122	-.0262	-.1629	.5951	.5384
N	-0.3024	.4585	-.0543	-.2244	1.0000	-.3333	.0124	.4055	-0.0580	-.1634	.9339	.1697	-.1715	-.0023
D	0.4558	.1949	-.1200	0.2669	-.3333	1.0000	-.0531	-.1579	-0.0804	.2467	.0103	-.1975	.1576	.0903
L	0.0944	0.0336	-.1289	-0.0309	.01242	-.0531	1.0000	.0447	-.1133	-0567	-.0812	-.0327	-.0999	.0189
F^2	-0.2794	.9431	.1724	-.3273	.4055	-.1579	0.0457	1.0000	.1346	-.2410	-.0425	.5864	-.1258	.1625
B^2	0.0348	.1575	.9333	.0946	-.0580	-.0804	-0.1133	.1346	1.0000	.0950	1.0000	.7528	.5833	.2383
C^2	0.4719	-.3568	.0744	.9122	-.1634	.2467	-.0567	-.2409	.0950	1.0000	-0.049	-.1369	.5190	.3217
L^2	0.1075	.0138	-.1054	-.0410	-.0497	-.0262	0.9339	.6103	-.0812	-.0425	1.066	-.0486	-0655	-.0267
FB	-0.1614	.6098	.7873	-.1629	.1697	-.1975	-.0327	0.5864	.7528	-.1369	-.0486	1.0000	.1785	.2911
BC	0.2671	-.1765	.5908	.5951	-.1715	.1576	-.0999	-.1258	.5833	.5190	-.0655	.1785	1.0000	.4841
CF	0.2400	.1627	.2938	.5384	-0023	.0903	.0189	0.1625	.2383	.3217	-.0268	.2911	. 4841	1.0000

FUNCTION LINEAR			COBB DOUGLAS			SQUARE			QUADRATIC		
endent able	b Coefficient	t Statistics	Independent Variable	b Coefficient	t Statistics	Independent Variable	b Coefficient	t Statistics	Independent Variable	b Coefficient	t Statisti
cept	-283.73		Intercept	1.35		Intercept	-	0.16	Intercept	-278.87	0.13
:	-198.98	0.96	F	-0.11	2.68	F	-73.02	0.13	F	-44.11	0.13
B	78.10	0.30	B	0.16	1.05	B	-835.72	1.22	B	-36.94	0.04
C	1.00	5.91	C	0.04	2.64	C	1.32	3.33	C	1.24	4.76
N	-15.53	1.01	N	-0.07	1.84	N	15.60	1.02	N	-14.22	0.91
D	6.73	4.88	D	1.04	6.44	D	6.37	7.49	D	6.87	4.92
L	73.30	2.18	L	0.11	1.51	L	12.70	0.15	L	22.49	0.23
						F^2	-53.21	0.15	-	-	-
						B^2	965.15	1.35	B^2	1279.93	1.64
						C^2	-0.0002	0.83	-	-	-
						L^2	4.49	0.67	L^2	4.15	0.56
									FB	872.04	0.85
									FC	0.39	0.49
									BC	-1.36	1.85
R^2	.653		R^2	.625		R^2	.960		R^2	0.667	

A STATISTICAL COMPARISON OF LINEAR AND QUADRATIC MODELS

Function	LINEAR			QUADRATIC I[1]			QUADRATIC II			QUADRATIC III	
Independant Variable	b Coefficient	t Statistics	Independent Variable	b Coefficient	t Statistics	Independent Variable	b Coefficient	t Statistics	Independent Variable	b Coefficient	t Statistics
Intercept	-283.73		Intercept	-453.43		Intercept	-	-	Intercept	-278.86	
F	-198.98	0.96	F	29.21	0.06	F	-4.88	0.01	F	-44.11	0.13
B	78.10	0.30	B	2742.88	2.02	B	-288.63	0.34	B	-36.94	0.04
C	1.00	5.91	C	- 3.62	1.79	C	1.70	3.82	C	1.24	4.76
N	-15.53	1.01	N	13.84	0.69	N	-16.20	1.06	N	-14.22	0.91
D	6.73	4.88	D	7.27	4.33	D	6.21	6.96	D	6.87	4.92
L	73.30	2.18	L	-36.39	0.31	L	-19.15	0.22	L	22.49	0.23
			F^2	63.17	0.92	F^2	16.22	0.05			
			B^2	2075.17	2.27	B^2	1391.99	1.78	B^2	1279.93	1.64
			C^2	0.004	1.42	C^2	- 0.0003	1.10	-	-	-
						L^2	6.81	1.00	L^2	4.15	0.56
			FB	-4676.98	2.28	FB	-742.94	0.76	FB	-872.04	0.85
			FC	7.96	3.20	FC	0.00	0.31	FC	0.39	0.49
			BC	5.92	3.18	BC	-1.28	1.85	BC	-1.36	1.85
R^2	0.653		R^2	0.725		R^2	0.961		R^2	0.667	

FOOTNOTE 1

Quadratic I was derived from Zero Grazing Farms of the sample.

