AN ECONOMIC ANALYSIS OF THE KENYA MILK SUBSYSTEM

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1978

ABSTRACT

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The study was designed with the broad objective of contributing to the understanding of Kenya milk production, marketing and consumption as a subsystem of the Kenyan economy. The specific objectives were to:

1) Analyse the supply of commercial milk from the national dairy herd and project the supply to 1985 under alternative assumptions, 2) evaluate the supply response of smallholder milk production in the Central Province of Kenya using parametric linear programming in order to derive some guidelines for increasing smallholder milk production in the country, 3) determine income and price elasticities through the use of time series data, 4) estimate the consumption of milk and milk products and project the demand of these products using income, population growth and other explanatory variables, 5) analyse the results of supply and demand projections and determine optimal pricing policies; and 6) determine export levels of milk products and assess Kenya's ability to continue as an exporter of dairy products.

The data were derived from several sources, including the Central Bureau of Statistics, the Ministry of Agriculture, the

Department of Settlement, the Kenya Dairy Board, the Kenya Co-operative Creameries, Co-operative Unions, publications and personal interviews.

The methods of analysis included descriptive, regression, and parametric linear programming. Projections of milk supply were made for the period 1978-1985 using alternative assumptions. Time series data were used to estimate the demand equation of domestic fluid milk from which price and income elasticities of demand were computed. The domestic demand for milk and milk products were projected for the period 1978-1985 using the results of the regression analysis, the 1969 household budget survey, and other scenarios. A simultaneous analysis of supply and demand for milk was made to derive projections of dairy exports for the 1978-1985 period.

Optimal solutions were obtained by parametric linear programming for a representative farm in each of the three agroecological zones--the coffee, tea and high altitude grassland (HALTG) zone. The generated data were used to estimate a continuous milk supply function for each zone from which price and operating capital elasticities were determined.

The results of the supply analysis indicated an annual growth rate of 5 percent. The demand of milk was inelastic with respect to price but elastic with respect to income. The respective elasticities were: 0.65 and 1.18. The export of dairy products were substantial at the low domestic demand projections but they disappeared by 1984 at the high demand projections. The LP analysis reveals that substantial increases in farm incomes could be achieved through a reorganization of production. The percentage increases in farm incomes were

17.3, 14.5 and 7.2 for the coffee, tea and HALTG zone respectively as compared with actual incomes. The marginal value products (MVPs) of capital were high in all zones implying that increasing this resource would lead to income gains. The MVPs of labor were high in peak periods when hiring of extra labor would increase farm income. Land was an important constraint in the coffee zone. The supply of milk was more responsive to increases in operating capital than to increases in milk prices. The price elasticities of supply were 0.67 for the HALTG zone, 0.18 for the tea zone and 0.38 for the coffee zone. The corresponding operating capital elasticities were 1.88 for HALTG zone, 1.52 for the tea zone and 1.61 for the coffee zone.

The findings of the analyses provide many insights into the milk subsystem of the Kenyan economy and could be useful in formulation of agricultural and consumer policies.

DEDICATION

In the memory of my father, Ruigu Kabui, who encouraged me but unfortunately died before he could see this disseration; and to my dear mother, Wanjiru.

ACKNOWLEDGMENTS

The author wishes to extend much appreciation and thanks to Professor Carl Eicher, the chairman of the Guidance Committee for his inspiration and leadership throughout the entire period of the graduate program and in the preparation of this dissertation. The study program and thesis preparation benefited greatly from the insights, suggestions and constructive criticisms of Dr. Lester Manderscheid, Dr. Glynn McBride, Dr. Stephen Harsh, Dr. James Shaffer, Dr. Vernon Sorenson and Dr. Mark Ladenson. I am indebted to all of them for their individual contributions and intellectual influence.

Special appreciation is extended to the Rockefeller Foundation for financial support through the graduate program and for funding part of my research in Kenya; the Institute for Development Studies of the University of Nairobi for supporting and funding my research and for granting me study leave to complete this thesis at Michigan State University; my compatriot, Dr. Muthaka Mwangi, for comradeship and moral support; Ms. Lucy Wells and Ms. Judy Duncan for their patient and untiring assistance in typing the draft manuscript and George Sionakides for helping with computer programs.

I am grateful to my family, brothers and sisters who sacrificed in all ways to see that I completed my program successfully; and to Ms. Sarah Njeri Mbuthia for her patience and understanding. Without their support and encouragement this endeavour would have remained undone.

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SCOPE AND NATURE OF STUDY

Introduction

Dairy development in Kenya has reached a stage whereby it has become essential for the general welfare of the population. The projected increase in population and the need for upgrading diets requires a steady growth of dairy output. Higher incomes reinforce the increasing demand for dairy products. The required increase in production must, however, be accomplished on a decreasing land base. Marketing and processing plants should be capable of handling increased milk quantities without waste.

The importance of this study is reflected in the expressed policy and current thinking of the Kenyan government which calls for increased emphasis on rural development through intensification of production, increasing productive employment and increasing incomes. Smallholder dairy production promotes efficient production through integration with cropping activities and is also an important enterprise in its own right, helping to generate income and employment.

The Problem Setting

Great strides have been made since commercial dairying was introduced in Kenya at the turn of the 20th Century. The dairy industry has also undergone substantial transformation within the last

two decades. From a predominantly large-scale system of milk production in the early sixties it has reached a stage where smallholders now account for over 40 percent of total commercial milk output. Very soon they will account for half or more of the total milk output just as in other agricultural products like coffee, tea and pyrethrum. Although a high level of animal husbandry exists in some areas in other areas a lack of knowledge of improved cattle management, feeding and disease control measures are important constraints on increasing productivity. Even in such areas however, genetic improvement of indigenous zebu cows is under way.

Dairy producer and consumer prices are now established by administrative fiat. There are difficulties in coordinating producer prices with consumer (retail) prices and in harmonizing both prices with fluctuations in production.

One of the major problems facing the dairy industry is pricing at the producer level. The level of producer prices has become a controversial subject because of large seasonal fluctuations in the supply of milk due to the availability of luscious pastures following the rains and reduced grazing in the dry season. Consequently there are large quantities of milk in the wet season and inadequate supplies during the dry season. Numerous observers think that the uniform price throughout the year is too high in the wet season and too low in the dry season and is responsible for the severe fluctuations in milk production that are a regular feature of the dairy industry.

The producer price is also uniform throughout the country. This pricing system does not promote efficient allocation of resources. Since milk is bulky and highly perishable the resultant

long hauls of milk over space involves a substantial hidden subsidy for producers in remote areas.

Another dimension of producer prices is associated with supply response of smallholders, large-scale farmers and those of settlement schemes. There are no previous studies of elasticity coefficients for the supply response in milk production in Kenya or East Africa. The available time series data in Kenya are inadequate and unreliable for use in determination of elasticity coefficients for the supply response. A synthetic approach is required to permit their estimation.

The establishment of attractive producer prices in order to stimulate greater milk production has led to a substantial increase in consumer prices. Consumption, however, has been growing substantially despite the increases of prices. Income has been rising steadily and migration to urban areas has been occurring at a rate of 6-8 percent per annum. This study will investigate the sources of increase in demand for dairy products taking into account such factors as income, population, and urbanization rates.

Exports of dairy products have always been a source of valuable foreign exchange. In recent years about 30 percent of total commercial milk production has gone to exports predominantly to the East African Community States. While the market outlook for Kenya's dairy products in the former Community States appear uncertain at present, in the long-run the situation could be different. An appraisal of the role of exports, their levels and the implications for the dairy industry is required.

Objectives of Study

A complete study of the Kenya milk subsystem and subsector[1] can only be undertaken by a large research team. Hence the scope of this study has been limited by the amount of time and resources available. The study will, however, develop a conceptual framework for putting together the vast but scattered information that is currently available on the dairy subsector.

The general objectives of the study are to 1) describe the important characteristics of the Kenyan milk subsystem, 2) diagnose the shortcomings of the present system, and 3) prescribe changes to improve performance.

The specific objectives of the study are to:

1. Analyze the supply of commercial milk from the national dairy herd and project the supply to 1985 under alternative assumptions.
2. Evaluate the supply response of smallholder milk production in the Central Province of Kenya by means of parametric linear programming in order to derive some guidelines for increasing smallholder milk production in the country,
3. Determine income and price elasticities of demand for fluid milk through the use of time series data,
4. Estimate the consumption of milk and milk products and project the demand of these products to 1985 using income, population growth and other explanatory variables.
5. Analyze the results of supply and demand projections and

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[1] For definition see page 7.

determine optimal pricing policies; and

6. Determine export levels of milk and milk products and assess Kenya's ability to continue as an exporter of dairy products.

Subsector and Subsystem Studies

The term subsector was introduced by Shaffer (62) in 1968 and subsequently modified and defined to include the vertical set of activities in the production and distribution of a closely related set of commodities (63, p. 3). It is a meaningful grouping of economic activities which are related vertically and horizontally. The "linkages" within a subsector could be market relationships or a rich assortment of other arrangements, including contracts and government rules (23, p. 52). A subsector therefore differs from an industry[2] as a unit of study in that a subsector includes both vertical and horizontal relationships. The production units are related horizontally in an industry.

French (11) contends that subsector studies tend to mean different things to different people. For instance, Manchesters (42) maintains that the term subsector and systems research are used synonymously in the Economic Research Service of the U.S. Department of Agriculture. Shaffer (64), on the other hand, argues that subsector studies represent a departure in research organization from the traditional approaches of agricultural economics research using

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[2]Bain (3) has defined an industry as consisting of a recognizable group of products which are close substitutes to buyers, are available to a common group of buyers, and are relatively distant substitutes for all products not included in the industry.

static efficiency to subsector analysis uses a dynamic systems approach and it takes into account feedback, sequences and externalities. The uniqueness of the subsector is not therefore in methodology but in scope and comprehensiveness of research (66).

Overall, French (11) concludes that subsector is a two dimensional concept: 1) subsector research systems as a way of organizing research and 2) subsector systems research as a methodological approach in which the subsector is the unit of observation. The subsector framework can serve to reveal holes and duplication of efforts, lead to improved planning and have a general synergetic effect on research pertaining to the subsector (11, p. 1020).

The goals of the subsector study are to improve the understanding of how the subsector is organized, how it is functioning, why and how the system is changing, the sources of change and where such change is leading (11).

A subsector study is obviously too broad for one individual to tackle. Consequently, a more productive orientation for a single researcher would be to break up the subsector into manageable units and to accumulate knowledge over time. An appropriate unit is the subsystem which enables one to concentrate on vertical relationships rather than focusing on a single function or level of activity.

Purcell defines a subsystem as a set of two or more interrelated parts of the total system which exhibits the important characteristics of the total system (58). Among such characteristics he cites are the price discovery processes, product information flows, separate manager centers, etc. Harrison, et al., on the other hand, define a commodity subsystem as the entire set of activities performed in

the production assembly, processing, distribution and consumption of a single produce (15, p. 56). Once the subsystem is identified a methodology has to be developed which can both isolate and evaluate important economic relationships.

Definition of the Kenya Dairy Subsector and Milk Subsystem

The subsector is being viewed under an industrial organization framework. Structure, conduct and performance are taken into account. The Kenya dairy subsector will be defined to include the production and distribution of important inputs, the production of milk at the farm level, the assembly, processing, the transportation and distribution of milk and milk products, wholesale and retail trade, and purchases by the consumer. In addition, the dairy subsector operates under an array of laws and regulations that influence its direction and performance. Such laws include first and foremost, the Dairy Industry Act, laws that govern the operation of co-operatives and Statutory Boards, health and sanitary regulations, including establishment of various dairy product standards, licensing and Presidential decrees. Several aspects of the subsector overlap various government ministries and related agencies, co-operatives, local companies and subsidiaries of overseas companies. The Ministry of Agriculture provides several services such as dairy research, artificial insemination service, and extension. Other important bodies include Department of Co-operative Development, Agricultural Finance Corporation, Agricultural Development Corporation, Ministry of Land and Settlement, the Ministry of Health, the Kenya Dairy Board (KDB) and Kenya Bureau of Standards. In addition, the Kenya Farmers Association

(KFA), and private companies such as feed processors and chemical firms supply important inputs such as feeds, dips and spray chemicals, vaccines, livestock drugs and dairy equipments.

The milk subsystem includes farm production and assembly of milk for fluid consumption and manufacture, the pasteurization and/or sterilization of ultra-high temperature (UHT) long life milk, and distribution, retailing and consumption of dairy products. Although all input delivery systems, regulatory aspects and institutions could be included within the scope of a study of a subsystem but the emphasis in this study is on fluid milk.

Measures of Performance

A relatively large body of economic theory has been developed in the field of marketing and industrial organization. Many writers (3, 30, 42, 60, 69, 70) have identified variables which influence economic performance and have also developed theories linking performance[3] to these variables. The "industrial organization" model focuses on the structure, conduct and performance of an economic system. The performance of a system depends on the conduct of the participants and conduct in turn depends on the structure. A certain structure could be desired for its own sake and the achievement of such a structure could indicate good performance. The

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[3]According to Sosnick (69) what is really intended by the term 'market-performance' are attributes of production and exchange in a segment of the economy that directly influence the welfare of the participants and society. Performance results are therefore used to mean attributes of general well being. Sosnick further states . . . evaluation of a market that directly influence welfare involve at least the consideration of the following issues: production efficiency, technological change, efficiency, cost of sales promotion, unethical practices, participant rationality, conservation, external effects and labor relations. Equity and full employment of resources could be added.

system's performance is described by observing its basic conditions, structure and conduct.

Structure is related to organization but they are not synonymous. Structure refers to the number, size and concentration of the various entities in a system whereas organization of a system refers to the matrix of power centers through which the organization is controlled (23). The organization linkages may consist of markets or other arrangements for decision making and transmission of power. While it is not possible to address all the dimensions of performance in detail, the study will endeavor to assess consequences of various organizational and structural changes with a view of promoting a more efficient milk subsystem in Kenya.

The following performance criteria were considered appropriate for this study: efficiency, progressiveness, product suitability, participant rationality and government regulations.

Efficiency

This is one of the most common yard sticks of performance. French contends that efficiency is a complex concept whose definitions and dimensions "vary at different levels within the market economy and becomes increasingly complex as we move from the firm to an industry or group to the total system" (10, p. 3). The individual firm is said to be technically efficient if its production firm "yields the greatest output for any set of inputs, given its particular location and environment (10, p. 3). There are no a priori reasons to assume that the technical efficiency assumption holds in milk production in Kenya. Indeed, there is overwhelming evidence to

the contrary. All Kenyan farmers are not producing milk at the same level of efficiency. Management capability varies among farmers as well as the capital position, credit worthiness, and each farmer's assessment of risk and uncertainty. Farmers may use inefficient input combinations which may not reflect relative factor prices. There may be shortages of inputs or pastures may be overstocked.

Firm pricing or allocative efficiency is measured relative to the efficient production function as the ratio of cost with optimal input proportions to cost with inputs proportions actually used. A firm may be technically efficient but inefficient in a pricing sense if it fails to combine inputs in such a way that marginal revenue products are equal to factor prices.

The product of the indices of technical and allocative efficiency is a measure of economic efficiency of the firm (23, p. 4). A firm may again be both technically and economically efficient for its scale but inefficient with respect to its optimum scale. Optimum scale may also vary with relative prices. The degree to which the total marketing system or an industry subsystem achieves economic efficiency for all firms, full capacity utilization of capacity and advantageous use of size of location is referred to as productive efficiency. Jones (30, p. 263) presents what he believes to be the essence of an efficient marketing system, i.e., its ability to allocate resources efficiently among firms rather than within firms. His contention is that marketing is exchange as opposed to the more visible technical element . . . The marketing system is an allocating mechanism. It exists to facilitate the national allocation of resources in production and of products among uses.

The dynamic view of marketing efficiency is also very important. For instance, Mellor (47) maintains that in any marketing system a consideration of the capacity of technological change and the potential of mobilizing resources and putting them to efficient production use should be included. Scherer recommends that a subsector should take advantage of innovations and inventions for both "increasing output per unit of input and making available to consumers superior new products" (60, p. 4). Shaffer (64) on the other hand urges a movement away from the narrow conception of performance couched in product output measures only, to more encompassing performance dimensions. He recommends economic aspects and more general aspects of life such as the production of alienation.

In assessing the performance of the milk subsystem it is noted that the perfect competition model probably cannot be achieved and even if it were possible it would not necessarily be desirable. Workable competition appears a reasonable alternative. An industry is judged to be workably competitive when, after the structural characteristics of its markets and dynamic forces that shaped them have been thoroughly examined, there is no clearly indicated change that can be effected through public policy measures that would result in greater social gains than social losses (45).

While dealing with efficiency questions a desirable goal would be to attain maximum output with minimum resource inputs, i.e., the costs of the subsystem should be minimized. Output levels should be consistent with an efficient allocation of resources and should not be deliberately restricted in order to raise prices which would generate unjustifiable profits and raise the level of expenditure by

quantity desired at given costs. Sufficient product varieties should be available to meet Kenyan needs. Adulteration and other fradulent practices should be eliminated.

Participant Rationality

Participants should be well informed if they are to exercise their freedom of choice rationally. For instance, improved knowledge about products and nutrition might reduce the common practice of boiling pasteurized milk and thus enhance the nutritional value to the consumers.

Government Regulation

Government regulation should promote the best performance possible by seeking to correct maladjustments in the subsector. Establishment of prices to producers should be in accordance with efficient allocation of resources and the consumer prices should be reasonable so as not to unnecessarily restrict consumption. Increased consumption of dairy products would enhance welfare through an improved nutritional status. Government regulation should promote equity. The interests of consumers and producers alike need to be taken into account in pricing policies. Any act of price fixing is ipso facto an act of income distribution.

It is not possible to apply all the performance measures to evaluate every aspect of the Kenya milk subsystem. The study will therefore utilize the performance measures to evaluate marketing in the Kenyan dairy industry. The performance measures will be mainly used in Chapter III where the structure, conduct and performance of the milk subsystem will be analyzed. Organizational aspects of the

dairy industry and government pricing policies will be appraised.

Organization of Study

In Chapter I the objectives of study were outlined and the theoretical background was provided. In Chapter II the background to the dairy subsector will be presented. This will include a short review of the Kenyan economy, a brief history of dairy development in Kenya and the composition of the dairy herd.

Chapter III will describe the Kenya milk subsystem, including the structure of the dairy industry, the role of the Kenya Co-operative Creameries Ltd., the Mariakani Milk Scheme, government regulation, pricing policy and foreign trade. A preliminary evaluation of the performance of the present system will be presented.

Chapter IV will analyze the supply of milk at the national level including the estimation of production and projection of national output of milk from 1978 to 1985. Chapter V will present the results of a normative supply analysis in Central Province of Kenya using parametric linear programming. As assessment of likely supply response and implications at the national level will be presented.

Chapter VI will present a simultaneous analysis of supply and demand incorporating the results of Chapter IV, V and VI. Chapter VII will present a summary and conclusions of the study, spell out policy implications and identify areas for further research.

CHAPTER II

THE CONTEXT OF THE KENYA MILK SUBSYSTEM

This chapter places the dairy subsector within the context of the Kenyan economy. The future development of the dairy subsector is conditioned by the extent of progress in the entire economy. The ability of consumers to purchase dairy products, for instance, depends to some extent on the prices of these products, but to a greater extent upon the general productivity of the economy and the distribution of income. This chapter provides a historic as well as an economic background for an analysis of the milk subsystem.

Kenya: The Country, Climate, and the Milk Shed

Kenya is an East African country located on the equator and bounded by the Indian Ocean and Somalia to the East, Ethiopia and Sudan to the north, Uganda on the West and Tanzania to the South. It is medium sized by African standards, covering an area of 582,644 square kilometres. Administratively the country is divided into eight provinces which are in turn divided into 42 districts. The districts are divided into divisions which are in turn divided into locations. The locations are in turn divided into sublocations which form the primary administrative units.

The climatic conditions in Kenya exhibit great variability, ranging from hot and wet tropical climates on the coastal areas to

desert and near desert conditions in the northeast and to temperate climate in the highlands. Temperatures and rainfall are significantly affected by altitude. Rain fall is highly variable and three-fourths of the country receives less than 762 mm. of rain per year. Only about 7 percent of Kenya can be regarded as good agricultural land in the sense that it has adequate and reliable rainfall and good soils. Another 4 to 5 percent is suited for crops in areas where rainfall is uneven from year to year and crop failure is common. The remaining land is suitable for stock raising with varying degrees of intensity depending on rainfall and soils. Great uncertainty in weather tends to prevail and agricultural output fluctuates considerably between seasons. This aspect is particularly relevant to dairy production.

The principal belt of high potential land is found around a line going from north-west to south-east through Nairobi. This belt coincides with the highlands. The core of the milk shed coincides with the highlands, especially the areas within the 875 mm. isohyet annual rainfall. Milk production is concentrated in the Rift Valley and Central Provinces. A generous rainfall and the existence of Kikuyu grass provide favorable conditions for milk production. Leading districts include Trans Nzoia, Uasin Ghisu, Kericho, Nyeri, Nyandarua, Kiambu, Nakuru, and Laikipia. The entire dairy milk shed covers about 103,600 square kilometres.

The area under irrigation is small, comprising 8,500 hectares in large scale irrigation, 10,000 hectares in small-scale organized irrigation and a further 2,400 hectares in non-project irrigation. The total irrigation potential of up to 700,000 hectares (50, p. 21) is largely unexploited.

consumers (69). The system should ensure adequate and stable remuneration to producers, processors and distributors by creating conditions that would ensure reasonable profits.

An efficient transport system is necessary to ensure an efficient movement of products from producers to consumers. Transport costs should not be excessive and economic facilities should exist in major producing areas so as to reduce bulk and enhance the value of products. Prices should be high and flexible enough to eliminate excess demand and low enough to avoid undesirable accumulation of stocks.

Progressiveness

The operation of the milk subsystem should be progressive, i.e., by taking advantages of inventions and innovations for both "increasing output per unit of input and making superior products available to consumers (59, p. 4). Progressiveness is however, difficult to measure precisely but optimum plants should be employed and an adequate diffusion of technological information should be sought for keeping operators informed of developments in leading dairy countries. Such factors as container types, sizes, products and processing equipment and services should be evaluated for potential use in Kenya.

Product Suitability

The products sold should be those desired by consumers. Some consumers would rather pay higher prices in order to obtain improvements in quality or variety while others may be willing to sacrifice both in order to receive cheaper products. Sellers should not suppress products (and inventions) nor persistently offer less than

quantity desired at given costs. Sufficient product varieties should be available to meet Kenyan needs. Adulteration and other fradulent practices should be eliminated.

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The Kenyan Economy

Kenya was a British Colony until it attained its independence in December 1963. During the colonial period the economic and social policies predominantly favored the non-African communities and particularly the Europeans. The European settlers alienated some of the best land in the country and developed the large-scale farm sector which produced for both the local and overseas markets. As its heyday the large-scale farm sector consisted of about 20 percent of all arable land. It was comprised of three million acres of which approximately 1.4 million was devoted to large-scale mixed agriculture and 1.6 million consisted of plantation and ranching enterprises.

The Africans were primarily engaged in subsistence agriculture because the growing of cash crops and rearing exotic dairy cattle breeds were actively curbed by the colonial government. Consequently, the large-scale farms produced the bulk of marketed agricultural output and enjoyed certain privileges and protection from domestic and foreign competition. Until recently, the large scale farms have been considered the backbone of Kenya's agriculture. A historical perspective of Kenya's agricultural development is clearly presented in Heyer et al (21).

The dual character of agriculture persists today although serious attempts have been made to alter it. There are two distinct sections consisting of the large-scale farm and smallholder farms. The former is used to mean all farms remaining in the former scheduled areas (i.e. areas reserved exclusively for European settlers use) but excluding settlement schemes which have arisen out of subdivision of some of the large scale farms. The smallholder sector

consists of all smallholdings in the non-scheduled areas or reserve areas (i.e. African areas), including the high density settlement schemes which constitute a major share of the total area that has been settled. Over a million acres of the former scheduled area is now broken up.

It was not until the 1950s that the colonial restrictions and inhibitions imposed on African agriculture were removed. In 1954 the Swynnerton Plan (73) spelled out a new approach to African agriculture. Many of the ideas outlined in the Plan form the basis of the present policies, including individualization of land tenure, the role of individual farm management, and planning, settlement policy, the importance of credit in small farm development and the establishment of marketing cooperatives under statutory boards. In 1955 the colonial government dropped its ruling which prohibited African farmers from owing grade cattle.[1]

In the smallholder areas individualization of tenure is the declared policy of the present government and is being pursued at an accelerated rate. However, the large plantations and ranches are almost unchanged since independence. Some large-scale mixed farms are still owned by Europeans but most are now owned by individual Africans and/or cooperative societies. The continuing large-scale/small farm debate poses one of the major political and economic problems

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[1] The term grade refers to any bovine animal with distinct dairy characteristics but of at least F2 standing. The crossing of exotic and zebu cattle increases productive capacity of the F1 generation from about 200 to 400 litres to about 1,300 litres with additional matings can be expected to bring an improvement of 1 to 2 percent per generation (25). Resistance to enzootic disease is largely lost. Zebu cattle will, however, continue to survive and produce milk (albeit in small quantities) in situations where grade and exotic breeds will not. In such rough areas it is usual to cross zebu with Sahiwals.

of present day Kenya. The problem is dramatized in the context of a rapidly increasing population and concomitant migration to the more marginal areas. The 1,540 large-scale farms averaging 600 to 700 hectares stand in sharp contrast to the small-scale farms averaging two to five hectares. The extensive arid lands are commonly owned and inhabited by the nomadic and pastoral ethnic groups.

The Growth of the Economy, Per Capita Income and Population

Kenya has experienced steady economic growth since independence. From 1964 to 1974 a cumulative growth of 6.8 percent per annum was recorded. The GDP rose from K£ 328[2] millions in 1964 to K£ 554 million in 1972 measured at factor cost and using constant 1964 prices. The agriculture sector has been a source of great strength and has grown almost *pari passu* with the rest of the economy. At the same time the population was growing at the rapid rate of between 3 and 3.3 percent, so that per capita income grew at a cumulative rate of between 3.3 and 3.8 percent, rising from K£36 in 1964 to K£46 in 1972.

Agriculture in the Kenya Economy

Agriculture constitutes the dominant sector of the Kenyan economy. About 90 percent of the population live and derive their employment and income in the rural areas. In the 1964-1974 period the agricultural sector (subsistence and monetary sector) accounted for some 35-40 percent of the Gross Domestic Product (GDP) as can be seen in Table 2-1. This compares with 10 to 13 percent from

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[2]Twenty Kenya shillings (Shs) make one Kenya pound (K£), which is equivalent to U.S. $2.45.

Table 2-1. Kenya's Gross Domestic Product--Sector Shares (at Constant 1964 Prices) 1964, 1969-74

	1964	1969	1970	1971	1972	1973	1974*
OUTSIDE MONETARY ECONOMY							
Agriculture (A)	22.26	19.72	19.08	18.45	17.89	17.27	
Forestry	0.60	0.56	0.54	0.53	0.51	0.50	17.67
Fishing	0.03	0.03	0.03	0.03	0.03	0.02	
Building & Construction	1.76	1.49	1.42	1.37	1.34	1.30	1.31
Water	0.63	0.58	0.55	0.53	0.51	0.48	0.47
Ownership of Dwellings	1.68	1.56	1.54	1.53	1.51	1.49	1.51
Total Product Outside Monetary Economy	26.96	23.94	23.16	22.43	21.78	21.06	20.97
MONETARY ECONOMY ENTERPRISES AND NON-PROFIT INSTITUTIONS							
Agriculture (B)	16.08	15.48	15.22	14.22	15.13	15.27	14.69
Forestry	0.57	0.57	0.60	0.61	0.58	0.61	0.66
Fishing	0.26	0.25	0.21	0.19	0.20	0.18	0.17
Mining & Quarrying	0.44	0.44	0.53	0.53	0.45	0.66	0.56
Manufacturing & Repairs	10.35	10.66	10.79	11.47	11.55	12.01	12.53
Building & Construction	2.07	2.60	2.48	2.54	2.85	2.93	2.42
Electricity & Water	1.47	1.41	1.47	1.51	1.61	1.55	1.60
Transport Storage & Communications	7.43	8.46	8.46	8.34	7.70	7.55	7.91
Wholesale & Retail Trade	9.99	9.64	10.00	10.27	9.20	9.12	7.74
Banking, Insurance, Real Estate	2.98	3.70	4.03	4.09	3.95	3.89	3.88
Ownership of Dwellings	4.04	3.08	2.97	2.88	2.73	2.74	3.56
Other Services	3.60	4.05	4.18	4.38	4.83	5.17	5.63
Total Enterprises	59.28	60.34	60.95	61.01	60.79	61.66	61.37
Private Households	0.89	0.76	0.73	0.74	0.69	0.68	0.79
GENERAL GOVERNMENT							
Public Administration	5.10	4.60	4.44	4.62	4.79	4.64	..
Defence	0.66	0.86	0.86	0.86	0.86	0.91	..
Education	3.39	4.68	4.98	4.98	5.39	5.50	..
Health	1.42	1.76	1.84	1.97	2.11	2.05	..
Agriculture Services	1.34	1.30	1.18	1.34	1.39	1.32	..
Other Services	0.95	1.75	1.92	2.03	2.20	2.17	..
Total General Government	12.87	14.96	15.16	15.18	16.74	16.59	16.87
Total Product Monetary Economy	73.04	76.06	76.84	77.57	78.22	78.94	79.03
Total Gross Product at Factor Cost (Monetary and Non-Monetary)	100	100	100	100	100	100	100
Total Agricultural Share (A & B)	38.34	35.20	34.30	32.67	33.02	32.54	32.36

Source: Kenya, Economic Survey, 1975.

*Provisional.

manufacturing, 13 to 17 percent from the government sector and 10 percent from commerce. Livestock and livestock products accounted for 22 to 30 percent of the marketed agricultural production in the same period. Dairy production contributed 29 to 35 percent of the livestock and livestock products share of GDP or 8 to 10 percent of the total contribution of agriculture. Obviously the livestock contribution is understated because the value of livestock in the subsistence economy is difficult to measure.

Agriculture also accounts for about 75 percent of the total employment and it provides an important source of foreign exchange earnings. In the period 1964-1970 agricultural exports made up to 70 percent of Kenya's total exports. Like in many other developing countries, the problems of employment, public finance, balance of payments, income distribution, price and income stabilization are closely tied to the performance of agricultural exports.

In monetary terms, the overall marketed agricultural output grew in value from K£55.9 million in 1963 to K£106 million in 1972 with smallholders producing half of it in 1972 (32, p. 57). This figure reached about K£150 million in 1974. Between 1964 and 1972 agriculture in the monetary sector grew at 6.5 percent per annum. In 1973 agriculture contributed K£87.6 million to the export earnings or 54 percent of the national total. Leading agricultural products include coffee (28.2%), tea (13.8%), pyrethrum (3%), meat products (3.1%), and sisal (2.9%). All livestock products including dairy products account for about 8 percent of the total exports and of the total exports dairy exports account for 24 percent.

Agriculture is the mainstay of Kenya's economy. The problems

of employment and migration to the cities, welfare and income distribution, can only be solved if sustained agricultural progress is achieved. Neither can problems of preserving a balance of payments or those of sustained industrial growth be tackled without an efficient agricultural sector. The industrial sector not only depends on increasing agricultural incomes to provide a market for its products, but needs investable funds which emanate largely from the agricultural sector.

Most of Kenya's increasing population will have to be absorbed in the rural areas. Despite the high growth rate of the formal[3] sector it cannot absorb all the increase in population. Taking this fact into account, the second Development Plan (1970/74) directed an increasing share of the national resources to the rural areas where a majority of the people live. The third Development Plan (1974/78) emphasizes rural development. The government believes that it is only through accelerated development of rural areas that balanced economic development can be achieved, the necessary growth of employment opportunities can be generated and the people as a whole can participate. There are problems, however, of translating this into coherent development programs. Despite these noble pronouncements the current development programs are still largely in favor of the urban and industrial sectors.

Within agriculture, the development strategy in the 1974-78 Plan focuses on raising productivity and commercialization of smallholder areas by providing infra-structure and ancillary services--

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[3]The formal sector refers to the modern sector and consists of industrial, commercial and government sectors.

technical, economic, and institutional. These include programs such as agricultural extension, training and research, credit, input supply programs, land adjudication and registration, disease control, cooperatives and marketing. While the strategy seeks to maintain the productivity of the large scale farms and subdivision of those farms where it is consistent with maintaining productivity, the aim is to help small farmers intensify their production. Emphasis is being placed on high and medium potential areas, but the Plan also calls for increased resources to the less developed and range areas. The current Plan calls for a 6.7 percent growth rate of marketed production through intensified land use. At the same time it calls for improved distribution of income, employment and nutrition (32, p. 197). Income distribution is very unequal and although the inequalities date back to colonial days, they appear to have been exacerbated in recent years.[4] Substantial income disparities exist between regions of high, medium and low agricultural potential.

Dairy Development in Historical Perspective

Commercial dairying dates back to the days of European settlement. Among the important settlers were Sandbach-Baker of Muthaiga, Lord Delamere and H. E. Watts of Lumbwa. By 1901 Mr. Sandbach-Baker made the first dairy butter in East Africa and it was of excellent quality.

The native cows belong to the Bos indicus family and carry a shoulder hump. The zebu animals were not and are not as productive as

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[4]For instance, about 40 percent of farm families receive less than KL40 annually.

the temperate Bos taurus breeds which do not carry a shoulder hump. Because of longer development and selection period in Europe the Bos taurus breeds are capable of much higher levels of milk and meat production than those of the Bos indicus group of tropical Asian origin. The differences in productivity result from the higher basic metabolism of the Bos taurus group and their faster growth and maturity. Consequently, early attempts were made to introduce exotic breeds into tropical areas as replacements for the less productive zebus. In 1903 a government stock farm was started at Naivasha and it was reported that "the first cross and graded stock are fully equal to expectation and foundation of a useful cattle is now in evidence. The upgrading from native cattle countinues to be an undertaking of much promise, and the young stock of all ages are giving every satisfaction" (23, p. 45). Upgrading is a slow process, although the policy of introducing imported stock to improve the quality of native cattle was well underway by 1907 it was pursued independently rather than as part of a pattern of sound farming.

The early years of dairy production in Kenya were beset by formidable and expensive setbacks. Soils and climates were unknown, means of communications were rudimentary or non-existent and new crops had to be introduced. Diseases took a heavy toll of the animals and there was no respite due to a lack of scientific knowledge of the fearsome array of endemic and epidemic diseases. The most prevalent diseases were East Coast Fever (ECF), Rinderpest, anthrax, pleuropneumonia, anaplasmosis, Black quarter, Rift Valley fever etc. East Coast Fever was first diagnosed in a herd of cattle driven to Nairobi from the Kilimanjaro district of German East Africa in 1904.

Although many of these diseases are now under control, some of them are a constant threat, requiring regular dipping or spraying of cattle using acaricides.

The Naivasha experimental station and several private farms introduced selective breeding and cross-breeding with imported breeds such as Friesians, Jerseys, Guernseys and Ayrshires continued with notable success. An artificial insemination service was later established at Kabete; the Central Insemination Service center today. The Veterinary Department was established in 1903 but it did not achieve great effectiveness until the Kabete laboratory was completed in 1910. The laboratory consisted not only for a center for investigating cattle diseases encountered in the field, but in addition, it undertook the job of developing serum and vaccine for disease treatment and immunization. Since then the center has been greatly expanded. Treatment of foot and mouth disease proved difficult but by 1970 the Wellcome Research Institute on Foot and Mouth disease was established at Kabete. Because of the limitations imposed on the expansion of dairy industry by the presence of tse-tse flies research on Trypanosomiasis, the tse-tse vector born disease, was launched and has proceeded actively to this day.

In 1908 Mr. H. E. Watts started to make butter on his farm near Lumbwa, and immediately developed trade with Uganda. His original dairy consisted of a small stone building with a thatched roof at the backyard of his house. Things moved steadily and soon the demand for his butter was greater than the output of his own herd. Consequently he invited farmers in the neighborhood to supply cream to his dairy. In 1911, Mr. Watts moved his dairy to a building near

Lumbwa Station. By this time more and more settlers were engaged in dairying around Nairobi, on the Kinangop, in the Rift Valley, and in Molo and Lumbwa districts. Nevertheless the output of butter did not meet demand, and annual imports of butter were valued at about 20,000 rupees.

In 1912, the farmers around Lumbwa formed the first co-operative society in Kenya. The co-operative built the first Kenya Co-operative Creamery at Lumbwa. The same year saw the opening of the Lumbwa creamery and also more importantly dipping was introduced to control tick-borne diseases. By 1921, the Lumbwa creamery had shipped the first exports of Kenyan dairy produce to London consisting of 68 Kg of butter and 690 Kg of cheese. In 1922 the exports of butter and cheese increased to 8,523 Kg of butter and 10,134 Kg of cheese, nearly all coming from the Lumbwa creamery.

In 1924 another creamery was built in the Rift Valley. Lord Delamere exerted his influence over other farmers to form a co-operative company and build another creamery at Naivasha. This led to the formation of Kenya Co-operative Creamery Ltd. in 1925. By the following year the company opened its creamery at Morendat near Naivasha. In 1927, another co-operative was formed and by 1928 its creamery started operating seven miles from Nanyuki. The original building consisted of a grass banda equipped with two old churns.

The depressions of the 1930's coupled with a limited domestic market induced the creameries to merge so as to avoid competition, pool resources and achieve economies of scale. Thus in 1931, the Nanyuki, the Naivasha and Lumbwa creameries amalgamated but retained the name of Kenya Co-operative Creamery, Ltd. In 1932 the Kenya

Co-operative Ltd. (KCC) became the first co-operative to be registered under the Co-operative Societies (Registeration) Ordinance, 1931. The Thomson Falls Creamery was opened in 1934 while the Eldoret factory started operating in 1935. In 1936 the Lumbwa creamery was moved to Molo and in 1937 the Nanyuki creamery found it congenial to relocate to a new plant in Nanyuki town.

For the year ended June 30, 1945, the KCC achieved an output of butter in excess of 2.3 million kilograms. In addition 2,027,400 liters of whole milk and 143,647 Kg of cheese were sold. The membership of the company had increased from 638 in 1938 to 1,028 in 1945 and gross assets and property of the company from £55,761 to £145,716. In 1945, the name of the company was changed from Kenya Co-operative Creamery Ltd. to the Kenya Co-operative Creameries Ltd. The KCC had weathered the disruptions of the second World War. In 1949 a factory was opened at Sotik to manufacture cheese and to supply while milk in the district and in the same year the Nakuru factory started operating. The Kitale factory was not founded until 1951. By 1953 the membership of KCC stood at 2007. The KCC was very much as we know it today except for the fact that virtually all the membership consisted of white settlers. The Nairobi creamery was opened in 1959 while the Kiganjo factory which superseded the Nanyuki creamery started operating in 1968.

Marketing Problems in the Thirties

Milk production increased rapidly in the 1930's. The number of dairy cattle recorded in the highlands rose from 64,000 in 1920 to over 169,000 in 1938 with a milk production of nearly 3.6 million

litres, 2.7 of which were converted into butter. According to the 1938 census of agriculture 5,991,600 litres of liquid milk were sold and butter production was 1.3 million Kg. African smallholders did not possess any grade stock and except for the Mariakani Scheme which was organized in 1930, African milk production was for subsistence only.

The dominant economic problems of the dairy industry of Kenya emanated from a small internal market and uncompetitive butter exports. The creameries had expanded and there was a large butter surplus for export. Before the creameries amalgamated in 1931 there were serious attempts to maintain the domestic prices of butter from all creameries at a high level in order to recoup the losses on export markets. The creameries were acting as a cartel and were discriminating between the two markets, acting as price takers in the foreign market while setting domestic prices. Indeed, the creameries amalgamated into one organization in 1931 in order to rationalize the industry under a single organization and maintain the internal prices at a level high enough to compensate for losses on the international market. The amalgamation itself proved inadequate to compensate for the losses of increasing exports of butter. The KCC export sales, in value, amounted to 40 percent of total sales. Export prices fell drastically during the depression years and the KCC, the only organization exporting butter, pressed for legislation to make all producers, including individual farmers, contribute towards compensation of export losses which were borne by the KCC members alone. The KCC argued that by exporting the bulk of its production it was helping to maintain domestic prices at a higher price than would otherwise be the case. The Government

accepted the KCC's case and imposed a levy on all local sales of butter and the proceeds were used to subsidize exports.

The price of butter in the international market deteriorated in 1932 and the butter levy proved inadequate to fulfill the objective. The KCC demanded an inquiry into the dairy industry with a view to controlling the production and distribution of all dairy products. The KCC members called for a marketing system under which non-KCC members could not reap undue advantage of the conditions created because the KCC exported the national surpluses. They argued that further development of the dairy industry could be achieved under stable conditions only if the differential in returns to all dairy producers was small irrespective of whether they were liquid milk or butter fat producers, exporters or sellers in the domestic market.

In 1935, the government set up the Dairy Industry Inquiry Committee to formulate a scheme for the complete control of the production and distribution of milk products. The committee recommended that a pool be established for the proceeds of all dairy produce except ghee, with the objective of reducing differentials in returns from all dairy products. The pool was to be administered by a Dairy Produce Control Board through the KCC which would act as its agent. Since the KCC did not handle liquid milk for the local market the recommendations were vehemently opposed by the whole milk producers.

The Committee Report was therefore presented to the Standing Board of Economic Development for review and it recommended that milk for consumption as liquid milk should not be brought into a common pool but that a cess should be levied on all milk sold in the larger

municipalities. The proceeds were to be used for the general well-being of the dairy industry, including the establishment of a reserve fund to assist any section of the industry which may have found itself at any time in temporary difficulties (22, p. 3). No implementation occurred and the outbreak of the second World War put the controversy in the background. High controlled prices were set for dairy products and production increased rapidly under this incentive. As long as high prices prevailed it was unlikely that there would be further demands for statutory control.

Problems After World War II

There was a rapid increase in milk production in the post World War II period arising from efforts to shift farm systems from cereal monoculture to a mixed farming system in the scheduled areas. Factors responsible for the expansion in milk production included rehabilitation and development loans, more intensive production by European farmers, increasing the number of dairy cows and the concomitant increase of productivity of the cows due to improved quality of animals and feeding by richer grazing of grass leys, planted fodder crops and even concentrates. The development of communications and modern methods of handling milk expanded the areas from which liquid milk could be supplied to urban areas profitably.

Domestic consumption increased significantly partly due to the rapid increase of non-African population and the rising incomes during the post-war boom. The European population increased by 110 percent from 1946 to 1955 rising from 24,900 to 52,400 while the Asian population rose by 63 percent from 88,400 to 144,100. The Asians were the

largest consumers of dairy products in the country. The urban areas, offered profitable outlets for whole milk, with Europeans and Asian communities consuming large quantities of butter, ghee and cheese. These products, however, were largely beyond the purchasing power of the African population.

Nevertheless, the expansion of the domestic market for dairy products could not cope with the production of milk which was expanding at an even higher rate. More and more milk was therefore being turned into butter and the proportion of exports in total butter sales started to rise again in 1953. The prices in the London market were reasonably high and the high price in the East African market continued to subsidize the uncompetitive butter exports. In addition, the KCC was further able to subsidize the butterfat producers from the profits of whole milk sales after they entered the whole milk market in the 1950s. The KCC was thus able to maintain a high payout to producers. Non-KCC members obviously did not benefit from subsidized butter production.

Statutory Control and the Kenya Dairy Board

Prompted by fears that the price of butter in the international market would fall and that a price-war might ensue in the domestic liquid milk market with serious consequences for the entire dairy industry, the KCC revived the demand for the overall control in the marketing of all dairy products in 1955. Although London butter prices remained high in the mid-fifties, there was a slight decline in 1955 and the KCC feared that this decline would accelerate. The KCC and the Kenya Dairy Co-operative Association, an organization of the non-KCC liquid milk producers, shared the Nairobi liquid milk

market and operated a system of voluntary control through a joint Milk Committee. Under this arrangement the producers supplied milk at guaranteed minimum prices, quantities being controlled by contracts based on minimum quantities which they could guarantee to supply continuously. From 1955 a voluntary quota system was introduced for producers in certain areas. With increasing volume of milk production, however, the individual producers were undercutting the price of milk sold through the Milk Committee, to the detriment of all dairy farmers who were members of the producer organizations.

In 1956, the government set up a Committee of Inquiry under the chairmanship of Mr. L. C. Troup "to consider whether some form of statutory control of the diary industry is necessary, and if so, to make recommendations to the minister as to the form this control should take" (21, p. 22). The Troup committee recommended that statutory control was essential to secure conditions of stability in the industry and it outlined the powers and constitution of the proposed statutory authority. The Kenya Dairy Board (KDB) was established in 1958, a year of particularly low butter prices in international markets, by the Dairy Industry Ordinance of 1958.[5] Its general functions are stipulated to (i) organize, regulate and develop the efficient production, marketing distribution and supply of dairy produce, having regard to the various types of dairy produce required by different classes of consumers; (ii) improve the quality of dairy produce; (iii) secure reasonable and stable prices for the producers of dairy produce; (iv) promote market research in relation to dairy produce;

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[5]Currently known as the Dairy Industry Act, 1972; CAP 336 of the Laws of Kenya.

(v) permit the greatest possible degree of private enterprise in the production, processing and sale of dairy produce consistent with the efficiency of the producer and the interest of other producers and of consumers; and (vi) ensure either by itself or in association with any government department or local authority, the adoption of measures and practices designed to promote greater efficiency in the dairy industry. Other provisions of the Act are: "the Minister may on the advice of the Board make regulations generally for the better carrying out of the purposes and provisions of the Act, and may make regulations concerning all aspects of dairy produce. The Minister may by order empower the Board to acquire by compulsory purchase all or any form of dairy produce" (21, p. 22).

The KDB was set primarily to stabilize supplies for the whole milk market and thereby maintain earnings from which exports of butter were subsidized. One of the most important functions of the Board was the operation of a system of quotas and licenses for the liquid milk sales and regulation of prices in the major markets. The quotas were based on dry weather production (January to April) and were allocated as a proportion of total deliveries including butterfat. Thus ab initio the quotas were to be 'earned' by a farmer's previous production. The KDB froze all voluntary quotas and adopted a policy of issuing new ones only if whole milk sales in quota markets increased. Possession of a quota entitled a holder to a guaranteed market for the guantities specified and at guaranteed prices. The producer on the other hand was obligated to deliver this quantity for if a farmer's deliveries fell below his quota for a period of 14 days out of 30 consecutive days, he was penalized by a reduction in his quota which was

revised annually.

The KDB appointed the KCC as its agent and this privilege requires that the KCC accept all surplus milk from producers. In addition the KCC adopted a system of licensing of liquid milk sales in order to accommodate producer retailers who were not members of the KCC. A license, however, did not guarantee any market and the KDB adopted a liberal policy except for the major urban markets, hence licenses tended to dominate in the rural areas.

The National Herd

The cattle population of Kenya consists of the indigenous zebu of the Bos indicus species, which accounts for about 90 percent of all adult female cattle, and the exotic European breeds of the Bos taurus species and their various crosses. The zebu cattle are relatively resistant to heat, drought and enzootic diseases but are poor milk producers even under optimum management. Numbering about 3,768,000 mature cows in 1974 they accounted for a meager one percent of all commercial milk production.

The zebu cattle may be classified as beef cattle although under traditional animal husbandry and outside the commercial ranging areas they are primarily kept for milk production. Among the pastoralists and to a lesser extent they are primarily kept to secure a living for the family as well as to gain social prestige in the community.[6] Since

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[6]Under the traditional system, cattle keeping is a way of life. Cattle often serve to express human relations such as payment of bride-wealth, play part in traditional ceremonies and influence nearly all aspects of life. An adult pastoralist could servive on 2100 calories. An average family of 6 (4 adult equivalents) would require 4546 litres per year supplied by 15 to 20 cows (55).

the herds are oriented towards milk supply for family consumption (or for sale) a high proportion of the herd (about 60 percent of the population) consists of heifers and cows in order to secure a steady milk supply. A large number of cows per family is necessitated by the harsh environment where most pastoralists live, poor nutrition and management and because of low genetic potential. Milk yields are low and frequently further reduced by long drought periods. Heifer calves are better looked after than bull calves and calf mortalities are often high. The high proportion of breeding femals lead to rapid herd growth in favorable weather with concomitant overstocking following normal or drought years.

Over time, however, the Masai and other pastoralists have been selling an increasing number of cattle to the Livestock Marketing Division of the MOA. The South Nyanza Ghee Scheme and Mariakani Milk Scheme have long provided outlets for milk produced by zebu cattle in Nyanza and the Coast. Zebu cattle also account for milk sold in other areas where grade cattle keeping has as yet not taken a footing. Zebu cattle in Kano plains contribute to the liquid milk sales of Kisumu. Table 2-2 indicates the distribution of zebu cattle by province.

The number of mature cows represents 42 percent of the herd. The calving rate is estimated to be 61 percent. Heifers first calve at 2.9 to 3.4 years. In 1970 for instance it was estimated that 2.2 million claves were born with a total of 34 percent. About 546,000 died a natural death while 225,000 were slaughtered. Some 10 percent of immature and nature cattle died (55). The other calves replaced stock over one year old that die or are slaughtered and increased

Table 2-2 Zebu Cattle--Mature Cows, 1974

Province	Heads (Thousands)	Percent of Total
Coast	222	5.9
Northeastern	283	7.5
Central	18	0.5
Rift Valley	1,818	48.2
Nyanza	499	13.2
Western	254	6.8
Eastern	674	17.9
Total	3,768	100.0

Source: Ministry of Agriculture (50).

the size of the national herd.

Commercial milk production is largely dependent on the grade and exotic cattle of which there were 416,000 mature cows in 1972 and an estimated 485,000 in 1974. The number is expected to reach 625,000 in 1978. Table 2-3 shows the estimated cow population by breed. Average milk yield per cow is variable and will depend on the type of breed, grazing and ley conditions and management. The life time production will depend on a cow's age at first conception, the calving interval, the output per lactation and the number of calves born in a lifetime of the cow.

Kenya milk is predominantly produced on grass and most of it is ordinary native grass. In 1974 there were just over 100,000 hectares of ley and 20,000 hectares of fodder. There is little provision for

Table 2-3. Grade Cow Population by Breed, 1974,Mature Cows

Breed	Heads (Thousands)	Percent of Total
Ayrshire	134	27.6
Guernsey	117	24.1
Friesian	105	21.7
Jersey	64	13.2
Zebu Crosses	65	13.4
Total	485	100

Source: Ministry of Agriculture, Kenya (50).

dry season feed, little supplementary feeding, no steaming up[7] and hence animals tend to start sactating under very poor conditions. Breeding plans are haphazard. For example, calving occurs at random with no conscious effort to breed so that calving occurs at the beginning of the rains. These problems tend to be much more pronounced on the small-farm areas, particularly where the dairy enterprise is a recent innovation.

Table 2-4 gives the estimated distribution of the dairy herd between the large-scale farms, the small-scale (non-settlement) and the settlement areas. In 1974 percent of all commercial milk was produced on smallholdings and the remaining 60 percent on large scale farms. The difference in the proportions is explained by the greater home consumption on smallholder farms and the lower yields of zebu crosses.

[7]Steaming up refers to the feeding of in-calf cow or heifer at a high level of nutrition for about 2 months before calving.

Table 2-4. The Kenya Grade Cattle Herd by Type of Farmer, 1974

Type of Farmer	Heads (Thousands)	Percent Share
Large-scale: grade	164	33.8
Settlement: grade	116	23.9
Small-scale: grade	140	28.9
Zebu crosses	65	13.4
Total	485	100

Source: Ministry of Agriculture (50)

The smallholder herd is growing rapidly with most of the increase coming from the introduction of grade cows. However, because of the lack of managerial experience on smallholdings it can be assumed that there will be a reduction in the average yield per cow as this phase continues.

Table 2-5 shows the regional distribution of the dairy herd. Grade cattle are largely found in the highlands where they were first introduced. They are concentrated in the Rift Valley and Central Provinces which account for 82 percent of the total. In all, 12 districts account for 84.6 percent while another 20 districts hold the other 15.4 percent. A number of districts in the more arid areas have no grade cattle at all.

Artificial insemination (AI) has played and will continue to play an important role in upgrading and improving the national herd. The percentage of the grade dairy herd under AI has risen steadily from 23 percent in 1968 to 40 percent in 1974; from 75,000 cows to

Table 2-5. Regional Distribution of the Dairy Herd, 1974

Province	District	Heads (Thousands)	Province Percent	National Herd Percent
EASTERN	Meru	19.4	53.6	4.0
CENTRAL	Muranga	29.4	17.4	6.1
	Kiambu	29.5	17.4	6.1
	Nyandarua	50.4	29.4	10.4
	Nyeri	52.5	31.1	10.8
RIFT VALLEY	Nakuru	43.2	18.9	8.9
	Nandi	28.7	12.5	5.9
	Kericho	44.7	19.5	9.2
	Trans Nzoia	41.5	18.1	8.6
	Uasin Ghisu	40.5	17.6	8.3
	Laikipia	15.6	6.8	3.2
WESTERN	Kakamega	15.3	54.6	3.1
Total 12 Districts		410.5	--	84.6
20 Other Districts		74.5	--	15.4
National Total		485.0	--	100.0

Source: Ministry of Agriculture (50).

200,000 cows in 1973 after allowing for 2.5 and 2.0 inseminations per pregnancy respectively. About one percent of the zebu herd is reached by AI despite the substantial increase from 7,000 in 1968 to 37,000 in 1973.

Dairy Development Strategy

According to Kenya's Development Plan, 1974-78 the dairy development programme primarily rests on expanded smallholder production. The strategy is based upon 1) greater number of dairy cattle being purchased from large-scale producers, 2) expansion of the present smallholder dairy herd through normal increases, and 3) increases in the numbers of crossbreds through the use of AI on zebu cattle. The strategy is said to be attractive because it is extremely easy to increase the size of national herd through upgrading while raising productivity through a combination of breeding and management is more difficult and costly (31, p. 248). Although the major emphasis is on the increase in the numbers of cattle, available evidence shows that where smallholders have gained experience yields are comparable to those of the large-scale farms (55).

The Plan projects that marketed milk production will increase from 270 million litres in 1972 to 400 million litres in 1978 which represents a growth rate of 6.8 percent per annum. The smallholders' share of total milk production is expected to increase from about 40 percent to 50 percent at the end of the Plan period.

Pricing Policies

One of the characteristic features of the marketing system in Kenya is the high degree of centralized control dating back to the

colonial period. Most of the important agricultural commodities are under the control of marketing boards and other statutory authorities. There are development regulatory marketing and financial boards. The Kenya Dairy Board (KDB) is the regulatory authority for the dairy industry.

The Kenya government fixes the prices of dairy products at the producer and consumer levels just as it does for maize, wheat, beef, sugar and cotton. For the major products such as maize, prices are fixed at all points of exchange: at the producer, produce buyer, wholesaler, processors, distributor and consumer levels and hence all the intermediaries operate within the straight jacket of fixed margins. Even for major export crops such as coffee and tea where prices are determined in the world market statutory bodies exist.

The problem that arises when prices are determined administratively is one of setting price levels that are in 'harmony' with the rest of the economy. The political entity should strive to ensure that the absolute level of prices and the relationship between prices are in 'harmony' with the rest of the economy. The relative prices influence the competitive positions of enterprises and therefore determine the output mix. There is adequate evidence that some of these administrative (regulations) are at times very much out of line, particularly for maize, and milk (20, 55). Several writers in the past have urged reduction of controls over the marketing system including the East African Royal Commission of 1953, Hopper,[8] Smith (66) the World Bank Mission of 1973, Heyer (20), etc. These writers

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[8]Hopper, M., Priviliged document, (1968).

contend that the practice of establishing producer and consumer prices by administrative fiat restricts economic forces and hampers the allocation of resources. Although there have been recent pronouncements about the reduction of restrictions, it remains to be seen whether they will be implemented. There is no reason why administrative pricing should not be able to include aspects of competitive price system in order to encourage greater production and consumption.

Summary

In this chapter the evolution of Kenya's dairy industry has been presented. The national cattle herd was described and the importance of subsistence and commercial milk production stressed. The present dairy development strategy was outlined and marketing was analyzed in a historical perspective.

In Chapter III the operation of the milk subsystem from the 1960s to today will be described. The operation of the quota system of milk pricing under changing milk production patterns will be discussed. In addition, the important factors and policy variables that influence the direction and performance of the subsector will be identified in order to set the stage for meaningful appraisal.

CHAPTER III

THE KENYA MILK SUBSYSTEM

The purpose of this chapter is to describe the Kenya milk subsystem, to identify the important factors and policy variables that influence its performance and direction.