Appendix VI

Milk and Milk Products, February, 1979

Grade	Gross Price Paid to Farmer KShs/Kg	Cost of Transport in cents /Kg	Cess deducted by KCC in cents /Kg	Producer Price KShs /Kg
1st Grade	1.27	10	3	1.14
2nd Grade	1.17	10	3	1.04
Mean Value[a]				1.10

Source:

Yields - Costs - Prices 1980

MOA, Land F.M. Division,

Nairobi, March, 1980.

[a] Mean value price used in the calculations.

Appendix VII

Prices of Concentrates

Item	Unit	Price per Unit Ksh	(Shillings) /Kg
Wheat bran	45 Kg	29.00	0.64
Maize bran	70 Kg	51.75	0.74
Wheat (rejected)	90 Kg	75.00	0.83
Feed Oats	70 Kg	80.00	1.14
Maize germ meal	70 Kg	65.00	0.93
Dairy meal	70 Kg	74.40	1.06
Dairy mix	70 Kg	82.65	1.18
Dairy cubes	70 Kg	74.40	1.06
Mean			0.9475
Standard deviation			0.1957

Source:

MOA, Land and Farm Management

Division, Nairobi, March, 1980.

Appendix VIII

Variable Costs of Forage Production

(Shs. / ha)

	Natural Pasture	Nandi[k] Setaria	Nandi Setaria +46Kg N	Nandi Setaria +76Kg N
Establishing costs				
Machinery Costs[a]	-	736	766	766
Seed [b]	-	315	315	315
Fertilizer[c]				
11:55:0			222	444
Transport fertilizer[d]			2	3
Total Establishing Cost	-	1051	1305	1528
Annual Establishing costs[c]		350	435	510
Machinery costs (f)	72	144	144	144
Fertilizer [g]	-	-	263	525
Transport	-	-	3	9
Fences [h]	15	15	15	15
Variable Costs/ha.	87	509	860	1203

Source: MOA, Land and Farm Management, Division, Nairobi, March, 1980.

Remarks

a) Cost of machinery use

This includes ploughing, harrowing, sowing, fertilizer, spreading and cultivation. This has been worked in Farm Management Service Book, March 1980.

b) Seed, Nandi. Setaria 7.5 per hactare @ Shs. 42/= = Shs. 315.

c) Based on 11:55:0 50 Kg for Shs. 222/- at K.F.A. Application 0,50,1000 Kg per hactare.

d) Transport for fertilizer based on 18 cents 100 Kg/Km. Assumed distance = 20km.

e) Assuming 3 years use of the ley

f) Slashing twice per year 1.25 hours for 1 operation. 1 tractor hour 80 hp) = Shs. 55. 1 hactare twice gyromown costs of repair x Shs. 17/= (Natural pasture = 1 cut with gyromower.

g) Based on CAN = Shs. 105/25 per 50Kg = Shs. 2/10 per Kg, application 0-125-250 Kg/ha.

h) Assuming cows kept in 15 ha. plots newly fenced, assuming shape 500 x 300 = 1600m. Fence approximately 106m per hactare, 4 strand of barbed wire at 30m. Posts every 8m (4"-5") and plan wire gates. 8 straining posts: Investment for cattle on leys.

k) Variable costs of Nandi Setaria assumed same as costs saved by use of by-products, i.e. if the farmer had no by-products, he would most likely rent a piece of land for grazing, or buy fodder from neighbours at price equal to (k). Hence, use of farm by-products is - a cost saving process in the whole farm.

Appendix IX

Some Descriptive Statistics of The Data

VARIABLE	MEAN	MINIMUM VALUE	MAXIMUM VALUE	STANDARD DEVIATION
Milk Kg	2173.79	701.00	5659.00	870.12
Farm Forage (ha)	0.47	0.03	1.80	0.32
By-products (ha)	0.22	0.00	1.16	0.21
Concentrates (Kg)	328.74	0.00	2087.60	355.75
Number of Cows	4.54	0.00	21.00	3.99
Days in Milk	294.53	148.00	373.00	40.99
Lactation	3.98	2.00	15.00	1.54

SOURCE : Author