The Marketing Channels for Fluid Milk and Milk Products

Milk, probably the most perishable of all major agricultural products presents some unique problems and therefore must be sold from the farm on a daily basis. The transporting of milk to the factories is the responsibility of the producer. The large-scale farmers deliver their own milk to the processing plants or organize contracts with private transporters to ensure economic loads. On the other hand, the smallholder because of his low output is forced to market his milk through cooperative societies which also arrange for the transpor of milk to the processing plants. Starting on the farm level where some milk may be sold to the neighbors, the marketing channel begins with the smallholder delivering the milk to the local dairy of the primary cooperative society or to the roadside shed to be collected for delivery to the local dairy. At the local dairy, the milk is checked for smell, churning, hairs, color or adulteration and weighing then follows. The producer obtains a receipt for his product but does not obtain cash payment on delivery because payments

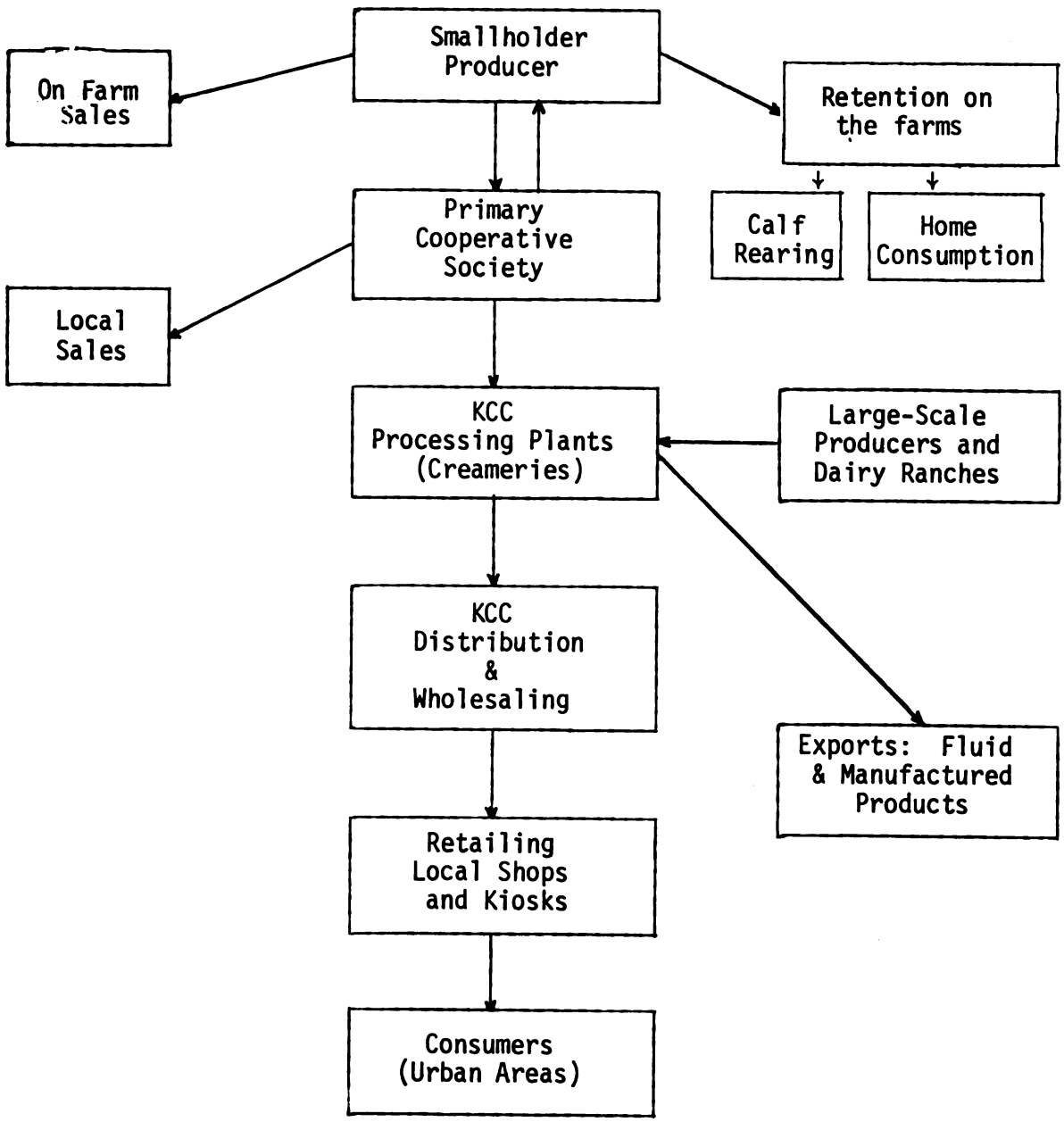

Figure 3-1. Marketing Channels for Milk and Milk Products

are usually made monthly. Cooling then follows after which the milk is put into 45-50 litre cans for delivery to the KCC plants. Raw milk is handled almost entirely in cans. Most of the cooperatives operate their own trucks while others hire transport. In addition, many of the primary cooperatives are licensed to sell milk locally, to individuals, restaurants and institutions.

The distance each cooperative has to ship its products and the mode and condition of transport constitute an important marketing cost and may indeed, determine the amount of product delivered. Some cooperatives operate in a more severe environment than others in terms of location, infrastructure and physical conditions. Indeed some cooperatives are constrained to deliver morning milk only. Many cooperatives, however, deliver milk twice daily. Obviously, the delivery of milk twice daily contributes to higher transport costs but in the absence of efficient cooling systems, higher quality milk is possible. About 25 percent of all milk sold by small scale farmers is marketed through primary cooperatives. Table 3-1 shows cooperative milk deliveries to the KCC for the 1974-75 financial year.

A total of 230 cooperatives sold their milk to the KCC. About 58 percent of these cooperatives are located in the Rift Valley while 36 percent are in the Central Province. In terms of actual production, however, the Rift Valley Province delivered 32 percent and Central Province 65.6 percent of the total. According to the KCC annual report for the same period, the total amount of milk delivered was 231.6 million kilograms. This means that approximately 34 percent of the annual KCC intake is supplied by cooperatives. The Development Planning Division of the Department of Cooperative Development

Table 3-1. Milk Sold by Cooperatives to the KCC by Province, 1974/75[1]

Province	No. of Societies	Quantity of Milk ('000 kgs)	Cream ('000 kg)	Value Milk KSh ('000)	Value Cream KSh ('000)	Total KSh ('000)
Nyanza	1	10	--	7	--	7
Western	3	88	--	68	--	68
Rift Valley	133	25,272	3.5	18,894	23	18,917
Central	83	52,317	6.1	38,381	44	38,425
Eastern	10	1,511	--	1,129	--	1,129
Total	230	79,198	9.6	58,479	67	58,546

Source: Department of Co-operative Development, Development Planning Division, Statistics Section, Section File, 1976.

[1]The Coast and North Eastern Provinces did not deliver any milk to the KCC. In 1975, however, the eight primary cooperatives of the Kwale-Kilifi Cooperative Union delivered 2.6 million litres of milk to the Mariakani Milk Scheme in Coast Province.

estimates that 25% of all milk delivered by smallholders is marketed by primary cooperatives which means that cooperatives handled about 105 million litres in 1974/75.

Inter-Plant Shipments

Once the produce has been accepted by the processing plant the costs of internal transport between factories are pooled and charged to the industry as a whole. A cess of 10 cents per litre is imposed on all milk and butterfat handled by the KCC. This cess represents a hidden subsidy. To accomplish the inter-creamery transfers the KCC operates a fleet of tankers for bulk handling of liquid milk in addition to railway transport. Table 3-2 shows the inter-plant milk movements among the KCC plants.

Table 3-2. KCC Inter-Creamery Milk Shipments, 1975-76

From	To	Distance (Km)	Quantity Litres
Naivasha	Nairobi	83	8,000,000
Nyahururu	Kiganjo	109	368,000
Nyahururu	Nairobi	168	8,855,700
Nakuru	Nairobi	155	39,000,000
Kiganjo	Nairobi	162	5,000,000
Kitale	Eldoret	68	7,000,000
Eldoret	Nairobi	308	14,000,000
Sotik	Nakuru	166	162,000
Total Shipments			82,403,700

Source: KCC Files.

The movements have important cost implications for the industry. Most of the milk is transported relatively long distances and transport costs are high because of the weight and volume of liquid milk relative to value, high perishability and cost of refrigeration.

Distribution and Retailing

The KCC has a monopoly on the distribution of milk and dairy products in the urban areas. It operates through retailers to whom the products are delivered. Home delivery services that once used to be undertaken by independent dairies are provided by KCC appointed agents. There appears to have been a decrease in quality and service provided by KCC agents in many areas (20). Outside the main urban centers substantial sales are undertaken by cooperatives and farmers who sell to individuals, restaurants and local institutions.

The Structure[2] of the Kenya Dairy Industry

In discussing the structure of the Kenya dairy industry it is necessary to recognize the existence of a dual marketing system, the first being the formal or commercial system comprising the KCC and Mariakani Milk Scheme on behalf of the Kenya Dairy Board (KDB) which also issues licenses to producers to sell liquid in certain cases in remote or small markets. The second or informal market exists largely in the rural areas where prices are determined by the forces of supply and demand, and with little or no constraints from the formal system. Most of the milk produced in Kenya does not enter

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[2]Structure embraces such features as the number and size distribution of sellers and buyers, degree of product differentiation, presence of absence barriers to entry, degree of vertical integration and geographical dispersion of buyers and sellers (60).

the formal or recorded market. In 1975, for instance, only 25 percent of the estimated milk output reached the formal market. An estimated 75 percent was consumed on farms or sold to neighbors. About 50 percent of total grade herd production and less than 2 percent of the zebu herd milk production reached the formal market (50). Table 3-3 shows that the KCC handles about 96 percent of all commercial milk, while the Mariakani Milk Scheme (MMS) and the other licensees of the KDB handle the other 4 percent.

Table 3-3. Market Shares of Recorded Milk Sales by Type of Operators, 1968-73

	68	69	70	71	72	73
Total Milk Marketed						
Million litres	226.5	228.5	236.0	223.7	274.6	284.3
KCC Total						
Million litres	209.4	210.1	223.1	214.0	264.4	274.6
Percent of total	92.4	91.9	94.5	95.7	96.3	96.6
Mariakani Total						
Million litres	6.7	6.8	5.4	3.7	7.1	7.4
Percent of total	3.0	3.0	2.3	1.6	2.6	2.6
Licensed by the KDB						
Million litres	10.4	11.6	7.5	5.8	3.1	2.3
Percent of total	4.6	5.1	3.2	2.6	1.1	0.8

Source: Computed from KDB and MOA figures.

Numbers and Types of Firms

The nature of business organization influences conduct in various ways. The dominant firm is the KCC which operate multi-unit firms which are geographically dispersed and the Mariakani Milk Schemes which operate in the Coast Province. Cooperatives and individual proprietorships exist in the rural areas and in small towns.

The Kenya Cooperatives Creameries Ltd. (KCC)

The KCC has a virtual monopoly on formal dairy products. It is a country-wide producer controlled cooperative registered under both the Companies Act and the Cooperative Societies Act.[3] The monopoly power of the KCC is more apparent than real since it does not determine producer or consumer prices directly. The control of the company is vested in a Board of Directors elected by the producer members. The preference share capital carries no voting rights or representation unless the company failed to pay the annual dividend. In 1968, KCC had 1,469 supplying members consisting of 1,254 individuals and 215 cooperatives. By 1975 this number stood at 3,062 including 2,768 individual members and 294 cooperatives.

The KCC is also the sole exporter of dairy products. It owns and operates eight milk plants (creameries) at Naivasha, Nyahururu, Eldoret, Nakuru, Kitale, Nairobi, Kiganjo and Sotik and sales depots at Nairobi, Nakuru, Eldoret, Kisumu, Kericho, Nanyuki, Mombasa, Thika, Machakos and Kitale. The KCC plants are organized on a national basis and theoretically enables plants to specialize in the manufacture

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[3]Under a special legal notice, the KCC affairs are exempt from the supervision of the Department of Cooperative Development.

of particular products.

Table 3.5 shows the milk and butterfat intake by KCC plants in recent years. It shows that as the liquid milk deliveries increased the proportion of milk disposed as liquid has declined with the concomitant increase of manufactured milk. Changes in liquid consumption have played a small part in absorbing the increased output of milk, there has been the decline in deliveries of butterfat as a consequence of the disappearance of on-farm separation as a result of changes in pricing system. These factors have resulted in a tendency of milk supplies delivered to KCC to rise more than proportionately. This has serious financial implications for the KCC which has to dispose of a growing proportion of its milk in the less lucrative manufactured products market.

Table 3-4 gives an indication of the manufacturing activities of the KCC.

Table 3-4. KCC Manufacturing Activity, 1969/70 to 1973/74 (Metric Tons)

Year	Butter	Ghee	Cheese	Dried Skim Milk Powder	Dried Whole Milk Powder
1969/70	3,740	704	504	N.A.	N.A.
1970/71	2,969	550	460	1,796	2,253
1971/72	4,064	670	595	3,969	2,764
1972/73	5,467	963	819	4,550	2,925
1973/74	3,938	648	917	2,908	3,357

Source: Kenya Dairy Board

Table 3-5. KCC Milk Intake and Utilization 1968-1974 (Million Litres)

Year	Liquid Milk Intake	Butterfat Intake Milk Equivalent	Total Intake	Liquid Intake Sold as Liquid	Liquid Milk Intake Manufactured	Liquid Sales as % of Total Intake
1968	129.6	79.8	209.4	86.5	43.1	67
1969	141.2	68.9	210.1	90.4	50.8	64
1970	172.1	51.0	223.1	94.7	77.4	55
1971	195.4	18.6	214.0	99.1	96.3	51
1972	248.4	16.0	264.4	115.9	132.5	46
1973	256.6	9.0	274.6	133.7	131.9	50
1974	240.0	6.4	246.4	148.7	91.3	62
Average 1971-74	8.1	-28.9	5.7	8.8	2.1	7.6

Source: Figures supplied by KDB.

The butter and ghee (clarified butter), is derived from the butterfat intake of the KCC, from standardization of milk to 2.3 percent butterfat and from the processing of skim milk powder and condensed skim milk. All the milk delivered to the KCC must, among other things, contain a minimum of 3.5 percent butterfat and 8.5 percent of solids not fat (SNF). Producers are likely to suffer financial loss if milk delivered does not fall in the first grade. The price is reduced by 10 cents per kg. for second grade. Any milk that falls below 8.5 SNF or 3.5 percent butter is downgraded and paid 20 cents per kg. compared to 80 cents per kg. for first grade. The butterfat content of cream should be at least 35 percent. Most of the cream delivered falls in the range 35-50 percent and falls into three grades. There is no inducement to produce cream above 50 percent butterfat in the KCC pricing system.

Mariakani Milk Scheme

The Mariakani Milk Scheme (MMS) was started by the Veterinary Department in the 1930's to organize the collection of milk produced by zebu cows owned by Africans along the coast. By that time, however, it did not have any pasteurising equipment. The MMS has one of the most modern dairy plants in the country and the only significant processing plant not owned by the KCC. It is now operated by the Kwale-Kilifi Dairy Cooperative Union which consists of eight primary cooperatives in the Coast Province.

Until recently the manufacture of dairy products did not depend on the availability of fluid milk surpluses over and above Mombasa demand, but on the need to produce milk powder to pay for the UNICEF

equipment and an agreement with the KCC to supply a maximum of 12,750 litres of milk a day to the Mombasa market. Extra milk could easily be absorbed in Mombasa market which took 19 million litres in 1973/74. MMS with a total of 7.4 million litres would still have been about 11.6 million litres short which means that the KCC would still have to haul milk from up country, a distance of 530 kilometers. Nevertheless, if the MMS could dispose all its milk in liquid form it could be a sure step towards viability and a reduction of its financial deficit which stood at shs. 3 million in 1976. As things stand now the creamery manufactures dried skim milk powder, ghee, cheese, cream and yogurt. This is shown in Table 3-6.

Table 3-6. Milk Intake and Utilization by MMS, 1968-73 (Million Litres)

Year	Total Liquid Milk Intake	Sold as Liquid	Manufactured	Liquid Sales as Percent of Liquid Intake
1968	6.7	3.8	2.9	57
1969	7.3	3.8	3.5	52
1970	5.4	3.8	1.6	70
1971	3.9	2.8	1.1	72
1972	7.1	3.0	4.1	42
1973	7.4	2.8	4.6	38

Source: Kenya Dairy Board

Types of Products

Liquid milk can be sold in various forms. According to drafted standards milk is defined as "the normal clean and fresh secretion obtained by completely emptying the udder of the healthy cow, properly and kept, but excluding that got during the first seven days after calving" (Colostrum) (31, p. 2). It should contain not less than 3.25 percent milk fat and not less than 8.50 milk Solids Not Fat. In addition, it should not contain any additives (including water) and should not have any proportion of a natural constituent removed.[4] Standardized milk has a portion of butterfat removed. The KCC's pasteurized milk has been standardized at 2.3 percent butterfat since 1972 but that of Mariakani Milk Scheme is not standardized.

Pasteurized[5] milk is the natural milk subjected to a heating process at specific temperatures and conditions that ensure the total destruction of pathogenic bacteria and almost all banal flora (but not their spores), but without altering the physiochemical nature, biological characteristics and nutritive value e.g. proteins are not denatures. Sterilized milk (ultra high temperature or UHT) is the natural milk subjected to a process of heating which ensures the total destruction of bacteria and most of the spores. The proteins are denatured.

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[4]Other specifications include density at 20°C (1.026-1.032 gm/ml, freezing point depression and bacteriological count). Very good quality: less than 50, per ml., good quality 50,000-100,000 per ml. Milk with counts above 100,000 per ml. cannot be sold in the liquid market.

[5]The Holder method of pasteurization increases the temperature of milk to no less than 62°C and not more than 65°C. It is retained in this range for 30 minutes and rapidly cooled to 10°C or less.

Pasteurized milk is available in 300 mls., half-litre and one litre tetrapaks, and in cans for bulk consignment from the KCC and in plastic satchets from the Mariakani Milk Scheme. Ultra-high temperature (UHT) long life milk is also available in half-litre and one litre tetra-paks. Pasteurized milk is available in the homogenized and non-homogenized forms.[6] Other products include acidulated or fermented milk (mala), sweetened condensed milk (skim and whole milk), evaporated milk, cream, butter, ghee and casein.

Processing Plants

The major processing plants are located at Nairobi, Nakuru, Eldoret, Kitale, Sotik, Kiganjo, Naivasha, and Nyahururu. Spray driers are located at Eldoret, Kiganjo and Kitale and roller driers at Naivasha. Pasteurized milk is packed in all plants except Naivasha but in addition, Nairobi and Kiganjo can pack 42 and 90 thousand litres of UHT long life milk per day. Butter, ghee, and casein are made in Kiganjo, Nakuru and Eldoret. Nairobi produces both conventional and processed cheese.

Table 3-7 below indicates the fluctuations of milk intake and the capacity utilization of the plants, including Mariakani, which is not a KCC plant. The daily utilization of manufacturing capacity amounts to 83 percent. Any higher utilization would force the company into greater wastages which currently stands at one percent. Since liquid requirements are rather static throughout the year, the major fluctuations in the utilization of capacity are found in the

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[6] In 1975 the quality of milk, the taste, the time it could be kept and the quality of packaging were the subject of complaints in the press. These problems have been resolved.

the manufacturing of milk products.

Table 3-7. Average Intake and Plant Capacity Utilization, 1971/72

Factory	Daily Average Intake	Highest Intake		Lowest Intake		Average Utilization of Capacity (Percent)
		Kg/day	Month	Kg/day	Month	
Naivasha	64,138	70,956	October	56,318	December	90
Nyahururu	28,212	34,556	October	20,196	April	82
Eldoret	157,037	196,381	June	114,769	April	80
Nakuru	143,961	165,677	September	108,025	April	87
Kitale	68,866	80,602	June	53,324	April	85
Nairobi	77,252	100,938	June	65,856	December	77
Sotik	11,440	14,685	October	8,379	April	80
Kiganjo	72,168	93,913	June	62,737	April	77
Kisumu	2,535	3,099	June	1,555	April	82
Mombasa	10,216	18,587	June	6,199	November	55
Total	635,592	779,394		497,358		83

Source: Ministry of Agriculture (9).

All plants operate on a one-shift per day basis except in periods of flush milk in the wet season. The only exception is the Nairobi Plant which normally operates on two shifts per day basis and on a three-shift basis during peak periods. In 1972, the Sotik plant was unable to process all the milk because of a shortage of capacity. Consequently, after extracting the butterfat the skim milk was poured down the drain. Although the industry is organized on a

national basis, it is not always possible to balance out regional shortfalls against regional surpluses for processing because of the long distances involved. Additional capacity expansion and modernization of existing plants have taken place since 1972 and further expansion is envisaged.[7] Seasonal fluctuations, however, have worsened with accompanying serious cost implications for the KCC. The Mariakani processing facilities are much larger than actual intake would warrant. However, a plan to replace the milk packing equipment (Hi-pak) with Tetra-pak equipment is under active consideration.

The location of processing plants relative to milk production appears to be satisfactory with the factories distributed in the major producing areas. The major consuming centers are also well served except Mombasa which is over 500 milometres from the nearest KCC plant at Nairobi. Despite being close to the Mariakani plant, Mombasa's daily requirements far exceed total milk available and consequently extra milk has to be hauled from Nairobi. With current pricing policies, however, the Mombasa consumers pay the same price for their milk as other Kenyan milk consumers. The major consuming centers and their intake of liquid milk per day are shown in Table 3-8, in conjunction with the processing plants that serve them. The vast majority of domestic milk sales have been in urban areas, with Nairobi and Mombasa taking about 50 and 20 percent respectively.

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[7]A sum of K Shs 100 million has been earmarked for the expansion and renovation of existing factories and plans for a new processing plant for Nairobi are at an advanced stage.

Table 3-8. Major Fluid Milk Consumption Centers and Supplying Creameries, 1975

Creamery		Kiganjo	Nairobi	Nyahururu	Nakuru	Naivasha	Kitale	Eldoret	Sotik	Mariakani
Total Utilizable Capacity (Litres)		216,000	300,000	180,000	216,000	144,000	200,000	216,000	180,000	20,000
Place	Consumption litres/day									
Nairobi	174,000		x	x						
Mombasa	62,000		x							x
Thika (& Muranga)	11,000		x							
Machakos	11,000		x							
Eldoret (& Webuye)	18,000									
Kiganjo, Nyeri Nanyuki, Embu Meru, Isiolo	16,000	x		x						
Nakuru										
Naivasha										
Gilgil	21,000				x	x				
Kitale	5,000						x			
Kericho	5,000								x	
Kisumu	30,000						x	x		
Kampala	100,000						x	x		

Source: The Kenya Co-operative Creameries.

X indicates major source of liquid milk after processing. We do not consider inter-creamery shipment before processing.

Product Differentiation

A general class of product is differentiated if there is a way to distinguish the goods or services of one seller from those of another. Such a basis may be real or fancied but as long as its important to the consumers it leads to a preference where buyers and consumers will be paired according to their preferences (12). Product differentiation is one of the non-pricing mechanisms of competition. The differentiation of dairy products may be based on such factors as butter fat content, levels of solids not fat, homogenization, packing materials, e.g. tetra paks, plastic satchets, bottles, metal containers, brands, advertising and wholesale delivery services. Advertising in the Kenyan fluid milk industry is at relatively low levels except for generic promotion by the Kenya Dairy Board and the KCC. Product differentiation is not very important in Kenya given the dominant position of the KCC. Even in Mombasa the sales level is fixed by agreement between the KCC and the Mariakam Milk Scheme. The MMS also envisages a switch from its present Hi-pak machinery to Tetra-pak.

Barriers to Entry

Barriers to entry are only important in the commercial channel of fluid milk sales. At the farm level any producer can retail milk to neighbors[8] and farm workers. The major barriers to entry in the commercial market are institutional. The most important barrier is that of operator licenses. In most urban centers (the scheduled

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[8]In theory this is illegal. The Dairy Industry Act permits sales only to on-farm workers and requires a license for off-farm sales except those made to licensed buyers like cooperatives or the KCC.

markets) only pasteurized milk is allowed. These areas are prescribed and gazetted and KCC, the only agent of the KDB permitted to supply liquid milk. In smaller townships the KDB licenses[9] producer/retailers or cooperatives to sell milk. In many of these towns cooperatives enjoy monopoly situations.

Economies of size in processing, distribution and promotion of fluid milk products do not appear to constitute an important barrier as licensing to entry on a priori basis. In 1970 the so called 'rationalization' of distribution was introduced and the KCC's monopoly position was consolidated in major urban centers. The KCC eliminated all private dairies and middlemen in Nairobi, Mombasa, Nakuru, etc. The KCC took over the sale and delivery of milk in bulk to institutions and replaced all bottle milk sales with tetra paks. The KCC thus took over a large portion of the milk business held by the dairies,[10] contending that it would "contribute to eliminating the incidence of milk adulteration, illegal sales by producers, etc." (49, p. 6). The KCC in fact wanted to increase its revenues substantially in order to start the manufacture of spray dried milk powders. The Kenyan processing plants are medium in size and

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[9]The KDB has an inspectorate that ensures that 'pirate' milk sales do not occur. Because of the increased sales opportunities to coops and because of the ever vigilant inspectorate illegal sales are minimal in many centers.

[10]Some members of the Dairy Working Party opposed the KCC moves contending that elimination of middlemen was not synonymous with reducing marketing costs, that elimination of competition was not conducive to efficiency, that elimination of bottled milk interfered with consumer preference and was likely to have adverse effects for a careful study of the system, including costs, margins, profits, and services but the KCC did not heed them.

all other things being equal are likely to enjoy economies of size, but this would need to be tested on empirical grounds.

Vertical Coordination

Vertical coordination has been defined by Mighell and Jones "to include all the ways in which the vertical stages of production are controlled and directed" (16, p. 1). It can also refer to a process which integrates and synchronises the functional inputs of subsector members, so that the subsector in total responds to market demands (43, p. 3). Vertical integration refers to situations where two or more stages of the process (such as production and manufacturing) are joined together into one business unit under a common management (15, p. 27). Vertical coordination can be effected through a market price system, an administratively regulated system or some combination of the two. Vertical coordination in the Kenya dairy subsector is achieved by both systems, but the balance is largely tilted on the administrative side. The actions of suppliers, processors, distributors, retailers and consumers are largely influenced by government action. The individual milk producers and smallholder cooperatives deliver their milk to the producer monopoly-cum-processor-cum-distributor, the KCC. As an agent of the Kenya Dairy Board, the KCC is expected to accept all milk that meet certain minimum standards. The producer and consumer prices are also administratively determined. The processing of dairy products is integrated vertically under the aegis of the KCC and by the Mariakani Milk Scheme at the Coast.

The Export of Dairy Products

Kenya is a net exporter of dairy products. Despite the rapid increase in demand for milk at 8-9 percent per annum supply has tended to outstrip domestic demand. The lack of purchasing power by a substantial proportion of the population means that the absorptive capacity for fluid milk and manufactured products in the Kenyan market has been limited. The very skewed distribution of income exacerbates restricts the purchashing power of a large percentage of the population.

Dairy Exports have been an important source of foreign exchange. In 1964, for instance, exports were worth K£2 million and by 1972 this figure had reached K£3.8 million or about 4.8 percent of the total agricultural exports. The majority of these products were sold to the East African partner states of Uganda and Tanzania which, together with Kenya, have always been considered the primary market. The breakdown of exports from Kenya are shown in Table 3-9.

Table 3-9. Dairy Product Exports, 1968-1974

Year	Milk	Cheese	Butter	Ghee	Milk Powder
	Million Litres		Metric Tons		
1968	17	210	2,140	451	943
1969	14	209	1,624	257	1,221
1970	10	197	1,596	327	2,310
1971	9	96	891	180	1,641
1972	18	324	2,399	359	3,900
1973	30	557	2,463	265	4,410
1974	33	267	1,742	155	1,273

Source: Kenya Dairy Board

In the period 1969/70 to 1973/74, 46 percent of all cheese exports, 54 percent of butter, 68 percent of milk powder and 31 percent of ghee exports were sold in the East African market. In the same period 99 percent of all liquid milk exports were sold in Uganda and Tanzania, with Uganda accounting for 85 percent of the total. The sales to Uganda has shown spectacular growth, rising from 9.9 million litres in 1969/70 period to 31.1 million litres in 1973/74 period. Payment problems and trade impediments have greatly restricted the scope of exports to these markets. Since import substitution is the goal of East African countries these countries are eager to develop their own dairy industries. In fact, Uganda had planned to phase out all fluid milk imports from Kenya by 1970. The risk of reliance on the Uganda and Tanzanian markets was recently realized by the Kenyan government. The current insecurity in Uganda and Uganda's failure to pay K Shs 20 million it owes the KCC means that this market is virtually lost. The closure of the Kenya/Tanzania border by Tanzania in February 1977 following problems arising from the now defunct East African community also meant the loss of the Tanzania market. In 1976 sales to Uganda and Tanzania were reduced to almost zero. In addition, the Malawi and Zambian markets were also curtailed. While replacements will be difficult to find, it is encouraging to note that the KCC realized sales worth Shs 15 million between July 1976 and June 1977 by exporting various products to Saudi Arabia, South Yemen and Djibouti.

Exports of dairy products outside East Africa are made at loss.[11]

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[11] Even butter is only competitive in East African market.

The domestic whole milk market has been very important because prices could be fixed at levels that always enable profits to be earned which could be used to subsidize the export of butter, cheese, ghee and various powders. The domestic market was always under pressure to maximize sales and to make high profits for subsidizing exports. Kenya is not at current prices, a successful competitor with major dairy product exporters such as New Zealand and Denmark. The fundamental reason for this is the low yields obtained from the dairy herds. Milk production per cow in other producing countries is as much as three times the Kenyan yields, which more than compensates for their higher costs of production and transportation. For Kenyan dairy exports to compete in export markets without subsidy, yields would have to be increased substantially without a corresponding increase in costs. Yields have been rising in Kenya but the rate of increase has been rather slow. There is a wide scope for improvement given the range of yields between the low and high yields of dairy herds. In some farms milk yields are nearly as high as those of our foreign competitors. The potential for high yield is present in Kenya but it may take a long time to achieve these increases.

Protection for the Local Dairy Industry

The domestic market for dairy products has enjoyed protection from overseas competitors for most of its products. Fifty percent duties were levied on imports of most dairy products (excluding baby foods) until 1973 when the duties were reduced to 25 percent. Even though duties were as high as 50 percent they did not always afford sufficient protection for some products like sweetened condensed

milk. The problem of tariff protection has been administered on an East African basis. The rule of thumb applied has been to price the products for East African market at a level whereby products from abroad, including the protective duty, do not enter the East African market at competitive prices. This has been especially important for the Tanzanian and the Ugandan markets where the differential between prices charged in the East African market and foreign exports was reduced in the early 1970s before the dissolution of the East African Community in 1977.

The Role of Government

The Kenya government through its various agencies is heavily involved in the activities of the Kenya Dairy subsector such as pricing, research, credit and the provisions of inputs. Various laws such as the Public Health Act govern the safety of milk and milk products. The Dairy Industry Act governs the dairy industry and regulations that govern the cooperative movement, etc. The government has the responsibility to see that the consumer is protected against products which are dangerous to health or do not have the quality or characteristics which may be claimed by the seller. The Kenya Bureau of Standards is expected to set such standards and to consolidate those under the Health and the Dairy Industry Act.

The government of Kenya has granted monopoly rights to the KCC to handle dairy products. This has been rationalized on the grounds of economies of scale and the need for an equitable sharing out of the burdens of seasonal and occasional surpluses. In addition, the government has instituted a regulating arm of the dairy industry by

way of the Kenya Dairy Board. The objectives of the KDB were enumerated in Chapter II. Certain activities of the KDB and KCC overlap and it has always been felt that the dairy industry would gain substantial savings and enjoy greater coordination of policy if the two bodies were merged. Echoing this policy in 1965, the Kibaki Commission Report (36) recommended the establishment of a Dairy Authority, the Kenya Dairy Commission, as a statutory corporation along similar lines to the Milk Marketing Boards of the United Kingdom. This would have, inter alia, involved the nationalization of the KCC and would have permitted the articulation of producer and producer interests. The Commission maintained that it was undesirable to allow the existence of a private producer controlled monopoly to operate only in producer interests. When the bill incorporating most of the Kibaki Commission Report was presented in the Kenya Parliament it was defeated. Despite this defeat the Ndegwa Commission Report (35) strongly endorsed the Kibaki Commission Report and reiterated the call for the amalgamation of KDB and the KCC into a Statutory Commission like the Kenya Meat Commission.[12] In addition to the

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[12]The merger has never taken place. In 1971 the Minister of Agriculture had referred the question of the 'Dairy Authority' to KDB and KCC with instructions that two agencies attempt to reach an agreement and report directly to him. The Chairmen of KCC and KDB recommended the continuation of KDB with certain changes in its Board. At the end of 1971/72 the appointed members and top executives of the KDB were retired and the day to day management of the Board devolved to the Ministry of Agriculture (MOA) which attached several officers to act in various capacities, e.g. executive officer. The Head of Animal Production Division of MOA became chairman of an Advisory or Management Committee which replaced the Board members. This meant that Services of Advocates and Public Relations Consultants were dispensed with. The Nutrition Team was permanently transferred to the KCC. The KDB cess would be collected by MOA on behalf of the Board and the MOA will over-see accounts also. This is the position today.

Kibaki Commission an official Dairy Working Party was set up on 1970/71 to examine, inter alia, the pricing policy, the competiveness of the dairy industry and its long-run development. The members of the Dairy Working Party saw their duty as formulating "a pricing and marketing policy for the dairy industry that would encourage the growth of the industry in the 1970's in the national interest" (49, p. 2). However, while the working party was sitting that the KCC announced the abolition of the independent dairies based on the recommendations of Tentoni (74). This resulted in the complete entrenchment of the KCC's monopoly position in the consuming areas. Although several attempts have been made to control the monopoly powers of the KCC, the KCC has a powerful lobby and it has resisted such efforts.

The KDB, the statutory authority governing the dairy industry, has made a number of efforts to rationalize the pricing system and to exert some control over the marketing system. Thus far these efforts have not been successful. In Chapter II it was indicated that the Dairy Board came into being at the instigation of the KCC, principally for the purpose of controlling non-KCC producer/retailers and the distributors of dairy produce. With the virtual abolition of non KCC distributors in the scheduled markets, the role of the Dairy Board has been reduced. Political considerations, particularly among producers, and the requirement that the KCC maintain financial viability in the face of a given producer price, have been responsible for pricing in the industry. Political expediency takes precedence over careful economic analysis.

The net effect of the structural and pricing policies is that there are inefficiencies in the processing and marketing system which

eventually raise the fluid milk price to the consumer. This reduces the consumption of fluid milk particularly among the poorer consumers. More milk thus has to be diverted into manufacturing where the net price realized per litre of milk is substantially lower. The losses involved in manufacturing milk, and in maintaining capacity must again be recouped from sales of fluid milk.

Pricing Policy in the Kenya Dairy Industry

Prior to July 1970 there were announced prices for milk under Pool I (quota) Pool II (contract) and Pool III (for separation) categories. Pool I implied a farmer's obligation to supply a given volume of milk every day of the year and the KCC's reciprocal obligation to purchase that amount everyday of the year. We described how a farmer qualified for a quota in Chapter II. The amount of contract milk purchased by the KCC was subject to the dairy industry's requirement for manufacturing, but the farmer was allowed more flexibility in that deliveries could fall 25 percent below the contract without penalty. If a farmer had a quota he was also able to supply contract milk as well but after 1965 most of the contracts were allocated to new farmers. Pool III, the milk for separation earned the lowest payment and the farmer could deliver as much as he wanted for that purpose. Since the payment for cream was better and the farmer retained the skim milk, most of the milk in excess of quota and contracts was delivered as cream.

Unlike today the prices paid to the producers prior to 1970 were not uniform throughout the country. They varied according to the distance from the principal markets. Table 3.10 shows there was

a premium of 35 cents per gallon in Nairobi area, 20 cents in Kisumu and 65 cents in Mombasa. In 1966/67 there was an announced price of Shs 1.80,[13] 1.30 and 0.90 per gallon (Shs 0.40, 0.29, 0.20 per litre) for Pool I, Pool II and Pool III milk respectively. The average pay out for Pool I and II was Shs 2.67 and for Pool III Shs 1.29, with an average of Shs 2.05 per gallon (Shs 0.45 pre litre) for all milk received. This average pay out is the price shown in Figure 3-2 for the years up to 1970. The figures from July 1970 give the uniform price paid for all milk received by the KCC. The corresponding consumer prices are also shown.

The quota system was a method of maintaining supplies of milk in the dry season by paying the farmer a higher price for a given quantity of milk that had to be supplied daily throughout the year, or the quota was forfeited.[14] While quotas are a farily common method of maintaining off-season supplies in most developed economies, the problem in Kenya was the need for a structural change from a colonial to a post independence economy in which the smallholder would play an important role in commercial dairy farming. Most of the quota suppliers were large established farmers (mostly European) with the effect that they were seen to be getting a higher price for their milk than the smaller African farmers particularly those in the

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[13] The higher costs of production of milk for fluid consumption arise through the necessity for fast and efficient transport of milk and the extra costs associated with observation of higher standards of hygiene.

[14] Production was maintained by staggering births of calves to coincide with other cows going dry, by growing fodder, by additional feeding of purchased feeds and sometimes by purchasing replacement cows ready to give milk when others in herd had completed their lactation. In 1965, it was estimated that it cost more than £10 per gallon to enter the quota market.

Table 3-10. KCC Milk Producer Prices in Shillings Per Gallon, May 1968

		Quota	Contract	Separation
Eldoret, Nakuru	Basic Price	1.90	1.90	1.00
and Naivasha	Quota Premium	.50	-	-
	Total for Month	2.40	1.90	1.00
Thompson's Falls	Basic Price		1.90	1.00
	Less Transport		.20	.20
	Total for Month		1.70	.80
Nairobi, Incl.	Basic Price	1.90	1.90	1.00
Thika	Quota Premium	.50	-	-
	Geographic Premium	.35	.35	.35
	Total for Month	2.75	2.25	1.35
Kisumu	Basic Price	1.90		
	Quota Premium	.50		
	Geographic Premium	.20		
	Total For Month	2.60		
Kericho	Basic Price	1.90	1.90	1.00
	Quota Premium	.50	-	-
		2.40	1.90	1.00
	Less Transport	.20	.20	.20
	Total for Month	2.20	1.70	.80
Mombasa	Basic Price	1.90	1.90	1.00
	Geographic Premium		.65	-
	Special Premium		.50	-
	Past. & Delvy. Allowance		.45	-
	Additional Payment		-	-
	Total for Month		3.50	1.00

Source: The KCC.

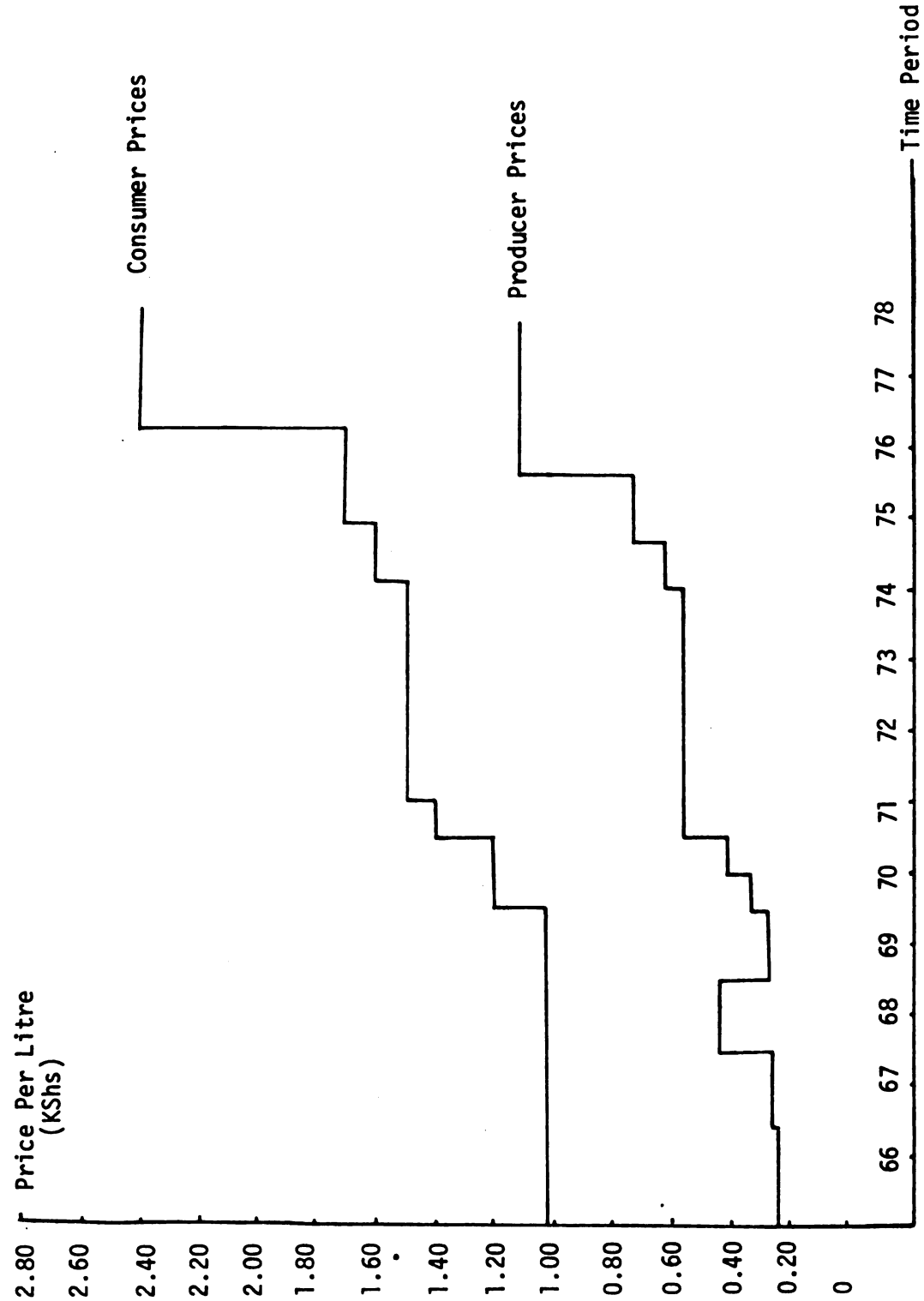

Figure 3-2. Producer and Consumers Prices for Milk, 1966-77

settlement schemes who supplied contract milk and milk for separation.[15] While quota suppliers earned a higher basic price plus 50 percent premium for the proportion of their sales used as fluid milk those with no quota received a meagre 22 cents per litre (Shs 1.00 per gallon) delivered to the factory. For the small producers who marketed their milk through cooperatives, it was not unusual for the net price to be as low as 11 cents per litre (50 cents per gallon) which was obviously below the cost of production. The quotas were, of course, worth money, and were traded at a substantial price per gallon. Thus distribution of quotas was based on the ability to pay for them as well as the ability to maintain supplies. Since the demand for fluid milk consumption was growing slowly the demand for quotas was too great to be satisfied. The other problem was that some of the newer African farmers who bought quotas had difficulties filling them in drought and consequently lost them. The quota system had a further disadvantage in that the quantity for which a high price was paid was fixed. Hence there was no incentive for the efficient producer to improve his methods of production and increase his output once his quota was met. The system was inequitable and lacked flexibility. Eventually three independent reports recommended the abandonment of the quota system. The Kibaki Commission Report concluded that "quotas in their present form were acceptable to many producers"

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[15]Confusion concerning quotas arose because the new African farmers could not understand why they should be paid different prices for the same product. This was aggravated by the fact that because of large transportation costs milk purchased from smallholders under Pool III would end up in liquid market, say around Nairobi, while milk under Pool I, around Eldoret would end up in manufacturing.

and called for their replacement with contracts (36, p. 14). Tentoni (74) also recommended their elimination and the Dairy Working Party backed the two reports (49). The quota system was terminated in June 1970.

Quotas were replaced in July 1970 by a pool pricing system involving a guaranteed minimum price of 46 cents per litre (Shs 2.10 per gallon) plus a bonus based on the amount realized by the KCC from the sale of liquid and manufactured products. All producers except those selling large quantities of quota milk received a higher return and they shared more equitably in the relatively lucrative liquid milk sales.

Since July 1971 the KCC producer price has been set by Presidential decree. A factory gate price of 77 cents per litre (Shs 3.50 per gallon) was set in 1971. This 45 percent increase stimulated increase production in a wet year. The price increase also led to a reduction in the amount of milk retained in the rural areas and also reduced butterfat intake by 44 percent. In addition, the boost in price led to the milking of beef cows which had implications for beef output.[16] Stotz (71) notes that because of the favourable price of milk, and the desire to increase land productivity, beef ranches are shifting toward a combined milk and beef production system. He contends that beef ranches only produce milk during the flush season when grass is available, thus further aggravating the seasonality of

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[16]The fact that the boost in milk price would tend to reduce the output of beef which was more competitive in export markets than dairy manufactures implies a misallocation of resources and does not serve to maximize foreign exchange earnings. The substantial increase in beef prices announced in 1978 should alleviate the problem.

milk production.

The requirement that the KCC purchase all supplies offered at 77 cents per litre brought about a major financial crisis[17] because the 35 percent increase in the volume of liquid milk intake resulted in a greater volume being manufactured as low paying dairy products. A shortage of processing capacity forced the discarding of some skim milk after butterfat extraction.

The financial squeeze of the KCC was only eased in 1975 as a result of increased demand for fluid milk and a short-fall in production because of drought in two consecutive years and also because of a decline in the real price of marketed milk (relative to prices of other products) and a consequent increase in rural milk consumption. In addition other administrative measures were taken to improve the financial position of the KCC.[18] The producer price was increased from Shs 0.80 to Shs 0.93 per litre (Shs 3.75 to Shs 4.25 per gallon) in November 1975 and again from Shs 0.93 to Shs 1.32 per litre (Shs 4.25 to Shs 6.00 per gallon) in September 1976. These recent increases have undoubtedly stimulated excess production during the wet season.

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[17] A net loss of KŁ721,376 over the two year period 1971/72 and 1972/73.

[18] These included: (i) The consumer price which had been raised by 10 cents per half-litre from 70 cents to 80 cents when the producer price went up to Shs 2.50 per gallon on July 1, 1977 was further increased by 5 cents in May, 1972 to 85 cents. (ii) The KCC was permitted to levy a 1 cent per litre cess to help finance payments for the expansion of Sotik, Kitale, and Nyahururu plants. In addition, the KCC was further permitted to retain 50% of the KDB cess of 2 cents per litre to help offset this deficit. (iii) The KCC liquid milk was all standardized at 2.3% with no payment going to the producers for the butterfat accrued by this method. (iv) The KDB Board of Directors including all sub-committees was suspended in May 1972 and the management drastically reduced in order to enable the Board to continue its operations within the one cent per litre cess. Effective management of the Board devolved to the Ministry of Agriculture.

Between September 1976 and March 1977 the KCC incurred a loss of Shs 35 million and by August/September 1977 it was unable to pay the farmers in Sotik, Uasin Ghisu and Kitale areas.[19]

Seasonal Fluctuation of Milk Supply

Predictably, the seasonal fluctuations in milk supplied to the KCC increased markedly with the introduction of a uniform price in 1970. Much of the increased production has gone into home consumption and informal marketing channels especially in the small farm areas where grade cattle are a relatively recent innovation and as yet little milk is exported from these areas. As production increases in the small-farms the local milk price declines until eventually it approaches the price at which the KCC buys fluid milk. Milk in these low income communities has a substantial price elasticity of demand and large increases are absorbed by local consumers as milk becomes increasingly available and the price declines.

When milk is scarce, consumers tend to come to the dairy farmers with their bottles. As production increases in an area, the farmers must take a more aggressive sales approach. At this point, if not before, the farmers tend to form marketing cooperatives. In the dry season these societies generally dispose of all milk locally (except where the local market is insignificant) but when surpluses develop

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[19] These losses arose from overproduction and the loss of Tanzania, Uganda, Zambia and Malawi markets after the closure of the Kenya/Tanzania border and insecurity within Uganda. Also, the KCC had to pay the Shs 1.32 per litre without any corresponding consumer price increase (between September and March 1977). A stop-gap measure of a government guaranteed loan was advanced to KCC to tide it through these difficulties and to enable it to pay the farmers. In addition to inflationary costs, there are allegations of short-comings in KCC's management which are as yet to be disproved.

they are sent to the KCC. At first deliveries to the KCC are strictly seasonal and in some areas they are likely to remain so. Even where a permanent surplus is produced the KCC tends to remain the residual buyer with local demand met first at a premium price.

According to this consumption and marketing model, in areas where the local price for milk is higher than the price obtained from the KCC (i.e. price paid out minus the transport costs to factory gate) the increases in production can be expected to be marketed locally until the price is driven down to the KCC floor price. The implications of having a relatively fixed local demand which is met before supplies go to the KCC is that percentage fluctuation in KCC milk deliveries are very much greater than fluctuations in overall production. All available evidence indicate the local prices are significantly more attractive than KCC producer price. Where local milk is below the supply price to the KCC the market can be regarded as being saturated and areas where the price is significantly higher than the supply price to KCC it can be expected to absorb considerable additional supplies as the price falls to the KCC produce price level. Only when the price is driven down to this 'floor' level, and only then, can an area be expected to start sending supplies to the KCC. The KCC is, in other words, the buyer of the residual surplus once the local market is satisfied at the KCC producer price.

Table 3-11 presents the monthly intake for the KCC between 1969/70 and 1973/74. The increase from the lowest monthly intake to the highest monthly intake was 28.7 percent in 1969/70 (quotas in operation). In 1973/74 the fluctuation was much greater with a 102.4 percent increase in intake from the lowest month to the highest. The

Table 3-11. Seasonality of Milk Supplied to KCC (Milk and Butterfat Intake in Milk Equivalent), 1969/70 - 1973/74

Month	1969/70	1970/71	1971/72	1972/73	1973/74
July	17.9	20.6	22.5	25.0	25.2
August	17.3	19.1	22.2	25.5	24.1
Sept.	17.0	17.8	22.0	23.3	23.7
Total 3rd quarter	52.2	57.5	66.7	73.8	73.0
Oct.	17.0	18.2	22.2	23.6	25.3
Nov.	16.7	17.4	20.3	25.8	24.7
Dec.	18.1	16.6	18.7	27.8	23.1
Total 4th quarter	51.8	52.2	61.2	77.2	73.1
Jan.	17.1	14.8	19.0	25.4	18.3
Feb.	17.3	12.3	17.6	21.0	12.9
Mar.	17.7	10.2	19.2	21.6	12.5
Total 1st quarter	52.1	37.3	55.8	68.0	43.7
April	19.6	9.9	15.6	16.7	18.1
May	21.5	17.8	19.1	20.7	24.0
June	20.6	20.6	23.7	24.1	23.4
Total 2nd quarter	61.7	48.3	58.4	61.5	65.5
Whole Year	217.8	195.3	242.2	280.5	255.2

Source: Kenya Dairy Board, 1975

intake fluctuation is illustrated in Figure 3-3. For the highest month the intake is markedly higher in the latter year, but for the lowest month it is 4.2 million litres lower. This is what should be expected with a uniform price between seasons and no incentive to maintain supplies in the off season. The uniform price is clearly too high for the flush season, but too low for the dry season when costs of production and the value of additional milk are both a great deal higher.

Seasonal Differentiation of Producer Price

One element of the milk pricing system that seems clearly irrational is its uniformity between seasons. The chronic surpluses in the wet season and the chronic deficits in the dry season are a direct and inevitable consequence of this pricing policy. Producing milk in the wet season when grazing is abundant is a great deal cheaper than producing milk in the dry season. A rational farmer's response to a uniform milk price is likely to be to calve seasonally, concentrate milk in the flush season and aim to dry off his cows when it is expensive and difficult to provide them with the necessary feed to maintain yields. Year after year the dry season fluid milk shortages[20] are blamed on drought as if a dry season were an annual surprise. However, these shortages are the predictable result of a uniform price given the fact of seasonal rainfall variations.

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[20]These shortages are usually severe and liquid milk requirements of the urban centers are unmet. KCC's manufacturing activities plummet to a minimum but some exports have to be maintained to protect hard won markets. Imports are allowed to meet shortfalls, e.g. butter which represents a loss in valuable foreign exchange. Black markets and tied sales arise in urban areas.

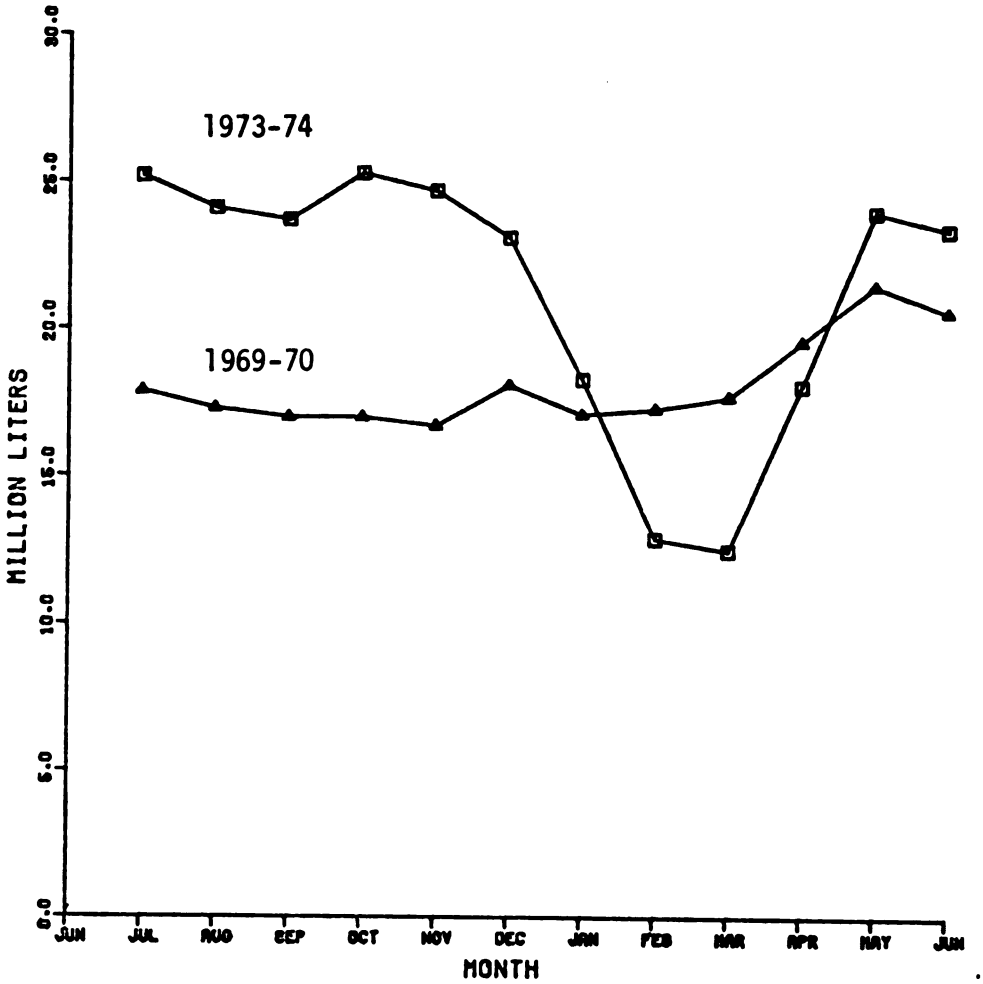

Figure 3-3. Seasonality of Milk Supplied to K.C.C. (Milk Equvalents)

In the dry season, not only could the fluid milk market absorb additional supplies but virtually the entire stock of equipment for processing milk products is substantially idle. The substantial fixed costs are incurred whether or not the capacity is utilized. The problem is that the capacity of the processing facilities must be capable of handling the peak output of the wet season, the extreme seasonality of supply necessitates the investment in capacity that is utilized for a short period.

Enormous costs are imposed on the KCC by the extreme seasonality of production. The KCC is required to purchase all milk irrespective of whether it is financially appropriate or not. In general large losses are made in the flush season when a large portion of milk purchased must be processed and sold at a loss. In the dry season huge financial gains are made as virtually all milk is sold as fluid milk at a high price. The KCC requires an excessive consumer price for milk in order to recoup its losses during the peak season. This high price substantially curtails consumption and forces the KCC to put more milk into unprofitable processing channels. In the meantime pressure from the farmers, who are themselves incurring substantial dry season losses, demand an increase in the milk price merely to cover their costs. Clearly, what is needed is a recognition that neither production costs nor the value of additional milk supplies is uniform between seasons. Milk supplies can be maintained in the dry season, but only at a substantially higher production cost. To stimulate such production, adequate incentives of higher dry season revenues are necessary for farmers.

Spatial Effects of a Uniform Milk Price

The existing pricing structure which pays a uniform price for milk irrespective of the location of the receiving plant and regardless of the season of the year is in urgent need of review. The uniform price paid for all milk in different parts of the country has the effect of concealing transport costs involved in the delivery of milk to the consuming centres. Consequently, rather than encouraging the economically optimal location of milk production in the country, it promotes a misallocation of resources. The total cost of getting milk to the consuming centres differs widely depending on where it is produced. The KCC operates a transport pool for ferrying milk from the more distant areas at a very substantial cost which is not reflected in the lower price to producers in those areas. Production in the more remote areas therefore receives excessive stimulation and production in the areas where the hidden transport costs are either non-existent or a great deal less receive inadequate stimulation. Areas near the main markets are thus subsidizing the areas that are more remote. There is thus an economic case to recommend the abandoning of the transport pool.[21]

Rational pricing systems for milk are complex, but if whole milk is being transported to an urban area such as Nairobi, the value

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[21] The Kibaki Report had endorsed a spatially differentiated price. "That where transport costs are saved to the industry, these should be passed to the producers. . ." (36, p. 17). Although the Dairy Working Party recommended a countrywide uniform price with no geographical differences for either producer or consumer price, the minority view while admitting the simplicity such a pricing arrangement felt that the differences in the supply for milk, the existence of deficit and surplus areas and transport costs justified geographical price differentials.

of milk at any given distance from Nairobi is the Nairobi price less the cost of transport. In economic terms, surplus milk produced far from consuming centres has a lower value and therefore the establishment of processing facilities in those locations is justified as long as adequate supplies are forthcoming so that processing facilities can be large enough to benefit from economies of scale. Processing reduces the physical bulk of the product and enhances its value, making it suitable for long distance transportation.[22] Thus processed milk products--cream, butter, cheese and dried or condensed milk--will incur far lower transport costs. Such processing facilities are to operate at a loss if a high price is paid for milk, just as the marketing system must sustain a loss if high priced whole milk must be transported long distances to consuming areas.

The KCC creameries are organized on a national basis in the interest of efficiency so that they can specialize in the manufacture of particular products, but according to this organization, no differences in producer or consumer prices exist on a geographical basis. There is certainly an economic case for differential produce (and consumer) prices based on existence of surplus and deficit areas and differential transport costs. In determining the price paid to the producer a premium might be paid for milk supplied to creameries where there is a large demand and where up to now considerable quantities of milk have had to be 'imported' (e.g. Nairobi and Mombasa) from other plants, often over large distances. The KCC does not also appear to have exploited the advantages of a national marketing

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[22]Transporting raw milk costs about 10 times as much as transporting butterfat (36).

system. For instance, there are substantial manufacturing activities such as cheese in the Nairobi plant that would result in substantial savings if relocated up country.

Cross Product Subsidization and Exports of Dairy Products

It has been mentioned that the so-called 'realized price' per litre of milk is far higher for fluid milk sales than it is for processed milk products. The consumer pricing system of the KCC has been one of using the considerable profits derived from the sale of whole milk to, in effect, subsidize the sales of processed milk products. Whole milk, which requires relatively minimal processing is sold at well over double the price that is paid for it. Processed milk products, on the otherhand, are sold at prices that do not even cover the costs of purchasing and processing the milk, both in the domestic and export markets. This is true for cheese, which is consumed by high income consumers, and for milk powder. The exception is butter, on which some profit is made for sales in the domestic market. While the KCC's purchase price of milk stood at Shs 0.77 per litre (Shs 3.50 per gallon), net realization estimates by the Economic Planning Division (9) once processing costs have been included are as follows:

	Shs per litre	(per gallon)
Liquid milk	1.02	(4.64)
Whole milk products	0.58	(2.64)
Milk for separation	0.50	(2.27)

The KCC's own estimates are that a net loss is made with 10 of the 14

products, with only fluid milk and butter being the only significant source of net revenue.

The problem of these loses and those made during the export of dairy products is relevant for the overall pricing policy of dairy products. The recouping of such losses from domestic sales of liquid milk inflates the internal price of dairy product and thus tends to reduce the domestic absorptive capacity of these products. It was also indicated that Kenya is not a very successful competitor in export markets. The international demand for dairy products is not strong and cannot be counted on as a reliable outlet for Kenyan products.

There are major issues regarding the appropriate level of output. The two extremes would be to contract the industry until it only supplied the local market or the continued expansion with concomitant subsidization of exports. The first extreme would be unacceptable since the restriction of output would have serious implications for mixed agricultural farming, and the distribution of the overheads of creameries and would also take place when the small holder is being encouraged to raise income through integrated livestock/crop husbandry in order to implement rural development. Also given Kenya's variability in climate it would be impossible to ensure supplies for local market in good and bad years unless there is some surplus beyond normal domestic requirements and the loss of valuable foreign exchange is unlikely to be welcome. Since Kenya can ill afford costly export subsidies the choice becomes one of optimizing the levels of surplus. This can be achieved by maintaining supply at a level adequate to meet Kenya's domestic needs and a small surplus

to supply neighboring export markets where Kenya enjoys an advantage over competitors because of lower transport costs.

Summary

This chapter has presented the major characteristics of the milk subsystem using structure, conduct and performance model as a point of reference. The marketing and pricing of dairy products were appraised. It was argued that there are serious irrationalities in the pricing system and that these have become an important constraint on the milk subsystem. The pricing system does not promote efficient allocation of resources. The price is uniform over space and between seasons. It leads to an excessive stimulation of milk production in remote areas and milk shortages in the dry season. Wet season surpluses are enormous and cause financial losses for the KCC. An excessive consumer price for liquid milk is maintained to subsidize manufactured dairy products. This curtails consumption especially among the low income groups. An alternative milk pricing system is proposed in order to include production costs of milk, the location of production and the seasonality of production. The export of dairy products was examined and discussed. The national supply of milk is presented in the next chapter and the actual prices that farmers receive are examined further since they differ from the prices decreed by the government.

CHAPTER IV

ANALYSIS OF MILK SUPPLY AT THE NATIONAL LEVEL

This chapter presents trends in milk production, explores the factors determining the supply of milk at the national level and projects milk output from 1978 to 1985. The examination of trends in the population of dairy stocks on the farms and the factors likely to influence these trends in the future is central to the study of the future of the dairy industry. Information regarding herd growth, yields and growth in milk output may be vital for the efficient intake and utilization of milk by the dairy industry.

Trends in Milk Production

Table 4-1 indicates the output of commercial milk in Kenya for the period 1968 to 1975. Since milk is predominately produced on grass, weather variation is a very strong determinant of milk production. Production declined in 1971, a dry year, and increased substantially in 1972 and 1973, years without drought. The cumulative effect of three dry years in 1974, 1975 and 1976 has left dairy herds in Kenya in very poor shape.

The increase of producer price by 45 percent in July 1971 and the abolition of the quota system also contributed to the substantial increase in milk output in the three subsequent years. Despite

Table 4-1. Total Milk Intake in Milk Equivalents, 1962-1975 (Million Litres

Year	Liquid Milk Intake	Butter Fat Intake: Milk Equivalent[1]	Total Intake	National Total Recorded Market[2]
1968	129.6	79.8	209.4	226.5
1969	141.2	68.9	210.1	228.5
1970	172.1	51.0	223.1	236.0
1971	195.4	18.6	214.0	223.7
1972	248.4	16.0	264.4	274.6
1973	265.6	9.0	274.6	284.3
1974	240.0	6.4	246.4	253.4
1975	222.8	4.1	227.0	236.3

Source: KCC and the KDB.

[1]The drastic decline in butterfat deliveries is an outgrowth of pricing policies with the abolition of the quota system.

[2]Includes KCC and Mariakiani plant intakes and licensees of the KDB.

increasing costs of production and inflation in excess of 10 percent per year, there was no further price increase to producers until an increase of 11 percent was granted in January 1975. This increase was not enough to stem the decline in output and the producer price was increased by another 12 percent in November 1975.

There has been a substantial increase in input costs especially since 1973. In 1974 the subsidy on feed maize was abolished[1] and the

[1]A subsidy of 25% was reintroduced in 1977 following a substantial maize surplus. While the MPB buys maize at Shs 80 per 90 Kg bag it sells the same bag to the feed manufacturers for Shs 60.

price of wheat bran, pollard, maize bran and daily cubes was also increased. The lack of credit for the purchase of feed, pasture improvement and fodder production accentuated the situation. Dairying had become increasingly costly and unattractive to the farmers and the decline in output continued in 1976. In September the government announced a 41 percent increase in producer price. This substantial price raise combined with a very wet 1977 should start the milk deliveries on an upward trend again, having restored the profitability of milk production. The price changes are shown in Table 4-2.

Table 4-2. Milk Producer Prices 1970-76

Date	Price		Change
	Shs/litre	Shs/gallon	Previous Period Percent
1970	.53	2.00	-
July 1971	.77	3.50	45
January 1975	.83	3.75	11
November 1975	.93	4.25	12
September 1976	1.32	6.00	41

Source: Compiled by author.

Table 4-3 indicates the spatial distribution of milk output among the creameries and points out the areas that increased supply substantially. The table indicates changes in KCC marketed supply only. Since the major proportion of milk is not marketed the elasticity of marketed supply is perforce different from that of total output. There were

substantial increases in both large scale and small holder areas. The Kitale creamery receives the bulk of its milk from large-scale and settlement schemes. Nyahururu is another area of settlement and large-scale farms. The Kisumu deliveries, although small in absolute terms, showed the greatest increases and represent small-scale output only. The Sotik supplies are also largely small-scale and settlement farms. Eldoret, Nakuru, Naivasha, predominantly large-scale farm areas (but with some settlement schemes) and Nairobi where small-scale farms dominate all showed small increases. The Nairobi suppliers may have suffered a net decline in price. The Mombasa suppliers registered a net decline and were unlikely to have enjoyed a significant boost in price because of the loss of the substantial quota premium.

The data in Table 4-3 do not claim to represent an accurate supply response because the time period involved is too short. Capital requirements, availability of in-calf heifers and cows, land and management will all tend to militate against a short period adjustment. If a farmer, for instance, decides to increase his milk output and assuming a lack of in calf-heifers or cows he will have to wait for a period of about three to four years for the heifer calf to reach milk production stage.[2]

Factors Affecting the Supply of Milk

The supply of milk is given by the following equation:

$$Q_S = f(N, P_m, P_c, C_i, T)$$

where: Q_S = supply of milk

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[2]Ten months for the dam to be in calf, 20 months before service and another 10 months before milk can be produced.

Table 4-3. Milk Deliveries to KCC Plants 1970/71 to 1974/75

Creamery	Million Litres[1]					Av. Annual Change %
	1970/71	1971/72	1972/73	1973/74	1974/75	
Naivasha	18	22	25	22	24	8.2
Nyahururu	4	9	10	9	8	29.2
Eldoret	44	54	64	58	45	2.4
Nakuru	41	50	50	51	47	4.0
Kitale	10	24	28	30	31	41.8
Nairobi	22	27	33	27	25	4.8
Kiganjo	17	25	35	31	24	13.2
Kisumu	.30	.93	.76	.54	.39	34.7
Sotik	2	4	10	10	9	53.7
Mombasa (Mariakani)[1]	3	3	6	4	1	-2
Total	165	223	265	247	218	8.8%

Source: KCC Files

[1]Milk delivered to Mariakami by KCC members.

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

P_m = past and present prices of milk

P_c = prices of competing commodities

C_i = cost of inputs (feed, labor and capital)

T = level of technology

The major factors that determine the supply of milk include the number of dairy animals, past and present milk prices, the cost of dairy inputs and the opportunity cost of dairy farming. Short-run changes in output are influenced by weather and diseases while long-run changes are attributable to changes in technology.

The price of milk has a crucial role to play in influencing production decisions. Overall agricultural output responds positively to an increase in real prices of agricultural products (39,75). The increase is hypothesized to occur at the intensive margin by encouraging more intensive agricultural production through improved practices and technologies; and at the extensive margin by making it worthwhile to use resources such as land, labor and capital which would otherwise remain idle.

In general, output will respond to a price increase in a significant way after a time lag because of the biological nature of dairy production. In addition production decisions are highly decentralized and made by thousands of individuals (peasants) managing small units and by hundreds of large-scale farmers. Given changes in expected prices a time period is required for a complete quantity adjustments.

Relative prices also influence output mix. The output of milk can be influenced to a large degree by prices of other commodities.

For example, the supply curve of milk will shift to the left if competing commodities such as maize, wheat and pyrethrum and to a lesser extent tea and coffee become more profitable. It will shift to the right if alternative commodities become less profitable. Relative changes in product prices, yields or efficiency can change the relative productivity of different commodities. A competing product (α) can be more profitable because the price of that commodity rises relative to a second commodity (β) or because costs of producing α declines. The gross or net returns per hectare (or per animal) would at times be more significant in changing the production plans of farmers than would price alone. The relationship between prices of different commodities determines the pattern of production and production which declines or gains preeminence.

A decrease in the price of inputs will have a similar output effect as that of a price increase for the product. Conceptually, a change in price of a factor is regarded as a supply shifter. An increase in the price of an input will shift the supply curve of each farm firm to the left, and hence the supply curve to the left, a decrease in the price of the factor has the opposite effect, ceteris paribus. The most profitable use of inputs in production is determined by the ratio of price of the product to the price of input. Thus an increase in the use of inputs and hence a concomitant increase in output of a commodity may occur as a result of either an increase in the price of the product price or a decrease in the price of inputs.

Improvements in technology are important causes of long-term shifts in agricultural supply functions. An improvement in technology is defined as something that enables firms to produce more

output with the same quantity of inputs. It shifts the production function upwards so that the producer will find it profitable to increase output at the same ratio of product to factor prices (75, p. 70). In dairy production the improvements[3] include all the innovations associated with improved management and husbandry such as improved breeds of cattle, artificial insemination, better methods of disease control such as sprays and dipping against tick-borne diseases, internal parasite control, rotational grazing and/or paddocking, pasture and grassland improvements, improved nutrition feeds, fodders, the fertilization of pastures,[4] institutional innovations and new methods of extension. The effects of technical changes are often difficult to identify and measure. It is also difficult to determine how much of a given change in output is due to improved technology and how much is due to price changes. As a consequence of the definitional and measurement problems it is common to use a time trend as a proxy measurement of technological improvements without specifically identifying and measuring those factors associated with shifts in supply.

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[3]The subject of tick-borne diseases and dipping programs has undergone considerable rethinking within the Kenya government and a detailed report was completed in 1976. In the same year detailed evaluation of the dairy improvement programs (with special emphasis to AI) was completed (26). Appendix II summarizes the technical aspects that need to be considered as part of an integrated dairy production program.

[4]The use of fertilizer on grasslands is still in its infancy with probably only 600 metric tons of straignt nitrogenous fertilizers (140 tons of N nutrient) being applied in 1969. The Havelock Report (Commission on Agricultural Inputs, 1971) notes that there is a large potential for fertilizer use on large areas of grassland especially the high rainfall areas.

Milk Prices Received by Producers

Since farmers must have incentives to increase milk output, the price issue needs further consideration. In Chapter III it was noted that the producer price has been fixed by the presidential decree since 1971. This is not however the price the farmer received *in stricto*. While the large-scale farmer will often receive this price less transport costs, cesses of the KDB and/or those of the County Council, the smallholder receives a wide array of prices depending on the performance of his co-operative society. The smallholder sells his milk through a co-operative society. The primary co-operative society often belongs to a district co-operative union which provides centralized services for the primary societies including bookkeeping, transport at times, storage, credit and saving facilities. Before the producer is paid, the primary and union societies deduct their costs incurred in handling milk.

Once the various costs of the co-operative societies and/or local government cesses have been deducted from the decreed price (less the KCC transport pool cess and KDB cess which the KCC collects on behalf of the Board), the farmer receives whatever is left. This residual is the producer price *in stricto* (i.e., the price after all mandatory deductions).

The prices paid to the smallholder differ to the extent of the variation in the costs of the various co-operative societies and unions. These costs are influenced by such factors as location and distance from KCC plants, type of transportation and size of trucks,

road conditions (infrastructure),[5] quantities and grades of milk handled, quantities of milk sold in the more lucrative local markets, other ancillary services rendered, e.g. supply of feeds, spray, chemicals, credit, etc. and management capabilities of co-operative officials. In theory, we can expect as many producer prices as there are co-operatives (there were 230 active dairy co-operatives in 1975). Some of these co-operatives are multi-purpose and the national trend may have been in that direction.

The performance of these co-operatives is very mixed. Some co-operatives are performing their jobs efficiently while others are struggling with one or more problems (20). Net price realization by farmers differ markedly because average costs of operation vary widely among societies, largely because of differences in volume, managerial skills and other factors such as penalties incurred through downgrading milk on quality basis and lack of integrity among employees (59). Theoretically, we would expect inefficiency of many co-operatives to be a result of their low volume.[6] Unit costs can be expected to increase sharply below a certain minimum volume of

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[5]Transportation costs are a major factor in cooperative operational costs. Transport costs are influenced by many factors such as terrain and topography, type of carrier, total amount of traffic, produce bulkiness, value, perishability, type of container and institutional setting. A survey of Nyandarua cooperatives indicated serious problems of utilization of transport and lack of cost consciousness in transport affairs (59).

[6]The Kenya government policy is one of encouraging mergers of such societies. "At the village level, the policy is one of developing viable primaries on a multi-commodity, multipurpose pattern so that the one village society may, in the long-run meet all the economic needs of its members (32, p. 3). There are several advantages such as economies of size but in a situation where entrepreneurship is limited, the burden of management which is likely to become greater, is likely to lead to a greater danger of maladministration.

commodity and vice versa. Some co-operatives have suffered mismanagement of funds and outright misappropriation while others have been doing a good job. Good management is a function of business acumen, knowledge of co-operative principles, etc. and the personal integrity of the staff employed. Studies of most business enterprises demonstrate that the basic prerequisite to success is the quality and leadership of management (27).

The problem of milk quality is not a serious one. Analysis of co-operative deliveries to Nyahururu, Kiganjo and Nairobi creameries indicated that only 2 to 3 percent of milk is downgraded (59). The Rural Dairy Development Program which was initiated in the 1960's has provided many of the societies with milk coolers and separaters in the remote areas.

The co-operative problem concerns the cost of marketing which could compromise efficiency in dairy production. If the cost of getting milk to the KCC takes too high a proportion of the decreed price, then production may become uneconomical irrespective of whether each function of the co-operative is performed economically.

The next section projects milk supply for the 1978-1983 period. The projections are useful for planning purposes. Their reliability however, depends on the realism of the assumptions made concerning the key variables. Some variables are manipulable using policy instruments but others are largely exogenous.

Projections of Milk Output

The projections are made assuming current trends. It is assumed that milk prices will rise to compensate for any increases in costs of

milk production so as to maintain the profitability of the dairy enterprise. It is further assumed that the relative prices will remain stable since any increases in the prices of milk is likely to be matched by similar increases in prices of competing commodities.

The statistics from which the projected production are made represent the best that could be drawn together given the available time and resources. Experts in livestock production agree that the statistics give a reasonable overall picture but the data are very shaky (55). The estimates of the population of zebu and grade cattle herds rely on several sources such as aerial surveys and the 1970 Sample Census of the Ministry of Finance and Planning (MFP) for the smallholder and Settlement Farms; and for the large-scale farms from the Large-Scale Farm Census of MFP. Other data are derived from Rinderpest and Compulsory Foot and Mouth Vaccination Campaigns. The Settlement figures were supplemented by data from the Department of Settlement. For some districts that were not covered by sample census extrapolations were made. The reports of Peberdy (55) and Meyn (48) contain some discussions of the data and their limitations. Fluctuations in cattle numbers can be explained by actual events such as floods (e.g. 1961) droughts (e.g. 1971) epidemics, price fluctuations and the political events (e.g. independence 1962-65).

The Growth of National Herd

The national herd was described in Chapter II. The grade cattle herd and the zebu herd components were identified. It was noted that except for Mariakani Milk Scheme, the South Nyanza Ghee Scheme and Kano plains, the zebu cattle are of little significance in

commercial milk production. The core of the dairy herd consists of grade cattle. The numbers and supply of grade cattle are of vital importance to milk production in the future. Changes in supplies of grade cattle will be limited by the availability of female stock, which in turn depends on the capability of breeding stocks and the time required to produce a new generation. Other factors such as prices and feeding rates can be adjusted more rapidly.

Although the zebu herd is largely insignificant in the terms of commercial milk output it cannot be ignored because further development of the national dairy herd will not only depend on the existing grade herd but also on the rate of upgrading of the zebu herd. The projections will consider grade and zebu herds and also differentiate between the large-scale, settlement,[7] and smallholder[8] components. By drawing upon historical trends in cattle numbers, knowledge of present and possible stocking densities and carry capacities and by assessing the growth possibilities in each district, it is possible to project the probable growth rate of cattle population.

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[7]The predominantly large farm/settlement districts are Laidipai, Uasin Ghisu, Trans Nzoia, Nakuru and Nyandarua.

[8]The smallholder districts can be further subdivided into (i) pastoral districts: Tana River, Garissa, Wajir, Mandera, Isiolo, Marsabit, Narok, Kajiado, Turkana, Samburu, Mukogodo (area in Laikipia). (ii) Range/subsistence cultivator districts: Kilifi, Kwale, Lamu, Taita, Machakos, Kitui, Embu, Meru, Elgeyo-Marakwet, Baringo, West Pokot. (iii) High potential small-scale districts: Nyeri, Muranga, Kirinyaga, Kiambu, Nandi, Kericho, South Nyanza, Kisii, Kisumu, Siaya, Kakamega, Bungoma, Busia (55).

Milk Output from the Zeub Herd

The zebu herd is expected to increase by about two percent per annum or from 4,079,000 cows in 1978 to 4,685,000 in 1985 as shown in Table 4.4. The growth rate of two percent assumes that there will be a decline in the densely populated high potential districts[9] because of the rapid changeover to grade cattle (one grade cow roughly replacing two zebu cows). In pastoral areas, a growth of 3 percent is assumed but increasing water supplies and clearing more bush and favorable weather could increase the rate up to 6 percent. In the medium potential[10] and some high potential districts[11] the herd will remain static or grow at less than three percent. A larger increase would result in overgrazing and would necessitate a greater intake to maintain herd balance. In the Coast Districts of Lamu, Kilifi, Taita the herd will grow by just more than 3 percent.

Estimates of milk yield present serious problems because of inadequate records and suckling of calves. Many zebu cows will refuse to let down their milk without the stimulation of calfs and hence cows are milked with the calf at the foot. Unlike cows in temperate climates where voluntary ejection of milk can be effected by stimuli other than sucking, zebu cattle respond mainly to sucking. The calf tends to suck more than half the total milk yield.

It is estimated that the lactation of the zebu cow will be of the order of 200 days at about 0.6 litre per day or 120 litres[12] per

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[9]Nyeri, Muranga, Kirinyaga, Kiambu, Kisii, Kisumu and Kakamega.

[10]Machakos, Meru, Embu, Elgeyo-Marakwet, Baringo.

[11]Nandi, Kericho, Bungoma.

[12]This is a conservative estimate, e.g. Peberdy used 273 litres

Table 4-4. Projected Zebu Herd Size and Milk Output,1978-85

Year	Mature Cows (Thousands)	Milk Output (Million Litres)	Commercial Supplies (Million Litres)
1978	4,079	489.5	4.9
1979	4,160	499.2	5.0
1980	4,243	509.2	5.1
1981	4,328	519.4	5.2
1982	4,415	529.8	5.3
1983	4,503	540.4	5.4
1984	4,593	551.2	5.5
1985	4,685	562.2	5.6

Source: Projected from MOA estimates, 1974.

year above what the calf sucks. The calf takes about 1.5 litres per day or 300 litres for the entire lactation. Constant yield per cow is assumed since no allowance is made for improved herd productivity other than disease control and increased off-take for beef production.

The projections of the zebu herd and milk output are illustrated in Table 4.4. Only 1 to 2 percent of this milk can be expected to enter the commercial market. Hence, even if the growth rate of the herd is assumed to increase from 2 to 3 percent per year the change in commercial output will be negligible.

(60 gal.) and the same amount for the calf. Mason and Maule quote 409-2273 litres at 5-6.8 butterfat for Boran herd at Ngong, and Nandi zebu at Baraton gave 545-1091. Stobbs (E. Africa Journal 32, 1967) quotes 773 litres while Naivasha National Animal Husbandry Research Station quotes 909 litres (200 gal.). The butterfat content is 4.7 to 5.0 percent which agrees with MMS figures (55).

Milk Output from the Grade Cattle Herd

In 1960 the national grade cattle population was almost completely in the hands of European farmers but by 1970 about 60 percent of the herd was in the hands of smallholders and settlement farmers. Between 1954 and 1959 the grade dairy herd grew at 5 percent per annum because of upgrading (55). The grade cattle population reached its peak in 1959 when there were 427,900 animals. The numbers declined slowly for the next two years but in 1962 and 63 the decline accelerated. In 1959-63 the herd fell by 20 percent or 90,500. This decline consisted of 29,000 mature cows and 49,300 heifers and heifer calves or 86.5 percent of total. The decline in numbers is tentatively attributed to the following reasons: (a) sales to KMC and slaughter of large numbers of females, (b) sale of cows and heifers to smallholders particularly in Central province (a redistribution of which did not reduce the number of cows), (c) slaughter at birth of a large number of heifer calves which in normal times would have been reared for herd replacement and sale as producers, (d) sale of "flying herds" for milk production in Uganda. These four factors were precipitated by a crisis of confidence which started in the early part of 1960 as Kenya moved towards political independence.

A large proportion of the sales made during the early sixties may have been marginal animals but nevertheless the slaughter of dairy animals constituted wastage and was a significant setback to the dairy industry.[13] The total number of bulls fell from 8,500

[13]Of 131 breeders registered in the National Stud Book in 1959 only 67 were still registering stock in 1963. Of the remaining 64, 40 were no longer registering while the other 24 dispersed their herds. Thus 64 herds lost identity and availability of pedigree animals was

in 1959 to 6,100 in 1963 and of the 2,400 decline pedigreed animals accounted for 1,000 and grade aminals for 900. Obviously interest in breeding animals of highest quality declined during the 'crisis' period. The high demand for dairy cattle by smallholders saved a bad situation from getting worse.[14] By 1962/63 20,000 cows had been taken over in settlement areas (despite problems of high mortality rates) and by 1965/66 23 percent of the dairy stock population was held by small-scale producers. By 1967 the situation had improved significantly and available evidence indicated that the herd was growing at 2.5 percent and by 1972 the estimates put the herd only marginally below the 1959 level. Forty percent of the calves were being produced through AI.

In projecting the numbers of grade cattle and total milk production the types of production units--large-scale, settlement and smallholders--need to be treated separately because they present contrasting conditions of milk production. The calving rates, calf losses, adult mortalities, replacement rates, feeding levels, milk yields and milk sales differ depending on the type of production

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reduced. Other farmers were not only registering herds but had lost interest in high calibre progeny. Instead they were putting boran bulls on their cows merely to get them in milk. In 1965 the problem of rebuilding the national herd was serious enough to warrant official attention. The Kibaki Commission was therefore required, inter alia, to address the problem--and "to report the actions necessary to increase the dairy herd to the maximum economic potential" (36). It recommended raising of stocks by ADC farms, etc. in a bid to overcome chronic shortages of grade cattle that prevailed then.

[14]The policy of Settlement Schemes was criticized because of its refusal to purchase dairy stock from the farms due to be sold to the Central Land Board.

system.

The national herd is expected to grow at 5.3 percent per annum (the rate recorded in recent years) from 596,300 cows in 1978 to 661,200 in 1980 and 856,000 in 1985. This growth is based on increases which are computed for the large scale, settlement and smallholder categories of producers. The estimates of cattle numbers also take account of artificial insemination trends, calving intervals and mortality estimates. Smallholder producers--grade herds--are estimated to increase by 2.5 percent per annum. The transfer of animals from the large scale farm sector is expected to boost the increase to 6.6 percent per annum.[15] Increased availability of credit would promote this transfer. Upgrading of zebu cows through AI and natural service is expected to continue at 10.7 percent per annum. Considerable attention has been given to encourage small-scale farmers to use AI to breed livestock. AI schemes are progressing satisfactorily and the conception rates appear to be rising. The number of inseminations per pregnancy has fallen from 3.2 in 1966 to 2.0 in 1975. The overall growth rate of the smallholder herd is expected to reach 8.8 percent per annum when the impact of upgrading is taken into account.

The large-scale grade-herd is expected to remain relatively

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[15]The calving rate is taken to be 69%, calf mortality 13%, adult losses 2.9% and herd replacement rates of 15% (48). IA surveys in Kiambu indicate lower adult mortality rates at 2.0% and calving interval of 12.7 to 14.4 months (average 14 months) but in other areas calving intervals are up to 17 months. 66% of all heifers born come into production. Heifers are inseminated at 20.8 months and calf down at 31.1 months. Herd replacement rates as low as 7.5% are not unusual. The number of upgrading by natural service is 5 times that by AI (AI Annual Report, 1973).

static over the 1978/85 period. Its potential increase of 6.8 percent per annum is presumed to be absorbed by smallholders, settlement schemes and some exports. A favorable milk price is a prerequisite for stimulating the growth of large-scale herds.

The grade cattle herd of the settlement component is expected to grow by 3 percent per annum but the total increase will be boosted to 5.6 percent per annum through transfers from large-scale farms. Table 4-5 shows the size of the projected herd indicating grade and zebu crosses.

Table 4-5. Projections for the National Dairy Herd, 1978-1985 (Thousands)

Year	Grade	Zebu-Crosses	Total
1978	498.4	97.9	596.3
1979	520.8	107.1	627.9
1980	544.2	117.0	661.2
1981	569.0	127.2	696.2
1982	595.1	138.0	733.1
1983	622.6	149.4	772.0
1984	651.7	161.2	812.9
1985	682.5	173.5	856.0

Source: Computed from MOA/KDB 1974 figures.

To estimate milk production, the number of dairy cows is multiplied by an estimate of average production per year. The estimation of production is equally problematic given paucity of data and

a wide range of possibilities in terms of milk yield, depending not only on genetic endowment, and even more so on management and feeding practice and ecological zones. Indeed, the actual production per cow is certainly far lower than potential, especially among the less experienced farmers, and also much lower than the economically optimal level. The main reason relates to feeding practices--poor or inadequate grazing with little or no supplementary feeding, no steaming up so that animals start their lactations in poor conditions and no provisions for dry season feeding. Other reasons include late first pregnancies, long calving intervals, random calving where breeding is not arranged to take advantage of the rains, low replacement rates and inadequate culling, and failure to upgrade stock using the best genetic material available.

Estimates of total production vary substantially. The MOA projection figures estimated the number of grade cows was 320,000 in 1968 and 449,000 in 1973. The yield per cow per year was estimated to be 1,340 litres in 1968, 1,490 litres in 1973 and 1,525 litres in 1977. Production per cow in 1980 was assumed to be 1,715 litres per annum.[16] No distinction was made between large-scale, settlement and small scale farms (non-settlement) nor between grade and zebu crosses. The zebu crosses were assumed to have the same yield potential as grade at the current management practices. The 1974/78 Development

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[16]The MOA paper argued that the yields used were anticipated increases citing higher yields of 2,775-4,150 litres (610-915 gallons) per year observed on the better farms (50). The higher yields are also collaborated by Livestock Recording Center (2,754 litres on large scale farms and 2,274 litres on the small farms). However the sample represented some of the better farms and was not statistically based. Thus the yield used for projections is conservative.

Plan estimates average production per cow to be 830 litres and it argues that the production per cow may fall because of the increased number of cross-bred cows being introduced into the national dairy herd through rapid upgrading (32, p. 248).

The projections assumed that output is a function of the increase in numbers of cows and increasing yield per animal. For the large-scale farms the MOA estimates of 1,525 litres will be used together with the anticipated increase of 32 litres per year. Thus the yield per cow will be expected to rise to 1,877 litres in 1985. The rehabilitation of mismanaged large-scale farms through a World Bank funded program makes this plausible. For the smallholders the yield will be assumed to be 932[17] litres per cow per year, the yield estimated by the Central Bureau of Statistics in 1974/75 Survey in the Central Province. The zebu crosses will be assumed to yield about half as much as grade cow or 500 litres. Moreover, these yields will not substantially change because of an increasing number of inexperienced farmers. Any declines will be offset by increases in the areas where smallholders have adopted grade cattle. For the settlement schemes the yield is assumed to be 1,293 litres, the weighted average calculated from the MFP data collected during the 1968 Economic Appraisal of Settlement Schemes (51). While the art of animal husbandry in the settlement schemes is not better than among small-holders in other areas there is more grazing land per animal in these schemes. Table 4-6 indicates the projected milk

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[17]1974/75 was a dry year but the estimate is marginally lower than Chuldleigh (6) estimate of 1,000 litres. The German Team Study of Kericho estimated the yield per cow to be 1,430 litres.

output of the grade cattle herd. The mean yield per cow is 1,137 litres per year over the 1978-1985 projection period.

Table 4-6. Projected Milk Production by Grade Herd,1978-1985

Year	Million Litres
1978	683.7
1979	717.3
1980	752.5
1981	789.2
1982	827.1
1983	867.8
1984	909.9
1985	953.7

Source: Own computation.

The projected annual rate of growth of milk production is 5 percent for the period 1978-1985 period which is slightly higher than the increase of 4.6 percent per annum for the 1968-1973 period. The 1974-78 Plan had projected the growth of marketed milk output to grow at 6.8 percent per annum which represented an increase of about 47.8 percent for the 1968-1973 period. Table 4-7 shows the likely commercial supply to KCC and the associates of the Kenya Dairy Board. It is assumed that only one percent of zebu milk and 50 percent of the grade cattle herd is available for commercial channels.

In projecting the supply of milk normal weather was assumed. To the extent that this assumption may not hold the projected output could be expected to increase or fall by about 10 percent. Current

Table 4-7. Projected Commercial Supplies of Milk, 1978-1985 (Million Litres)

Year	Zebu Herd	Grade Herd	Total
1978	4.9	341.8	346.7
1979	5.0	358.6	363.6
1980	5.1	376.2	381.3
1981	5.2	394.6	399.8
1982	5.3	413.5	418.8
1983	5.4	433.9	439.3
1984	5.5	454.9	460.4
1985	5.6	476.8	482.4

Source: Computed.

technology was assumed. Improved management could cause the figures to change substantially. Better methods of disease control, improved pastures and better feeding including concentrates could be adopted. The period, however, is too short to allow a dramatic change.

Summary

The chapter presented the trend in milk production, discussed the factors that determine milk output and projected milk output for the 1978-1985 period. The analysis in the chapter covered the entire country and considered the zebu and grade cattle components of the national herd. The projections of milk output assumed constant relative prices, current technologies, current trends, normal weather and differentiated among large-scale, settlement and smallholders

producers. The projected milk output showed an annual growth rate of 5 percent for the 1978-1985 period which can be compared with the growth rate of 4.6 percent per annum for the period 1968-1973 and the 1974-78 Plan projection of 6.8 percent per annum. The growth of milk supply most likely will fall below the target. In Chapter V the assumption of constant relative prices will be relaxed. The supply of milk will be analyzed using parametric linear programming. It will be a more restricted analysis covering smallholder milk production in the Central Province of Kenya.

CHAPTER V

A LINEAR PROGRAMMING ANALYSIS OF SMALLHOLDER MILK SUPPLY

Although government policies on dairy development emphasize smallholder milk production (32) little is known about the dynamics of smallholder milk production. The purpose of this chapter is to analyse the supply response of milk production on smallholder farms in the Central Province of Kenya. The impacts of alternative pricing policies will be appraised and the competitive position of the dairy enterprise will be assessed. The analysis is restricted to the examination of the representative farm in each of the three ecological zones in the Central Province, on the basis of existing technical relationships, average yields, prices, resource base and other limitations specified by the smallholder environment. The analysis employs parametric (variable pricing) linear programming. While no pretense is made that the results will be applicable to all smallholders of Kenya, the author believes that the Central Province is fairly representative of smallholder milk production and that the results of this case study will be invaluable to policy makers.

Area of Study

The Central Province was chosen because it is one of the most important smallholder milk producing areas of Kenya. In 1975, for

instance, the Central Province produced 65.6 percent of all milk sold to the KCC by smallholder co-operatives of Kenya. In addition, Central Province is one of the most progressive and dynamic smallholder areas of the country. Smallholder agricultural development has been actively promoted for the last twenty-five years. Land holdings have been consolidated and registered and as a result individual owners possess free hold titles. The degree of commercialization and the use of purchased inputs such as fertilizer, feed, seed varieties, hired labor etc. are widespread.

The rainfall in Central Province varies from 750 mm in the lower parts of Kiambu, Kirinyaga and Muranga districts to over 1500 mm on the Eastern Aberdares. Most of the agricultural land of the Province is high potential, receiving 1200 to 1500 mm per annum in a bimodal distribution. The altitude varies from less than 1550 meters in the East to over 2150 meters to the Aberdares on the West. Nyandarua district consists of high altitude grass (1850-2450 meters). The soils consist of loams and friable clays. The most common grasses consist of Pennisetum clandestinum (Kikuyu grass) and Cynodon spp (star grass). Many pastures consist of natural grasses and are paddocked. Small acreages of fodder are grown. By-products such as maize stover and sweet potato vines are fed to cattle.

The farm sizes range from less than 0.5 hectares to just over 8 hectares as shown in Table 5-1. Land sizes are decreasing due to inheritance and concomitant subdivision. The farm sizes tend to be larger in the tea zone and smaller in coffee zone. Nyandarua, a settlement district, tends to have above average farm sizes.

About 51 percent of the farms are operated by male owners,

Table 5-1. Distribution of Holding Size, 1974-75

Hectares	Percent of Total
Below 0.5	6.74
0.5-0.9	10.50
1.0-1.9	36.96
2.0-2.9	16.47
3.0-3.9	11.86
4.0-4.9	5.92
5.0-7.9	7.63
8.0 and over	3.92
Total	100.00

Source: CBS Basic Report (34).

29 percent by the wife, 5 percent by the son, 4 percent by a relative and 11 percent by a nonrelative (34). Land constitutes the biggest asset of the household. Hired labor is used to supplement family labor. A substantial proportion of milk output, maize, beans, etc. is consumed by the household while cash crops consist of tea, coffee and pyrethum.

Medium-term credit for purchase of cattle, fencing and general farm development is available from the Agricultural Finance Corporation (AFC), Commercial Banks and the Cooperative Bank. Over 50 percent of AFC loans are used for dairy development. Short-term credit for purchase of inputs such as feed is in very short supply. But some dairy cooperatives stock feedstuffs and acaricides and provide them to members on credit or cash. Credit for establishment of pastures is also not readily available.

Data Sources

The study utilizes data derived from several sources, including the Central Bureau of Statistics (CBS), published and unpublished data of the Ministry of Agriculture such as the District Farm Guidelines, and data compiled by the author from various publications and interviews. The cross-sectional data were gathered by the CBS under the 1974-75 Integrated Rural Survey (IRS) of smallholder areas (34). A two stage stratified sample procedure was used to select the respondents. The primary sampling unit (PSU) was the sublocation, the basic administration unit. The sublocations were classified into agro-ecological zones based on the major cash crops, rainfall or special areas. This stratification improved the efficiency of grouping the sample into homogeneous units. Since the primary focus was the agricultural population stratification by land use classification was justified. Twenty-three sublocations were selected in order to record the data on a provincial basis. Land registers were used for sampling frame. In each sublocation 12 households were selected for inclusion in the sample giving a sample size of 276 for the Central Province.

The measuring instrument was a structured interview schedule. The data were gathered on repeated visits to the farm. Data on household members was taken at the beginning of the interview. Other information such as capital stock, inventories, livestock numbers, etc. were recorded at the beginning and end of the survey. Values of non-capital inputs were based on purchased items. Inventories were valued at the local marekt prices. Information about specified crops such as hybrid maize, local maize, pyrethrum, beans, English

potatoes, coffee, tea, and all other crops were recorded separately for specific crop analysis.

The enumeration procedure tried to reconcile the problems associated with using different recall periods, the need to minimize respondent fatigue and administrative considerations. The survey year was divided into 13 four-week cycles. Each cycle was the same length and always started on the same day of the week. This eliminated the biases arising from visiting households only at the beginning or the end of the month.

Each enumerator was assigned 12 households divided into four closely grouped clusters. Each group was then enumerated in one of the 4 weeks of the cycle, and visits to the household in that group were always made during the specific enumeration week. Visits to households and respondents in any PSU were always perfectly spaced across any one cycle. During any enumeration week an enumerator was required to visit his respondents assigned to that week twice, with a maximum gap of 4 days between visits. The two visits were particularly important to the collection of detailed information relating to the single enumeration week.

Enumerators and supervisors checked the questionnaire before transmitting them to the provincial statistical office for further checks and subsequent transmission to Nairobi. Editing, coding, punching, validation, including consistency analysis were undertaken by the CBS.

Supply Response

Supply response or production response refers to the relationship between the total supply of a product and factors determining that supply. In the traditional or static theory of production the supply curve is completely determined ceteris paribus by (a) the production functions--the relationship between resources or factors and output--for the product and the competing products; (b) prices of inputs or resources assuming profit maximization and perfect knowledge; (c) price of the product and prices of competing products. It is difficult to measure precisely the product response for a commodity because of complexities in the real world. Among the theoretical and measurement problems are uncertainty, lack of knowledge, capital rationing, non-monetary objectives of decision makers, technical changes, fixed factors, complementary and supplementary relationships among products, etc. The response concept, a dynamic concept, is based on the hypothesis that when price changes, new techniques of production are more likely to be introduced and adoptions of new innovations may be accelerated (75, p. 71-2). A response relation is likely to involve both movements along the supply curve and shifts in the supply curve. The elasticity of supply response is therefore greater for rising prices than for declining prices. Forecasts based on response relationships tend to be higher than those of static supply concept.

An analysis of milk production response in Kenya is influenced by the extreme disequilibrium of the industry arising from the removal of legal and pricing constraints and accompanying shifts in the milk supply function. Moreover, structural changes are

proceeding. A major redistribution of the dairy herd from the large-scale farms to small-scale and settlement farms has already been mentioned in Chapter II. The introduction of grade cattle to smallholders is still proceeding unabated. The pricing problems have also been raised in Chapter III. The general premise is that all necessary adjustments have as yet to manifest themselves, and because of the paucity of reliable time-series data, this study does not seek to analyse supply response in terms of carefully measured elasticities. Rather, the study will resort to a linear programming analysis in order to evaluate a normative supply response.

Applications of Linear Programming (LP) Technique in African Agriculture

The application of linear programming (LP) methods to smallholder problems in Africa has increased in recent years. Clayton (7) demonstrated the versatility of linear programming in optimising smallholder farms in Nyeri district of Kenya. He addressed problems associated with cropping patterns including cash and subsistence crops, soil fertility maintenance, and mechanisation. Heyer (20) employed the technique to analyse peasant farms in lowland Machakos district of Kenya. She evaluated various alternatives of changing constraints, such as crop mixtures under changing land labor ratios and new varieties. She also incorporated off-farm labor in the model and extended it to evaluate risk and uncertainty. Ogwel (54) applied LP analysis in a regional planning model as a tool for agricultural planning in Nyeri district. He imposed minimum subsistence requirements in his model to take account of risks and uncertainties. In addition, he modified the analysis to evaluate risks and uncertainties.

In addition, he modified the analysis to evaluate risks and uncertainties by incorporating game theory and quadratic programming. Norman (52) used LP technique to evaluate the profitability of agricultural production and labor utilization among the Hausa of Northern Nigeria. The adjustments included reallocation of existing resources, increased prices for products, increased labor inputs and use of new technologies, all of which tended to increase farm income. Ogunfowora (53) used linear programming technique to estimate the derived demand for fertilizer, to estimate the supply of various crops and to evaluate alternative technologies in Northern Nigeria. He determined elasticities of demand and supply with respect to the various prices and capital and evaluate various policy alternatives. Atta-Konadu (2) employed LP analysis to evaluate resource allocation among subsistence farmers in Ghana in order to evaluate various policy instruments designed to increase production.

The Linear Programming Model

The Linear Programming model has three components: 1) the objective function, 2) resource constraints, and 3) activities. According to Heady and Candler (17) the mathematical formulation in matrix form is given as follows:

Maximize $Z = C'X$

Subject to restrictions

$$AX \leq B$$

$$X \geq 0$$

where:

Z = objective function to be maximized

C = nxl vector of prices

X = nxl vector of activity levels

A = mxn matrix of input-output coefficients

B = mxl vector of resource restrictions

To obtain a determinate solution several assumptions are:

a) additivity and linearity of activities, b) divisibility of activities and resources, c) finiteness of alternative activities and resource restrictions and, d) single value expectations, i.e., resource supplies, input coefficients and prices are known with certainty.

The objective function in this study is assumed to be the examination of the financial returns of farmers. While LP technique provides a versatile tool for planning, it has several limitations. It does not include any allowance for risk, which is central to smallholder decision making. The importance peasants attach to securing an adequate food supply as a primary objective is well documented (8, 20, 54). Even farms with well developed market production continue to produce all or most of their subsistence requirements.[1] Many scholars contend that the low levels of income of peasant farmers are closely associated with a high degree of risk aversion (8). Since the peasants must subsist on food produced on the farm, the objective function may indeed be security maximization rather than cash income maximization (47).

The other assumption that strikes a discordant note with the

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[1]Unreliable marketing organizations, the wide gap between buying and selling prices for identical or readily substitutable foods, and the year-to-year variation in prices and crop yields accentuate the risk aversion.

norms of agricultural production is that of neutrality of preferences. That is, that the farmer will adopt any enterprise combination as long as it promises the highest income. Often certain crops and livestock[2] weigh more heavily than others in the preference of farmers. Whereas a linear programming solution might require a farmer to grow certain crops on available land to maximize income, the farmer may instead keep cattle regardless of their economic value. Heyer (20) contends that the objective function is difficult to determine under peasant farming because it is ambiguous and risk considerations tend to dominate production decisions. Cultural and institutional factors constrain the production environment further. Some realism could be introduced by maximizing the assumed objective function within the framework of the consumption habits, intercropping system and socio-economic factors. When uncertainty exists modified simplex methods can be used to advantage (17, p. 232). A linear programming problem with parametric objective function is presented by Ogunfowora (53) as follows:

$$\text{Maximize } Z_{\alpha} = \sum_{j=1}^{n} C_j X_j$$

$$\text{Subject to } \sum_{i=1}^{m} a_{ij} X_j \leq b_j$$

$$\text{and} \qquad X_j \geq 0$$

where:

$$Z = Z(X_1, X_2 \ldots, X_j, \ldots, X_n)$$

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[2]Livestock, for instance, will be kept by farmers even when unprofitable for several reasons: 1) tradition; cattle will not only represent wealth, but a farm without cows may be an anathema, 2) regularity of income from dairy cattle can be relied upon to ensure a regular income every month, 3) intangible benefits.

$$C_j' \leq C_j \leq C_j''$$

$$\frac{C_j'' - C_j'}{\lambda} = k \text{ or } C_j'' - C_j' = k.$$

Z_α = the α^{th} objective function to be maximized for given price level within the acceptable price range

b_i = the level of the i^{th} resource available

C_j' and C_j'' = the lower and upper limits of the j^{th} activity

λ = constant increment in the price of the j^{th} activity

k = the number of optimum solutions within the price range.

The farms are assumed to have achieved an optimum organization before price change occurs. The derived short-run function presupposes that no other changes other than changes in prices.

For programming purposes an average or representative farm was defined for each ecological zone by using the arithmetic mean of each factor. The choice of the representative farm depends on the purpose for which the results are to be used. Since the objective of this study focuses on identifying the direction of farm adjustments and estimating the degree of farmer response to changing prices and resource levels the construction of representative farms appears justified.[3] Ogunfowora (53) and Ananikas (1) used similar methods. The approach is normative, indicating how farmers ought to respond given the assumptions of profit maximization and perfect knowledge about prices, technological changes and environmental factors. Normative supply functions can be expected to diverge from actual response

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[3]The object of the study is not to estimate regional or national supply which requires the aggregation of the results of bench farms. The problems of aggregation bias and their control are therefore not addressed in this study.

(78). There is ample evidence that supply elasticities associated with normative supply functions are biased upwards (18, 38, 78) when compared with those obtained from time series data which incorporates lags and inflexibilities stemming from uncertaintity and resistance to change (18). The extent to which normative and positive responses would diverge (what ought to be vs. what is) will vary according to circumstance and especially how the assumptions match the actual area studied. The smaller this divergence, the more useful the normative curve will be for predictive purpose.

The Objective Function

The objective function is assumed to be the maximization of net farm income on fixed factors subject to meeting basic subsistence needs of the farm family. This type of objective function is called security and profit maximization (52) and is rationalized on the basis of peasant behavior. It is also consistent with government policy which emphasizes self-sufficiency in food production.

Crop and Milk Production and Selling Activities

Activities in the LP analysis includes hybrid maize, local maize, English potatoes, beans and dairying activities in all three ecological zones. In addition, a pyrethrum growing activity was established for both the high altitude grass (HALTG) zone and the tea zone while tea and coffee growing activities were included in their respective zones. The associated selling activities were established separately to facilitate parametric programming.

Labor Hiring Activities

Thirteen labor buying activities were defined to allow the purchase of labor to augment family labor. Each cycle covered four weeks; the first cycle being December 1 - December 28, 1974 and the last one November 3 - November 30, 1975.

Food Consumption Activities

Since farmers prefer to grow food crops to meet their own subsistence requirements risk and uncertainty were taken into account by requiring certain amounts of food crops such as maize, potatoes, beans and milk to be produced and consumed to meet subsistence requirements before selling activities of the products could be permitted.

Resource Restrictions

The resource restrictions for programming were derived from the farm characteristics in the CBS Survey. Data from all farms in each zone were averaged out. The average farm size for each zone was computed by subtracting the amount devoted to other food crops. The average size of the holding was 8.23 hectares in the high altitude grass land (HALTG) zone, 3.39 hectares in the tea zone and 2.35 hectares in the coffee zone. The cultivated areas were 1.54 hectares in the coffee zone, 2.20 hectares in tea zone and 4.26 hectares in HALTG zone. The average hours of operator and unpaid family labor available, less the quantity used for overhead labor tasks (farm general) and other food crops for each 13 cycles were regarded as labor available. The average size of the family in both the HALTG zone and coffee zone was 7 persons and 9 persons in the tea zone.

Since the average farm is a net buyer of labor especially at peak times, no labor selling activity was established for the farm family. An average of 494 man-hours of labor was hired in the coffee zone, 439 in the tea zone and 191 in high altitude grass zone. The working was assumed to be 8 hours per day.

Capital Data

The farm expenses on crops and livestock were used to represent operating capital. The expenses involved typical inputs in peasant agriculture such as seeds, planting materials, manure and fertilizers, sprays, animal feeds and veterinary expenses and hired labor. The operating capital restraint was entered on an annual basis. Short-term capital borrowing activity was included to augment operating capital at 10 percent interest cost after establishing the base plans. No capital was charged on the purchase of cattle. It was assumed that either cattle were available or medium-term capital was not a constraint. The demand for operating capital by the various enterprises was assumed to be variable costs per unit of production. The total operating capital in the tea zone was Shs 1,266, Shs 1,056 in high altitude grass zone and Shs 832 in the coffee zone.

The Tableaus

One tableau was prepared for each zone. The tableau for the coffee zone is presented as an illustration. The only differences existing between it and those of the other zones was the absence of pyrethrum growing and selling activities in the tea and high altitude grass zones. In the tea zone, coffee production and selling

activities were replaced by tea activities. Since neither tea nor coffee is feasible in the high grass zone these activities were excluded.

The tableau is broken up into three portions, vis. labor related activities, crop and milk production activities and crop selling and consumption activities. The tableau's negative signs in the objective function indicate costs while positive signs indicate income. Consumption is associated with zero C_j value. An additional row, however, was included to keep track of the total value of subsistence consumption at local market prices. Positive signs in the a_{ij} coefficients indicate use of resources while negative ones indicate increment of resources and/or output.

The negative C_j for the production activities refer to the costs of production. The budgets were synthesized from the survey data, previous studies, personal interviews with MOA officials and from unpublished sources such as district guidelines. For the annual crops variable costs were considered, including interest at the rate of 10 percent per annum. For pyrethrum a productive life of three years was assumed. For the tea and coffee a productive life of 15 years was assumed. Since there is a continuous income stream in the future it was necessary to discount the costs and returns to the present in order to make them comparable to the returns of annual crops. A 10 percent interest was charged.

For the dairy enterprise a replacement period of 10 years was used. The C_j value was adjusted to take into account replacement costs, interest charges after allowing for salvage value of the cow and mortality losses of 6 percent for adult cows. Variable costs

Table 5-2. Labor Hiring Activities[a]

Row No.	Re-sources / Obj. Function Cj(Shs)	Units	Labor Hiring Activities													Sign	RHS (Base)
			A_1 HRL2 -0.24	A_2 HRL3 -0.25	A_3 HRL4 -0.60	A_4 HRL4 -0.28	A_5 HRL5 -0.35	A_6 HRL6 -0.55	A_7 HRL7 -0.88	A_8 HRL8 -1.08	A_9 HRL9 -0.91	A_{10} HRL10 -0.29	A_{11} HRL10 -0.27	A_{12} HRL12 -0.51	A_{13} HRL13 -0.48	S^1	
3	FLAB 2	HRS	-1													≤	360.7
4	FLAB 3	HRS		-1												≤	277.7
5	FLAB 4	HRS			-1											≤	366.8
6	FLAB 5	HRS				-1										≤	331.0
7	FLAB 6	HRS					-1									≤	301.2
8	FLAB 7	HRS						-1								≤	341.3
9	FLAB 8	HRS							-1							≤	368.8
10	FLAB 9	HRS								-1						≤	297.8
11	FLAB 10	HRS									-1					≤	272.8
12	FLAB 11	HRS										-1				≤	306.1
13	FLAB 12	HRS											-1			≤	360.1
14	FLAB 13	HRS												-1		≤	315.4
15	FLAB 14	HRS													-1	≤	281.8

[a]The explanation of the abbreviations are given in Appendix I, Table 1A.

Table 5-3. Crop and Milk Production Activities[b]

Row No.	Resources	Unit	Milk Production Activity	Crop Production Activities					Capital Borrowing Activity	Sign	RHS (Base)
	Objective Function (Shs),g		A_{14} PRMLK -450	A_{15} PRCOF -546	A_{16} PRHMZ -563	A_{17} PRLMZ -175	A_{18} PRPOT -1150	A_{19} PRBEN -126	A_{31} BROPC -0.1		
1	LAND	HA	0.4	1	1	1	1	1	-1	≤	2.15
2	OPCP	SHS	45.0	546	563	175	115.0	126		≤	832
3	FLAB2	HRS	32.4	365.2	166.0	106.2	153.7	113.0		≤	360.7
4	FLAB3	HRS	27.5	389.6	161.4	130.0	132.1	105.2		≤	277.7
5	FLAB4	HRS	34.1	380.4	155.7	63.8	197.4	78.5		≤	366.8
6	FLAB5	HRS	29.8	292.6	163.6	89.8	231.0	95.7		≤	331.0
7	FLAB6	HRS	24.9	186.5	115.7	120.2	176.0	98.0		≤	301.2
8	FLAB7	HRS	29.5	176.5	102.6	118.6	183.2	113.0		≤	341.3
9	FLAB8	HRS	32.6	216.9	122.0	123.0	155.8	117.5		≤	368.8
10	FLAB9	HRS	31.5	250.4	80.0	93.1	158.4	86.5		≤	297.8
11	FLAB10	HRS	33.4	275.2	176.0	90.3	195.8	75.5		≤	272.8
12	FLAB11	HRS	32.4	193.9	203.1	65.9	256.6	107.7		≤	306.1
13	FLAB12	HRS	32.8	220.9	197.1	125.7	191.0	57.5		≤	360.1
14	FLAB13	HRS	34.4	176.6	109.1	134.8	195.0	92.2		≤	315.4
15	FLAB14	HRS	32.0	133.9	154.6	123.8	181.5	91.2		≤	281.8
16	PRMLK	LIT	-1183							≤	0
17	PRCOF	KG		-2250						=	0
18	PRHMZ	KG			-2858					=	0
19	PRLMZ	KG				-1578				=	0
20	PRPOT	KG					-3374			=	0
21	PRBEN	KG						-368		=	0
22	BROPC	SHS							1	≥	0

[b]Explanation of abbreviation is given in Appendix I, Table 1A.

Table 5-4. Selling and Consumption Activities[c]

Row No.	Resources / Objective Function Cj (Shs)	Units	Milk Selling Activity	Crop Selling Activities					Milk Cons Activity	Crop Consumption Activities				Sign	RHS (Base)
			A_{20} SMLK	A_{21} SCOF	A_{22} SHMZ	A_{23} SLMZ	A_{24} SPOT	A_{25} SBEN	A_{26} CNMLK	A_{27} CNHMZ	A_{28} CNLMZ	A_{29} CNPOT	A_{30} CNBEN		
			.84	.97	.76	.85	.89	2.48	0	0	0	0	0		
16	PRMLK	LITRES	1						1					=	0
17	PRCOF	KG		1										=	0
18	PRHMZ	KG			1					1				=	0
19	PRLMZ	KG				1					1			=	0
20	PRPOT	KG					1					1		=	0
21	PRBEN	KG						1					1	=	0
22	CNMLK	LITRES							1					≥	545
23	CNHMZ	KG								1				≥	199
24	CNLMZ	KG									1			≥	461
25	CNPOT	KG										1		≥	319
26	CNBEN	KG											1	≥	82
27	TCNSM	SHS							.48	.76	.85	.89	2.48	=	

[c]Abbreviations are explained in Appendix I, Table 1A.

[1]Before a selling activity can enter the solution the consumption activity associated with it must be satisfied. No food purchasing activities were defined since according to farmers goals stipulated complete specialization is not likely.

include dip and veterinary costs, and feed supplements. Milk yield was highest in high altitude grass zone and lowest in the coffee zone, perhaps reflecting greater abundance of grass and rainfall while the tea zone fell in between. The respective yields were 1,875, 1,183 and 1,340 litres per cow. Only the direct revenue from dairying was considered. Intangible benefits to the system of mixed farming accruing from the contribution of dairy stock to soil fertility and manure were excluded.

Base Plans

The optimum resource use and activity levels were determined for the average farm considering the prevailing conditions in the province by zone. The output of LP provides information on the optimum combination of activities in the solution, the objective value of the model, the resources used with their respective marginal value products and the activities which are not in solution with their costs of entering the solution. The stability limits information concerning prices and basic resources for the optimum solution is also provided. The actual and optimal organization for each area Base Plan will be presented. The base plan for farms in the coffee zone is shown in Table 5-5.

Total income in the objective function increases by 17.3 percent. The optimal solution does not include coffee and the dairy activity is reduced to one cow while hybrid and local maize dominate the plan. Shillings 1940.58 and Shs 984.45 worth of hybrid and local maize are the only selling activities in solution. Only 9.53 man hours of labor are purchased in the second cycle. Five hundred and

Table 5-5. Base Plan: Coffee Zone (Capital Level Shs 832)

Item	Unit	Actual Use	Optimal Plan	% Change
Total Income	Shs	2524	3050	17.3
Produce Milk	Cows	2 cows	1.02	-49
Produce Coffee	Ha	.23	0	-100
Produce H. Maize	Ha	.07	.75	971.4
Produce L. Maize	Ha	0.42	.92	95.2
Produce Potatoes	Ha	.19	.09	52.6
Produce Beans	Ha	.4	.22	45
Non Specified Crops	Ha	.20	.20	0

forty-five liters of milk, 199 Kg of hybrid maize, 461 Kg of local maize, 319 Kg of potatoes and 82 Kg of beans are consumed. This accounts for Shs 1488 of the total income.

The optimal solution differs from the actual practice of the farmers since the LP model is normative showing what the farmers ought to do in order to maximize farm income. The model does not simulate the situation exactly since farmers may have other goals in actual practice.

Marginal Value Products (MVP)

The marginal value products (MVPs) or shadow prices indicate the productivity of resources on the farms. The MVPs are zero for excess (slack) resources and are positive for limiting resources. A relatively high marginal product indicates a scarcity of the resource. To be meaningful the MVPs have to be considered relative to the

marginal factor costs of the resources. The shadow price for operating capital is Shs 2.40 compared to the Shs 0.10 interest cost for borrowing. This represents a substantial return and may be on the higher side since not all costs have been considered, e.g., risks. The shadow price for labor in cycle 3 is Shs 0.25 which is less than the cost of Shs 0.60 per man hour and as a result the farmer should hire more labor. The shadow price of land is high at Shs 850.16 but since renting or buying of land is very uncommon a similar interpretation cannot be made.

While the MVPs derived from LP are analogous from those obtained from continuous functions they are not synonymous. For continuous function the MVPs are evaluated at the margin without considering the effects of other restricting resources. The MVP from LP represents the rate of change in the objective function associated with a unit change of resource. Usually the MVP behavior with respect to further additions of the resource is erratic. The erratic behavior is due to corner solutions in LP since the solution holds for a range and only changes when other resources become limiting.

Stability Limits for the Base Plan

LP output indicates the price ranges over which the optimal solution holds. The sensitivity of the plan to changes in prices and/or resources can be determined. The base plan is stable as indicated in Table 5-6. The lower and upper bound represent the range beyond which the optimal solution will change. The cost of producing subsistence crops is indicated as infinite since a minimum amount of each must be produced at all times. The upper bound prices

indicate the prices above which the associated selling activities enter the optimal solution.

Table 5-6. Stability Limits for the Base Plan Resources: Coffee Zone

Activity	Unit	Initial Level	Lower Bound	Changing Variable	Upper Bound	Changing Variable
FLAB 3	Hrs	9.53	-6.67	PRPOT	0	--[1]
PRMLK	Cows	1.02	-∞	0	-34.97	SMLK
PRHMZ	Ha	.7499	-633.99	PRCOF	729.24	--
PRLMZ	Ha	.916	-423.30	SBEN	75.83	PRCOF
PRPOT	Ha	.0945	-∞	0	-255.76	SPOT
PRBEN	Ha	.2228	-∞	0	168.04	SCOF
SCOF	Shs	0	0.0	--	1.01	PRCOF
SHMZ	Shs	1941	.74	SCOF	1.21	--
SLMZ	Shs	984	.69	SCOF	1.01	--
CNMLK	Litres	545	-∞	0	1.20	--
CNHMZ	Kg	199	-∞	0	.76	--
CNLMZ	Kg	461	-∞	0	.85	--
CNPOT	Kg	319	-∞	0	1.15	--
CNBEN	Kg	82	-∞	0	3.28	--

[1] -- indicates slacks.

Costs of Forcing in Non-Optimal Activities

LP provides information about excluded enterprises. The least profitable enterprises are excluded from the optimal plan, i.e. their level is zero. The cost of forcing the excluded enterprise into solution indicates how much the returns will be reduced when the activity is included. The higher the cost the lower is its competitive position. Forcing coffee into the optimal plan would reduce income by Shs 99 while hiring a unit of labor in cycle 9 would penalize income

by Shs 10.8. Hiring labor in all other cycles except 3 reduces income by less than one shilling.

Base Plan: Tea Zone

Table 5-7 indicates the Base Plan for the tea zone including a comparison of actual practice with the optimal plan. The capital level for the optimal plan was estimated to be Shs 1266.

Table 5-7. Base Plan: Tea Zone

Item/ Activity	Unit	Actual Use	Optimal Plan	Percent Change
Total income	Shs	2861	3349	14.5
Production Activities				
Milk Production	Cows	2	1.89	-5.5
Produce Tea	Ha	0.68	1.71	151.4
Produce H Maize	Ha	.35	.31	-11.4
Produce L Maize	Ha	.26	.49	88.5
Produce Pyrethum	Ha	.17	0.0	-100
Produce Beans	Ha	.16	.13	-18.7
Produce Potatoes	Ha	.20	0.1	-50
Non Specified Crops	Ha	.36	.36	0

Tea production dominates the optimal solution while dairy activity declines by 5.5 percent. Pyrethrum does not enter the solution. The only selling activities are tea and milk which account for Shs 3831 and Shs 283 respectively. Labor is hired in cycles 1, 8, 10, 11, 12 and 13, a total of 247.9 man hours in all. The shadow price of

hiring labor is highest in cycle 13 when it stands at Shs 1.85 compared to its marginal cost Shs .57.

Again consumption activities of 866 litres of milk, 385 Kg of hybrid maize, 540 Kg of local maize, 372 Kg of English potatoes and 64 Kg of beans are in solution. They account for a total of Shs 1969 of the total income. In addition, a total of 0.36 hectares is devoted to other food crops.

Unlike the coffee zone, the MVP for land is zero indicating that land is not a constraint. The shadow price of capital is Shs 1.31 showing that capital is a constraint and therefore income could be increased if more of it could be acquired.

Base Plan: High Altitude Grass Zone

Table 5.8 shows the base plan for the third zone. The capital level was estimated to be Shs 1056. Income increases by 7.2 percent in the optimal solution. Growing of local maize dominates the plan while the cattle activity declines by 42 percent. The only selling activity is that of local maize which raises Shs 6793. Consumption of 1314 litres of milk, 158 Kg of hybrid maize, 1040 Kg of local maize, 540 Kg of English potatoes and 51 Kg of beans were included. Labor was only hired in cycle 4 and 5 which gave a total of 127 man hours.

The shadow price for land was zero indicating land is not a constraint. About 3 hectares were left unused at prevailing conditions. The shadow price for capital was Shs. 8.25 indicating that the relative scarcity of capital is highest in this zone.

In all the three zones there was a reduction in the dairy

Table 5-8. Base Plan: High Altitude Grass Zone

Item/ Activity	Unit	Actual Use	Optimum Plan	Percent Change
Total Income	Shs	5315	5728	7.2
Production Activities				
Produce Milk	Cows	3	1.75	-42
Produce Pyrethrum	Ha	.37	0.0	-100
Produce H. Maize	Ha	1.32	.12	-91
Produce L. Maize	Ha	1.25	3.72	297
Produce Potatoes	Ha	.51	.16	68.6
Produce Beans	Ha	.11	.1	-10
Non Specified Crops	Ha	.70	.70	0

activity when compared with actual plans. This reduction reflects the declining competitive position of dairy enterprise in the 1974/75 period. The dairy enterprise was so uncompetitive that even after raising the yield of milk per cow by 15-20 percent without increasing costs the cattle enterprise was reduced to meet the minimum consumption constraint. Without this imposed constraint the dairy enterprise would not be in solution. At the 1974/75 milk prices milk production was not competitive enough to be included in the income maximizing plans above the subsistence requirements.

Effect of Increasing Operating Capital

Capital is augmented through a borrowing activity and the optimum solution derived. The following tables indicate the resultant

solutions. The total amount of labor hired is summed up over the cycles. Consumption levels are maintained at the same level as in base plans.

Increased operating capital leads to higher returns. Milk production activity becomes the dominant enterprise as operating capital rises. There is an initial increase in hired labor but as the level of the dairy activity increases there is a decline in the amount of labor hired because dairying is not a labor intensive activity. The shadow price of land increases while that of capital falls as capital scarcity is reduced.

Similar results are obtained in the tea and high altitude grass zones as shown in Tables 5-10 and 5-11. Here too dairying emerges as the dominant enterprise as capital increases.

Supply of Milk by Parametric Programming

Starting from the Base Plans parametric programming was used to determine the changes in production needed to maximize income as milk price is varied over an appropriate range while other prices were held constant. The level of operating capital was also varied. Discrete changes in production plans and output result in "stepped" supply function and indicates the exact price boundaries. The supply function could be represented as follows:

$$S_m = f(P_1, P_2, P_m \ldots P_n; R_1, R_2 \ldots R_n; a_1, a_2 \ldots a_n)$$

Where:

S_m = the supply of milk

$P_1 \ldots P_n$ = the net prices of the enterprises in the model

$R_1 \ldots R_n$ = the levels of fixed resources

Table 5-9. Influence of Capital: Coffee Zone

Item	Unit	Levels of Capital			
Total Operating Capital	Shs.	832	1,332	1,832	1,976
Total Credit	Shs.	0	500	1,000	1,144*
Total Income	Shs.	2,895	3,154	3,250	3,274
Produce Milk	cows	1.02	2.78	3.72	4.24
Produce Coffee	Ha.	0	.06	.13	0
Produce H Maize	Ha.	.75	.94	.14	.07
Produce L Maize	Ha.	.92	.29	.29	.29
Produce Potatoes	Ha.	.09	.24	.75	.88
Produce Beans	Ha.	.22	.22	.22	.22
Hired Labor	Hrs.	9.5	48.5	65.4	45.0
Sell Milk	(Shs.)	0	946	1,449	1,727
Shadow Price Land	Shs.	850	1,190	1,190	1,447
Shadow Price Capital	Shs.	162	.29	.29	.100

*Unrestricted credit.

Table 5-10. Effect of Increased Operating Captial: High Altitude Grass Zone

Item/Activity	Unit	Capital/Activity Levels			
Total Operating Capital	Shs.	1,056	1,556	2,056	5,219
Total Credit	Shs.	0	500	1,000	4,162[a]
Total Income	Shs.	5,728	8,672	8,843	9,681
Produce Milk	Cows	1.75	2.35	5.75	27.27
Produce Pyrethrum	Ha.	0	0	0	0
Produce Hybrid Maize	Ha.	.12	.12	.12	.12
Produce L Maize	Ha.	3.72	6.57	5.74	.49
Produce Potatoes	Ha.	.16	.16	.16	.16
Produce Beans	Ha.	.10	.10	.10	.10
Total Hired Labor	Hrs.	126	1,051.3	1,118.9	151.7
Sell Milk	Shs.	0	451	3,002	19,141
Sell L Maize	Shs.	6,793	12,818	11,069	0

[a]Unrestricted Credit

Table 5-11. Effect of Increased Operating Capital: Tea Zone

Item/Activity	Unit	Capital/Activity Levels			
Total Operating Capital	Shs.	1,266	1,766	2,266	2,713
Total Credit	Shs.	0	500	1,000	1,447[b]
Total Income	Shs.	3,349	3,833	4,376	4,785
Produce Milk	Cows	1.89	5.55	9.36	11.55
Produce Pyrethrum	Ha	0	.13	.32	0
Produce Hybrid Maize	Ha	.31	.31	.31	.31
Produce Local Maize	Ha	.49	.49	.49	.49
Produce Potatoes	Ha	.10	.10	.10	.33
Produce Beans	Ha	.13	.13	.15	.13
Produce Tea	Ha	1.72	1.06	.24	0
Hire Labor	Hrs	247.9	171.8	111.0	100
Shadow Price Land	Shs.	0	251	310	1,598
Shadow Price Capital	Shs.	1.31	1.20	1.18	.1

[b]Unrestricted Credit

Table 5.12.--Price Adjustment and Milk Supply: Tea Zone

Capital Level (Shs.)	Price of Milk (Shs.)	Number of Cows	Quantity of Milk (Litres)
1266	.78	1.89	2,873.6
1266	.85	2.01	3,051.7
1266	.92	2.03	3,085.4
1266	1.02	4.35	6,600.3
1266	1.32	4.57	6,932.7
1266	1.53	4.61	6,983.8
1266	1.86	4.65	7,050.5
1266	2.47	4.81	7,285.9
1266	2.84	5.02	7,611.4
1766	0.83	5.54	8,409.2
1766	1.03	7.35	11,142.6
1766	1.32	7.43	11,266.5
1766	1.53	7.47	11,320.0
1766	1.86	7.58	11,491.6
1766	2.47	7.62	11,556.5
1766	3.00	7.79	11,813.0
2266	.84	9.36	14,184.4
2266	1.09	10.28	15,581.8
2266	1.32	10.29	15,656.1
2266	1.53	10.33	15,656.1
2266	2.00	10.44	15,823.2
2266	2.60	10.51	15,932.4
2266	3.00	10.56	16,015.0
2713	.78	11.55	17,516.2
2713	.84	12.25	18,575.2
2713	.90	13.01	19,727.3

Table 5.13.--Supply of Milk: Coffee Zone

Capital Shs.	Price Shs.	Number of Cows	Quantity of Milk (litres)
832	1.28	1.02	1,362.4
	2.02	2.06	2.765.4
	2.85	3.054	4,092.7
1,332	.84	2.78	3,727.2
	.97	3.58	4,799.5
	1.17	3.69	4,948.95
	2.02	4.96	6,642.7
	2.85	5.54	7,429.3
1,832	.84	3.72	4,984.8
	.93	7.16	9,597.4
	1.04	7.20	9,647.7
	1.16	7.42	9,943.8
	2.02	7.85	10,520.3
	2.85	8.03	10,766.2
1,977	.84	4.2	5,684.9
2,059	.90	9.12	12,283.8

Table 5-14. Supply of Milk High Altitude Grass Zone

Capital (Shs.)	Price (Shs.)	Number of Cows	Quantity of Milk (Litres)
1,056	.69	1.75	3,285.0
1,056	2.33	1.80	3,379.7
1,056	2.46	2.29	4.301.2
1,056	2.85	4.20	7,874.1
1,556	1.26	2.35	4,412.3
1,556	1.98	3.68	6,895.8
1,556	2.33	4.83	9,058.6
1,556	2.46	5.21	9,765.9
1,556	2.85	6.97	13,071.1
2,056	1.26	5.75	10,791.1
2,056	1.98	6.78	12,721.4
2,056	2.33	7.87	14,737.0
2,056	2.46	8.12	15,230.2
2,056	2.85	9.74	18,267.2
5,219	.69	27.27	51,139.7

In all three zones, increasing milk output by 15 to 20 percent did not change the optimal plans once the milk price reached Shs. 1 per litre and above.

$a_1 \ldots a_n$ = the column vectors of technical coefficients of production

The supply of milk is not just function of milk price and resources since it takes into account the array of competing enterprises.

Table 5-12 shows the supply of milk in the tea zone. Similar tables for the coffee and high altitude grass zone are Tables 5-13 and 5-14. The plans developed by parametric programming are those expected to hold over a period of time long enough to permit adjustments to take place. Krenz, et al. (38) have argued that the step function is the appropriate function for individual farms. They contend that ordinarily farmers change their production pattern only for fairly large changes in expected prices and then in a discrete manner. Few, if any individuals make adjustments in a continuous manner.

Milk Supply Model Using Regression

The use of a single representative firm results in a stepped supply function[4] which is not particularly useful in estimating supply elasticity. The prices of milk can vary widely from no response to large jumps in output. It is difficult to generalize such response in a single elasticity measure. Moreover, the magnitude of elasticicy is highly dependent on the segment of the curve for which the elasticity is computed and the range over which the supply is elastic or inelastic cannot be determined apriori. To derive a meaningful

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[4]A continuous regression would typify an aggregate supply situation since the steps in the individual supply function would occur at different prices because of differences in resources and coefficients of production. The effect of any individual change also would be virtually unnoticeable in the typical aggregate supply functions found in agriculture.

point elasticity therefore, a continuous supply function was fitted to the data obtained by parametric programming. The model used was given as:

$$M = \beta_0 + \beta_1 P + \beta_2 K + \varepsilon$$

where:

M = supply of milk in litres per year

P = price of milk in shillings per litre

K = level of operating capital in Shs

β_i = parameters to be estimated

ε = disturbance term

The dependent variable was the production of milk rather than the number of cows. The supply response for each zone was thus obtained from the optimum solutions of the programming models. From economic theory the coefficients β_1 and β_2 would be expected to be positive, implying that the supply of milk increases as the prices of milk and levels of operating capital are raised.

It is assumed that the midpoints of the vertical portions of the steps were most stable with respect to price change. The midpoint of the stability limits was used as observations in fitting the estimating equations. A similar procedure was used in a milk supply response study in Iowa (38). The level of price was allowed to vary up to Shs 3.00 per litre while four capital levels were used. Such data do not meet the assumptions of normality and independence used in regression analysis and hence statistical inference and probability statements cannot be made.

The estimated equations are presented in Table 5-15. The R^2 are high and the coefficients are significant at least at the 5

percent level. These results would be statistically valid if the assumptions for regression were to hold.

Table 5-15. Estimated Supply Equations

Zone	β_0	β_1 (Milk Price)	β_2 (Operating Capital)	R^2	$F_{\alpha,\gamma}$
HALTG	-1,980.0	3,915.75** (4.72)	12.64** (23.78)	.98	340** (2,12)
Tea Zone	-8,222.41	1,293.56** (4.37)	9.52** (21.9)	.95	242** (2,23)
Coffee Zone	-6,751.08	1,692.06* (2.98)	7.28** (6.90)	0.79	24* (2,13)

*Significant at 5 percent.
**Significant at 1 percent.
T values are given in parentheses.

Elasticities

The elasticities of supply with respect to its own price and capital were calculated at their mean values[5] by the equations:

$$\varepsilon\bar{P} = \frac{Y}{P} \cdot \frac{\bar{P}}{Y} \qquad \text{Price elasticity}$$

$$\varepsilon\bar{K} = \frac{Y}{K} \cdot \frac{\bar{K}}{K} \qquad \text{Capital elasticity}$$

The mean values of the dependent variable, price and capital and the associated elasticities for price and capital are shown in Table 5-16.

Elasticities calculated at the means are less subject to errors

[5]Elasticity is strictly defined only with respect to a particular point (75, p. 28).

Table 5-16. Means and Supply Elasticities by Zone

Zone	Milk (Litres)	Price (Shs)	Capital (Shs)
	Means		
HALTG	12,328.70	2.05	1,833.50
Tea Zone	11,272.60	1.56	1,836.81
Coffee Zone	6,824.81	1.52	1,511.50
	Elasticities		
HALTG		0.65	1.88
Tea Zone		0.18	1.52
Coffee Zone		0.38	1.61

than those calculated elsewhere since the mean lies on the fitted line. Using different prices and capital will give different elasticities. Manderscheid (14) argues that the method of estimation affects the elasticities obtained.

The price elasticities calculated are less than one while elasticities associated with capital are greater than one. The prices used are nearly double the prevailing prices in 1974/75 period but about 30 percent above those prevailing in 1977. Using the decreed price of Shs 1.32 per litre of milk to compute new elasticities given an elasticity of 0.42 for high altitude grass zone, 0.15 for tea zone and 0.33 for coffee zone. There is a greater drop for the high altitude zone. The elasticities tend to increase with rising mean prices.

It is not possible to compare the results obtained in this study since no previous studies in Africa are known to the author. There is ample evidence, however, that the supply elasticities associated with normative supply functions are biased upwards (78) when compared with those obtained from time series which represent historical events encompassing all the lags and inflexibilities stemming from uncertainty and resistance to change (18).

The results obtained in this chapter have important implications for policy makers. The estimated price elasticities with respect to change in milk price are positive in all three zones. The elasticities provide a rough guide if the government wanted to anticipate how smallholders would respond to changes in milk prices or when investment in dairy production is envisaged. Peasants tend to be more familiar with product prices and will be probably more sensitive to their variation (39). The information obtained could help in formulation of an appropriate pricing policy given a target quantity of milk. This would be important should the milk supply projections of Chapter IV prove either too high or too low.

The results also indicated that increase in capital has a high potential for increasing milk supply. Furthermore, the elasticity of milk output to changes in operating capital are higher than those associated with milk prices. Capital was also found to be limiting in the three zones. This would imply that any policy designed to increase or intensify milk production should provide for adequate credit. The simultaneous use of two or more policy instruments will generate the greatest response.

Summary

The purpose of this chapter was to analyse the supply response of small-holder farms in Central Kenya in order to contribute to the understanding the dynamics of small-holder milk production. Cross-sectional data of the CBS were utilized in a normative analysis to determine the efficient organization of farms and parametric linear programming to generate the supply of milk in smallholder farms. The analysis focused on what producers would do if they had income maximization goal and perfect knowledge but were constrained by certain consumption levels, prices, technical conditions of production and institutional restraints. The results indicated substantial farm income gains could be obtained by using optimal resource allocation in all zones. Supply elasticities were computed to indicate how smallholders would adjust their milk production and determine the degree of supply response. The elasticities were all positive and suggest the magnitudes by which prices and credit could be manipulated in order to generate a given output of milk. This could be important for policy formulation depending on availability of milk supplies. The interactions of supply and demand relationships will be analyzed in the next chapter.

CHAPTER VI

SUPPLY AND DEMAND FOR MILK IN KENYA

This chapter investigates the determinants of the demand for milk and milk products in Kenya. It presents the estimation of income and price elasticities of demand for fluid milk using time series data. The demand for milk and milk products is projected for the 1978-1985 period using the estimated elasticities supplemented by the results derived from the 1969 Household Budget Survey for Nairobi, Mombasa and Kisumu. In addition, an overall analysis of supply and demand relationships for the 1978-1985 period will be compared and the implications for the export of dairy products will be appraised.

Demand for Milk in Kenya

The pattern of consumption of dairy products is difficult to document except for the sales made through the formal market. The vast majority of commercial sales are in urban areas with Nairobi and Mombasa taking about 50 to 20 percent, respectively. The greatest proportion of milk production is used for subsistence and unrecorded rural markets. Just as cattle are valued by many traditional societies in Kenya, milk and milk products are highly valued, and are regularly consumed throughout the country when they are available. At the same time, milk may be considered a luxury food and

consumption is restricted because of the high price of milk in both formal and informal markets. The Nutrition Survey for the 1964-68 indicated that almost half of the rural households in Kenya did not consume milk on a regular basis.

Per Capita Milk Consumption

Per capita milk consumption statistics for Kenya are generally derived by dividing production estimates less exports by population estimates. The estimated figures vary considerably depending on the year, production data and other factors. A sampling of available estimates is shown in Table 6-1.

Table 6-1. Estimates of Per Capita Consumption of Milk in Kenya, 1965-1973.

Source	Year	Litres/Annum	Total: Million Litres/Annum
FAO (67)	1965	57.3	NA
Smith (67)	1969	78.5	863.7
Peberdy (55)	1970	71.6	780
Mission[a]	1973	74.5	NA

Source: Compiled by author.

[a]IBRD. Agricultural Sector Survey, 1973.

Milk consumption per capita in Kenya is low compared with developed countries. Per capita milk consumption is however a crude estimate and tends to over-estimate availability in some districts. There is great variability in consumption between districts depending on production conditions. Consumption is high among pastoralists and

is unlikely to increase further.[1] This is also true for the subsistence areas. Per capita consumption is expected to grow at 2 to 3 per annum to about 94 litres in 1985, based on the growth of income and population.

The Kenya Population

The Kenyan population will continue to experience rapid growth. The analysis of 1948-1962 intercensal growth rate suggested a median growth rate of 2.94 and a modal rate of 2.64 percent per annum. The total population was 10,942,705 in 1969. The 1962-1969 intercensal annual growth rate of the African population was estimated to be 3.5 percent per annum. There is a clear indication that the population growth rate is now 3.5 percent per annum and is likely to remain so up to 1985. There are many reasons for this, including a sharp decrease in death rates, sustained high birth rate and the young age structure of the population. The population aged under 15 years represented about 50.5 percent of the total population. The death rate now stands at 17 per 1,000 and is falling about 0.5 per 1,000 each year. The birth rate is estimated at about 50 per 1,000 and birth rates and family size continue at high levels because of traditional views of having many children. The total fertility rate, i.e., the average number of children born alive to a woman who survives to the age 50 is estimated at 7.6. The expectation of life at birth is estimated at 51 years for female and 47 years for males or an average of 49 years for both sexes.

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[1] The Masai consume about 1.7 litres per day or 8 times the national average.

Table 6-2 indicates the CBS projections of population up to 1985. For all projections life expectancy increases by 0.5 year per annum. For high projections age specific fertility rates are held constant and for medium projections age specific rate is constant to 1975 and then falls steadily declining by 50 percent to 4 in Year 2000. For the low projections the age specific fertility rate is constant to 1975 and then falls by 60 percent to 3 in Year 2000.

Table 6-2. Total Projected Population, 1978-1985

Year	High	Medium	Low
1978	14,875	14,806	14,757
1980	16,053	15,877	15,752
1982	17,263	17,008	16,809
1985	19,310	18,635	18,186
% Growth Rate	3.7%	3.5%	3.3%

Source: Kenya Statistical Digest, Vol. X, No. 3 (1976).

The population growth rate is unlikely to change significantly in the projection period. Although an organized national family planning program exists, it is new and has not yet reached a significant number of mothers, the majority of whom are in rural areas. According to the most recent estimate 87 percent of the 13.4 million population in 1975 was estimated to be rural while the rest was scattered in settlements of 2,000 to 10,000 and above (34). Nairobi and Mombasa accounted for

70 percent of the urban population. By 1985 and according to medium projections, the urban population is expected to reach 2,894,000 or 15 percent of the total population. The annual growth of urban population has been 6-7 percent in recent years.

Population is the single largest factor which determines the trends of most economic activities. Spengler (68) contends that during the process of economic development changes in population are a cause, an effect and indicator of change. Street (72) has demonstrated the importance of age distribution of population on the demand for milk. Others have shown that milk consumption is highly correlated with crude birth rate while yet others have demonstrated a strong connection between size of household and consumption (33, 46). The demand for milk in Kenya will increase as rapidly as the population increase ceteris paribus, and will hence be 3.3 to 3.7 percent per annum depending on whether the low or high population projections are used.

Change in Per Capita Income

Increasing per capita income is one of the most significant factors affecting the demand for milk. Per capita income depends on the rate of growth of GDP and the rate of growth of population increase. Between 1964 and 1972 the GDP grew at 6.8 percent per annum. During the same period the population grew at between 3 and 3.3 percent and per catpit income grew at constant 1964 prices at the cumulative rate of 3.5 and 3.8 percent or from KŁ 36 in 1964 to KŁ 46 in 1972. In 1974 the GDP per capita was KŁ 48.

Table 6.3 indicates projections of percapita income under the

medium projections of population. Alternative demographic assumptions would give different growth rates of per capita income. The low population projections of Table 6-2 would give slightly higher growth rates while the high population projections would give a lower gorwth of per capita income.

Table 6-3. Projections of Per Capita Income, 1978-1985, Kenya Pounds (K£)

Year	Low (3 percent)	Medium (4 percent)	High (5 percent)
1978	56.04	59.39	59.91
1980	59.46	64.24	69.36
1982	63.08	67.49	76.46
1984	66.92	75.15	84.29
1985	68.93	78.16	88.51

Source: Own computations.

Taking population growth of 3.5 percent per annum the growth of GDP was assumed to grow at 6.5, 7.5 and 8.5 percent respectively for the three alternatives of per capita income growth.

Income Elasticity of Demand

Reliable estimates of the income elasticity of demand are crucial for economic planning. For a country like Kenya, however, income elasticities are difficult to derive given limited empirical work in estimating income elasticities. It can however be hypothesized that income elasticity of demand for milk is elastic because low income consumers will increase their expenditure on milk

proportionally more than the high income groups. Among the higher income groups milk consumption is not constrained by income and increasing incomes are unlikely to increase milk consumption significantly. For the general population however, the demand for milk is expected to rise faster because income elasticity is expected to be high.

Given this paucity of data several writers in the past have used an array of widely varying income elasticities of demand for milk. In 1968, for instance, Hopper assumed an income elasticity of demand for milk to be 2. In absence of better information Smith (67) used the income elasticities and functions included in FAO agricultural commodities projections for 1975 in order to estimate consumption levels. The semilog function indicated an income elasticity of 0.6 for milk while the double-log function gave an income elasticity of 1.0 for butter. The lack of reliable estimates thus constitute a significant barrier to planning.

Cross-Sectional and Time Series Estimates

No time series analysis of food consumption exists for Kenya. Time series analysis enables income and price elasticities to be determined simultaneously under the assumption that the structure of demand remains stable over the period under consideration. The significant relationships among variables are thus assumed to have not changed and hence time series data can be used as parameters of those relationships. It is possible that the structure of relationships over time may change. If a shift in the structure is identifiable a shift variable can be introduced in the regression equation.

Increasingly however, it has been realized that aggregate consumption functions derived from time-series are not sufficient for forecasting consumption or for demand analysis (25, 76). Among the difficulties involved are problems of obtaining a homogeneous sequence of data that covers a reasonable length of time, and the problem of the presence of serial correlation. These problems lead one to consider alternatives such as the use of cross-sectional data, budget studies obtained in household surveys or the pooling of time series and cross-sectional data. The utilization of mathematical relationships, based upon various assumptions could also be used to estimate the required parameters.[2]

Cross-sectional data analysis enables many more variables to be handled such as quantities consumed, income, family size and composition, urbanization or regions, education, social class, etc. In a single cross-sectional sample, it is assumed that prices and indeed other market variables are held constant. Prices paid, interest, wage-rates and other variables can be said to be held constant over that time period (37). The popularity of using household expenditure surveys for a wide variety of purposes stems from two basic reasons. The first is the frequent occurrence of collinearity of time series data, a problem that seems to be less severe in cross-sectional data. The second is the desire to construct more complicated behavioral models (40). Several functional forms such as logarithmic, semi-logarithmic, log-inverse, and log-log inverse[3] are used to estimate

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[2]Such relationships include the homogeneity condition, the Slutsky condition and the Engel aggregation condition (76).

[3]If Y is per capita demand and X per capita income, the various

the income elasticity of demand. The double logarithmic form implies constant elasticity, i.e., consumption changes by some fixed proportion of per capita income change. It is most suitable when food consumption is expressed in terms of expenditures rather than in terms of quantities. It does not permit "saturation level" i.e., the hypothetical highest level of consumption is very high and approaches infinity. The semi-log function implies that consumption increases at some declining proportion of income as income continues to rise. It has been recommended to fit the consumption of food "necessities" though it does not allow for saturation level (57). The log-inverse function implies that consumption rises as income rises to a certain (saturation) level while log-log inverse function implies that consumption rises to a "saturation" level and thereafter further increases in income lead to a decline. The log-inverse function seems to provide a better fit when food consumption is expressed in terms of quantities, and when data available covers a broad range of income (14). The log-log inverse function is suitable for cereals.

Cross-sectional surveys include the possibility of bias due to educating the reporting families when a panel study is used, loss of randomness due to "fall-out" and difficulty in keeping track of changing economic and social characteristics of the sample (4).

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functional forms are as follows:

logarithmic function: $\log Y = \alpha + \beta \log X + \mu$

semilogarithmic function: $Y = \alpha + \beta \log X + \mu$

log-inverse function $\log Y = \alpha \frac{-\beta}{X} + \mu$

and log-log inverse function: $\log Y = \alpha \frac{-\beta}{X} - \gamma \log X + \mu$

Often in empirical analysis income elasticities cannot be estimated and observations on expenditures are used rather than observations on physical quantities and on incomes. Expenditure on a particular commodity is made a function of total expenditure because observations on expenditures are sometimes more easily obtained than on physical quantities. Observations on income obtained in budget surveys often contain errors and do not correspond to the economic concept of income (12). Total expenditure as an indicator of income however, is a better explanatory factor because it is more closely related to the permanent economic status than income which is more likely to include transitory or unexpected elements (37, p. 58).

Coefficients which measure the responsiveness of expenditure to a change in income (total expenditure or other instrumental variable) are called expenditure elasticities. They may represent the percentage change of expenditure on an individual commodity to a 1 percent change in total expenditure. These elasticities are generally larger than those based on physical quantities, i.e., expenditures are usually more responsive to changes of income than quantities. This is reasonable since consumers with higher incomes probably buy higher quality items (hence higher priced items) as well as larger quantities.[4] Hence, the expenditure change includes a price effect due to quality as well as quantity effect (37).

Elasticities estimated from cross-section data tend to be long-run elasticities and would be suitable for long-run income changes.

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[4]Although prices paid and qualities consumed by different households differ it is reasonable to expect that these differences are systematically related to income levels, prices are assumed constant in cross-section data (37, p. 55).

Estimates of elasticities from time series data on the other hand, tend to be short-run elasticities and are appropriate for examining changes in income over short periods of time.

Household Budget Survey in Kenya

Few household budget studies exist in Kenya and the few that exist pertain to urban areas where the major emphasis has been on providing weights for price indices or data on the cost of living of various wage-earning groups. Survey data is scanty for the rural areas.

This study will utilize the results of the December 1968 to October 1969 household survey. The aim of the survey was to provide information on income and expenditure patterns on the African and Arab households living in purely urban areas of Nairobi, Mombasa and Kisumu. The sample sizes were 498, 424, 224 for the three towns respectively. The sample was stratified according to level of income,[5] upper, middle and lower. The Nairobi fieldwork ran from December 1968 to June 1969, in Mombasa from February 1969 to August 1969 and in Kisumu from June 1969 to October 1969.

Each household was visited daily for 32-35 days and a separate form filled in for each day's consumption.[6] A few upper income residents preferred to fill in simple consumption details themselves

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[5]Income was defined as all earnings and gifts received (cash and kind) of all members of the family including housing allowance and the estimated value of any housing subsidy received.

[6]A slight bias in expenditure on milk and milk products could be expected because of seasonality in milk consumption. For instance, in 1975 the variation in the quarterly sales of milk varied by 8.9 to 12 percent from the mean for the three towns.

and were visited every three or four days. A separate form was filled by employers as a check of income, fringe benefits, trade union activities, etc. Table 6-4 shows the planned sample size and actual or response rates for the three towns. As can be seen the response rate was consistently lower in the upper income groups. Within each stratum therefore there might be a slight bias due to disproportionate numbers of higher income groups failing to cooperate. This would tend to imply an underestimation of income and items of expenditure that systematically vary positively with income.

Table 6-5 presents estimates of the income elasticity of demand for milk and milk products for Nairobi, Mombasa and Kisumu individually and for pooled data of the three towns. The analysis was restricted to "explaining" expenditure by two independent variables; disposable income and household size (33). Disposable income was defined as total household income, including income in kind (mostly housing subsidies) but excluding taxes. Household size is simply the number of people but with children under 16 given a weight of one half.[7] Total household expenditure rather than expenditure per capita was used. The functional form used was double logarithmic, its principal advantage being its simplicity since the expenditure elasticity is β_i.

$$\text{Log } E_i = \alpha_i + \beta_i \text{ Log } Y + C_i \text{ log } N + \mu_i$$

where:

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[7]This represents the usual weighting problem of adults and children to get consumption units. The use of uniform weights for all products is unsatisfactory especially for milk. Since it is possible that weights could vary with the item but in absence of conclusive evidence of best weighting system the given weighting system was resorted to.

Table 6-4. Results of Household Budget Survey 1968/69

Income Level	Planned Sample Size	Actual	Response Rate
I NAIROBI			
upper	63	32	0.51
middle	140	103	0.74
lower	399	363	0.91
Total Nairobi	602	498	0.83
II MOMBASA			
upper	70	46	0.66
middle	91	76	0.84
lower	343	302	0.88
Total Mombasa	504	424	0.84
III KISUMU			
upper	21	14	0.67
middle	63	57	0.90
lower	168	143	0.91
Total Kisumu	252	224	0.89
Overall Total	1,358	1,146	0.84

Source: Central Bureau of Statistics. Household Budget Survey File SD 110/13/06

E_i is expenditure on item i in Shs.

Y is income per year in shs.

N is household size in adult equivalents

β_i and C_i are parameters to be estimated

μ_i is the error term.

Although the sample size was 498 for Nairobi, 424 for Mombasa, and 224 for Kisumu, the data was grouped for regression analysis (there being five households in a group in most cases). Thus the number of grouped observations became 100 for Nairobi, 86 for Mombasa and 45 for Kisumu. Grouping eliminated zero values since the log of zero is undefined.

Table 6-5. Estimated Parameters: Milk and Milk Products[a]

Town	Disposable Income	Household Size	R^2
Nairobi	0.361**(.033)	0.416**(.057)	0.740
Mombasa	0.470**(.052)	0.538**(.081)	0.760
Kisumu	0.387**(.067)	0.265**(.099)	0.615
Pooled	0.411*(.028)	0.454**(.045)	0.726
Total Food (pooled)	0.330 (.017)	0.362**(.027)	0.828

Source: Kenya Statistical Digest. Vol. X, No. 2. 1972.

[a]The figures in the brackets are standard errors of the estimates. Those significant at 5 percent level are marked with one asterick while those significant at 1 percent are marked with two asterisks.

The results are comparable to those obtained by Howe (29) for the 1957/58 and 1963 surveys when an income elasticity of 0.452 was obtained for milk and eggs in Nairobi. Massel and Heyer (46), using the 1963 household budget Survey of African middle-income workers in Nairobi, derived an expenditure elasticity of 0.493 for milk and milk products. This expenditure elasticity was converted to income elasticity by multiplication with total expenditure elasticity of 0.687 for Nairobi to give an income elasticity of 0.339 for Nairobi and like Howe's it is not too far below the 1968/69 estimate.

Price Elasticity of Demand

The price elasticity of demand was estimated by ordinary least squares (OLS) using time series data for the period 1962-1975. The 1963-1964 period was marked by some changes in the Kenyan economy associated with the movement towards independence and a dichotomous dummy was therefore used to mark this period. The dependent variable was the quantity of fluid milk sold in the Kenyan market (i.e., total fluid milk sales less fluid milk exports) divided by the estimated population, while the independent variables were price of milk deflated by consumer price index, real per capita income, and the dummy variable. The estimated equation was represented as follows:

$$Q = \alpha + \beta_1 P + \beta_2 Y + \beta_3 D + \mu$$

where:

Q = per capita milk sales in litres

P = price of milk in shs. per litre

Y = per capita income in shs. (or real GDP/population)

D = dichotomous dummy } 1 if 1962 - 1964
0 otherwise

α, β's are parameters to be estimated

μ is the disturbance term.

The estimated equation is shown below:

$$Q = 3.1482 - 3.9165^{**}P + 0.2421^{**}Y + .7723^{**}D \quad R^2 = 0.9122$$

$$t \qquad (3.1139) \quad (9.4577) \quad (2.7508)$$

$$DW = 1.6849, \qquad F\ (3, 10) = 34.62$$

The coefficients of price, per capita income and the dummy variables were significant at the 1 percent level and are marked by a double asterisk.

The elasticities of demand with respect to its own price and per capita income were calculated at their mean values using the formula:

$$\varepsilon P = \frac{\partial Q}{\partial P}\frac{\overline{P}}{\overline{Q}} \quad \text{price elasticity}$$

$$\varepsilon Y = \frac{\partial Q}{\partial Y}\frac{\overline{Y}}{\overline{Q}} \quad \text{income elasticity}$$

Where the partials are the estimated parameters (β_i). The price elasticity was calculated to be -0.65, while income elasticity was estimated to be 1.2. The income elasticity, as expected, is much higher than the one derived by cross-sectional data.[8] Using the price elasticity of -0.65 and the 36 percent increase consumer price of milk in March 1977 the demand for fluid milk would be expected to decline by 23.9 percent. Caution is, however, essential in using these elasticities since they cover only the formal market and the time period of 14 years is short. By using logarithmic form the price and income

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[8]The two elasticities are not comparable because the time series data also covers non-urban areas and hence is much more inclusive.

elasticities became -0.80 and 1.02, respectively. Dropping 1962 and 1963 data and fitting post independence years only causes the price elasticity to decline to -0.4 while income elasticity becomes 1.1. This suggests that the demand of milk is inelastic with respect to price and close to unitary elasticity with respect to income. In countries at Kenya's stage of development commodities such as dairy products are highly susceptible to changes in income (67). Including a time trend to take care of change in tastes, etc. did not result in a significant parameter.

Demand Projections

To obtain countrywide demand projections a set of household budget surveys covering representative consumer groups for the country as a whole would be ideal. The available surveys in Kenya however, tend to emphasize urban areas (but even here non-Africans who are important consumers of milk are omitted). The Nairobi, Mombasa and Kisumu surveys could be construed to represent the urban population until more complete data become available. The results will be used to obtain tentative demand projections. The projections are tentative because forecasts based on elasticities obtained from cross-section data tend to be long-run while for short periods short-run elasticities would be required.

In projecting demand three basic variables are involved: 1) rate of growth in per capita income, 2) the rate of population growth, and 3) income elasticity of demand. The relationships between these variables were expressed mathematically by Mellor (47) as follows:

$$D = P + \mu Y$$ [10/]

where

D = percentage increase in demand for milk

P = rate of population increase (percent)

Y = rate of increase in per capita income (percent)

μ = income elasticity of demand

It is assumed that income and population are the independent variables while milk consumption is the independent variable which is determined by income level and population. It is further assumed that the elasticity coefficient will be stable within the projection period and that all other factors affecting the household such as size and tastes will be constant. No substantial changes in relative prices is envisaged.

Using the given formula to estimate the percentage change in demand does not require knowledge of the actual per capita income or the actual size of the population either in the base year or in the target year. Only the rate of growth of each is required.

In projecting the national demand for milk it is difficult to project the demand for rural and urban areas. One alternative is to use a weighted elasticity for both areas combined. The other is to compute separate projections. If separate projections were used it would have been possible to estimate each demand using appropriate rates of change of per capita income and population for each area

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[10] The equation should include the interaction, i.e., $D = P + \mu Y + \mu PY$. The projections were made for every successive year and hence the interaction effect was taken into account automatically. Dropping the interaction term in this case does not affect the results.

and then derive the total demand for fluid milk by summation. This procedure would have been preferred had adequate information been available. The weighting procedure, on the other hand, would raise questions regarding the accuracy of the weights under dynamic conditions. Given the paucity of data, however, both procedures were impracticable. It was therefore necessary to use a range of income elasticities of demand in a scenario type of analysis without any distinction between rural and urban areas.

The cross-sectional estimate of income elasticity will be regarded as the lower bound (urban areas) while the time series estimate will be considered the upper bound (rural areas). The use of this range of elasticities could be justified by consideration of either weighted or separate elasticities for urban and rural areas under dynamic conditions involving rapidly increasing urban population (6-7 percent per annum). Lewis (1964) argued that as rural people migrate to urban centers, their consumption may not drastically change during an adjustment period. In any case, the rapid population increase in urban areas will be undoubtedly faster than the growth of gainful employment which would imply a defacto decline in per capita income in the urban areas. In addition, any weighted elasticity is likely to fall between the two extremes.

Using three plausible rates of growth of income and population alternative rates of growth demand for fluid milk were estimated as illustrated in Table 6-7.

The lowest growth rate of demand per annum is 4.5l which is associated with the lowest growth rates of per capita income and population. The highest rate is 9.7 which is associated with the

Table 6-6. Annual Rate of Growth in Demand for Fluid Milk

Income Growth Rate	Population Growth Rate 3.3	3.5	3.7
Income Elasticity = 0.41 lower bound			
3	4.51	4.71	4.91
4	4.94	5.14	5.54
5	5.35	5.55	5.75
Income Elasticity = 1.2 upper bound			
3	6.9	7.1	7.3
4	8.1	8.3	8.5
5	9.3	9.5	9.7

higher levels of population and income growth and the upper bound of income elasticity. The projections of fluid milk demand for the 1978-85 period are shown in Table 6.7.

Demand for Milk Products, 1978-85

There are inadequate data to estimate the income elasticities for the various dairy products. Time series data is not available and cross-section data gathered in household surveys, have not addressed themselves to the problem of dairy products. Instead the consumption of milk products have tended to be lumped together into a category 'milk and products.' Perhaps one contribution of this study is highlighting the gaps and inadequacies in the data and in pointing directions for further investigation.

Table 6-7. Projections of Commercial Demand for Liquid Milk, 1978-1985, Thousand Litres

Year	Rate of Growth to Percent 5	7	9.5
1978	146,496	164,057	188,441
1979	153,821	175,541	206,343
1980	161,512	187,829	225,946
1981	169,588	200,977	241,762
1982	178,067	215,045	270,915
1983	186,971	230,098	296,652
1984	196,319	246,205	324,834
1985	206,135	263,439	355,693
Total Increase 1978-1985	40.7	60.6	88.7

The demand of each milk product (butter and ghee, cheese and various powders) will be projected separately, then the converted milk equivalents will be aggregated to estimate the total liquid milk. This method would however, require knowledge of the level of consumption of each type of milk product in the base year and its income elasticity coefficient but these data are not available. We could also convert all forms of consumption of each product to the liquid milk form and utilize the income elasticity for milk and products to project the aggregate demand for milk.

The consumption of the major dairy products is shown in Table 6-8.

Table 6-8. Consumption of Milk Products in Kenya, 1969/70 to 1974/75, Metric Tons

Year	Butter	Ghee	Cheese	Casein	Condensed Milk	Milk Powder
1969/70	2,151	521	290	14	NA	2,809
1970/71	2,168	353	256	13	267	3,110
1971/72	2,216	390	307	11	217	3,258
1972/73	2,142	442	312	14	178	3,693
1973/74	2,191	532	309	15	153	2,915

Source: Kenya Dairy Board, 1975.

The per capita consumption of the major dairy products could be computed from Table 6-8. The per capita consumption of butter has almost stabilized at 0.20 Kg per head per year. Cheese is a luxury commodity which is consumed by high income groups. Ghee (clarified butter) is used for cooking especially by the Asian community who, being vegetarians, do not consume animal fats. It faces stiff competition from vegetable fats and animal fats. The demand for whole and skim milk powder has grown at about 5 percent per annum.

Table 6-9 indicates the projections of the demand of liquid milk necessary to manufacture butter, cheese, condensed milk and milk powders to meet the domestic market requirements over the 1978-85 period. The figures were obtained by converting the projected quantities of the various products into their milk equivalents. It was assumed that half of the milk powder and all casein are derived from whole milk and butterfat. Butter derived from standardization of fluid milk at 2.3 percent butterfat will be exported. Cheese and

ghee are also assumed to require whole milk. The milk requirements for ghee may be underestimated because relatively large amounts are manufactured in rural areas and consumed locally.

Table 6-9. Domestic Demand for Milk Products (Milk Equivalents), 1978-1985, Thousand litres

Year	Butter	Milk Powder	Ghee	Condensed Milk	Cheese	Total
1978	63,357	22,749	11,804	811	4,141	102,862
1979	66,525	23,887	12,394	851	4,348	108,005
1980	69,851	25,081	13,013	894	4,565	113,404
1981	73,344	26,335	13,664	939	4,794	119,076
1982	77,011	27,652	14,347	985	5,033	125,028
1983	80,861	29,035	15,065	1,035	5,285	131,281
1984	84,904	30,486	15,818	1,086	5,549	137,843
1985	89,149	32,011	16,609	1,141	5,827	144,737
% Change 1978-85	40.7	40.7	40.7	40.7	40.7	40.7

For demand projections the income elasticity of demand was assumed to be 0.41 as determined in the 1969 household budget survey (33). The population growth rate was assumed to be 3.5 percent per annum while growth of per capita income was taken to be 4 percent per annum. This gives an overall growth rate of 5.1 percent per annum for the demand of dairy products. The projections were therefore made at 5 percent per annum.

By combining Tables 6-7 and 6-9 the total domestic demand for

milk and milk products is obtained. The total quantity demanded is compared to the supply projection derived in Chapter IV. The combined results are shown in Table 6-10. The demand for manufacturing milk is held at an overall growth rate of 5 percent per annum while demand for fluid milk is allowed to grow at 5, 7 and 9.5 percent. The total demand at these alternative levels is presented as low, medium and high.

Table 6-10. Domestic Supply and Demand for Milk and Milk Products, 1978-1985, Million Litres

Year	Supply	Demand (Liquid + Manufacturers)[1]		
		low	medium	high
1978	346.7	249.4	266.9	291.3
1979	363.6	261.8	283.5	314.3
1980	381.3	274.9	301.2	339.4
1981	399.8	288.7	320.0	360.8
1982	418.8	303.1	340.1	395.9
1983	439.3	318.2	361.4	427.9
1984	460.4	334.2	384.0	462.7
1985	482.4	350.9	408.2	500.4

[1]See text for definition of low, medium and high.

Table 6-11 shows the potential surplus of liquid milk available for export as fluid milk and manufactured products. The high projection corresponds with the low demand in Table 6-10 and vice versa. If the low level of domestic demand prevails potential surplus for exports will remain at substantial levels. The amount of exports are moderate at the medium projection rates. If domestic

demand remains high as indicated in Table 6-10 the potential surplus will be very small and would disappear in the early 1980s. In times of adverse weather the surplus available for export could be expected to disappear since supply may fall by 10 to 20 percent. Even in 1978 the surplus at the low projection level is only 15.9 percent of total supply.

Table 6-11. Potential Milk Surplus for Exports, 1978-1985, Million Litres[1]

Year	High	Medium	Low
1978	97.3	79.8	55.4
1979	101.8	80.1	49.3
1980	106.4	80.1	41.9
1981	111.1	79.8	39.0
1982	115.7	78.7	22.9
1983	121.1	77.9	11.4
1984	126.2	76.4	-2.3
1985	131.5	74.2	-18

[1]See text for definition of low, medium and high.

If the high surpluses are realized they may constitute a serious burden on the dairy industry but if the low level of surpluses materializes domestic self-sufficiency will be threatened. Declining surpluses indicate that Kenya's export potential for milk and milk products would be curtailed which would help reduce the burden of exports that have to be undertaken at a loss. In 1984 milk production

under low projections is below domestic requirements. Measures to increase production are needed to meet domestic requirements or imports would have to fill the gap. The government of Kenya could employ various instruments to stimulate greater production. The supply response analysis in Chapter V can be used to guide government policies to stimulate milk production. Since the elasticity of supply is known the effect of a given producer price for milk could be anticipated. The price should provide adequate incentives for producers and thus help in generating the quantity of milk desired. Since a combination of policy instruments is more effective than a single instrument all the other technical issues discussed in Appendix II should be simultaneously employed.

Summary

The chapter analyzed the demand and supply of milk over the 1978-85 period. The results show that the demand for milk with respect to its price was inelastic but it was elastic with respect to income. The domestic demand has increased despite substantial price increases. Projections of demand were made covering the 1978-1985 period. These projections were compared with supply projections derived in Chapter IV in order to determine Kenya's ability to maintain self-sufficiency in milk and milk products and to determine whether Kenya could continue to be a net exporter of dairy products. It was shown that if a high level of domestic demand prevails a deficit of milk and milk products will arise in 1984. To maintain self-sufficiency would require adequate measures to increase production or it will be necessary to import dairy products.

CHAPTER VII

SUMMARY, POLICY IMPLICATIONS, AND AREAS FOR FURTHER RESEARCH

Summary

This study was designed to contribute to a better understanding of Kenya milk subsystems including milk production, marketing and consumption and international trade in dairy products. The specific objectives of the analysis were to: 1) analyse the supply of commercial milk from the national dairy herd and project the supply to 1985 under alternative assumptions, 2) evaluate the supply response of smallholder milk production in the central Province of Kenya by means of parametric linear programming in order to derive guidelines for increasing smallholder milk production in the country, 3) determine income and price elasticities through the use of time series data, 4) estimate the consumption of milk and milk products using income, population growth and other explanatory variables, 5) analyse the results of supply and demand projections and determine optimal pricing policies, and 6) assess Kenya's ability to continue as an exporter of dairy products.

Kenya's dairy herd is composed of indigenous zebu, grade and exotic cattle. The zebu cattle play a minor role in commercial milk production. In 1975 the large-scale farms, settlement farms and small-scale farms (non settlement) account for 33.8 percent, 23.9

percent and 45.3 percent of the grade cattle herd, respectively. The dairy development stragegy of the Kenyan government calls for increased emphasis on smallholder production.

The analysis of milk marketing was made within the industrial organization framework of structure, conduct and performance of the Kenya milk subsystem. Performance was measured by the criteria of efficiency, progressiveness, product suitability, participant rationality and the soundness of government regulations.

Seventy-five percent of Kenya's milk production is disposed off in non-formal markets with most of it used for subsistence consumption. Only 25 percent of the total milk production enters the formal market (the known commercial market). The dominant organization is the KCC, a bilateral monopolist (monopolist - cum - monopsonist) which handles 96 percent of commercial milk. It operates all the major dairy plants in the country except Mariakani, and has a monopoly on the milk distribution in all the major towns of Kenya--the scheduled market. The Mariakani milk scheme (MMS) and other licensees of the Kenya Dairy Board (KDB) share the other four percent of commercial milk market. The MMS plant at the Coast is operated by the Kwale-Kilifi Co-operative Union with assistance from the Ministry of Agriculture. The KDB is the regulatory board for the dairy industry and the KCC is (theoretically) its appointed agent. Since the abolition of the quota system of milk pricing the importance of the KDB has been reduced and its effectiveness in controlling the KCC is dubious. The control of the dairy industry remains one of the fundamental problems of the dairy industry. The KCC is a producer controlled co-operative as well as a private company with strong

monopoly powers. The KCC lobby is very strong but attempts to exercise greater governmental control have not been successvul. Administrative pricing was adopted in 1970. The government of Kenya sets both producer and consumer prices. The system of administrative pricing was analyzed and it was found that the pricing system is largely responsible for a number of problems in the dairy industry. For example, the uniform producer price does not take seasonal variation in costs of milk production into account and hence it accentuates seasonality in milk production. Since the producer price is also uniform over space it does not encourage efficient allocation of resources. The pricing system has also created difficulties for the KCC because it is required to accept all milk irrespective of whether a profitable market exists. This is especially true during the wet season when luscious pastures generate excess supplies of milk. Sales of fluid milk are used to subsidize manufactured dairy products for domestic consumption for exports. Exports outside East Africa are subsidized in order to dispose of available supplies. The fluid milk consumers pay the export subsidy indirectly through higher fluid milk prices because the government of Kenya does not subsidize the dairy industry. However, high fluid milk prices curtail consumption especially for the low income groups. Since the domestic market is limited a greater expansion of imports would imply lower producer prices at least in the long-run unless the government reverves its policy and provides an export subsidy.

The supply of milk was analysed in order to determine the major factors influencing output and to project the supply of milk under alternative assumptions over the 1978-1985 period. Presently

smallholder dairy yields are approximately 1000 litres per year as compared with over 2000 litres on the better managed smallholder farms in Kenya. The reasons for low lactation yields on smallholder dairy farms include poor management, poor feeding, poor pasture management, overstocking, little supplementary feeding, poor disease control, failure to use the best genetic material including AI and long calving intervals.

Projections of the supply of commercial milk from smallholders and large-scale farms and for the 1978-1985 period were presented under various assumptions about the milk yields of the zebu and grade cattle herds, production by the large-scale, and small-scale settlement and non-settlement farmers. The zebu herd was assumed to grow at two percent per annum while the grade herd was presumed to grow at 5.3 percent per annum. The total supply of commercial milk was estimated to grow at five percent per annum over the 1978-1985 period compared with actual growth of 4.6 percent per annum during the 1968-1973 period and the 1974/78 Plan projections of 6.8 percent per annum.

Static linear programming (LP) was used to analyse the economic organization of small-holder farms in the Central Province of Kenya in order to determine the potential effects of resource reorganization and increased supply of operating capital on farm income and milk supply. The Central Province was selected because it is a leading small-holder milk production area and the results of the case study should shed light on the supply response of small-holder producers in other parts of the country. The data used for the LP analysis were the average resource quantities and input output coefficients, yields and prices constructed from the Integrated Rural Survey of the

CBS and were supplemented by published and unpublished data from various sources including the District Farm Guidelines of the Ministry of Agriculture. To estimate the optimum plans, an average farm was selected for each agro-ecological zone and assumed to be representative of farms in that zone. The LP models were then solved under existing resources, prices, technology and variable levels of milk price. The LP models were formulated to maximize farm income subject to meeting food and milk subsistence requirements of the rural household.

The LP results reveal that the optimal reallocation of existing resources under prevailing technologies and prices would result in substantial increases in farm income. The increases were 17.3 percent, 14.5 percent, 7.2 percent for the coffee, tea and high altitude zone respectively compared with actual incomes. The MVPs of operating capital were high in all zones when compared with the cost of capital implying that increasing this resource would increase farm incomes. The MVPs of labor were high during peak periods which suggests that hiring extra labor would increase farm incomes during these periods. Land was an important constraint in the coffee zone at the 1974/75 product prices but was not a constraint in the tea and high altitude grassland (HALTG) zones.

The cropping patterns under optimum LP plans in the Central Province were not specialized because of the imposed condition of meeting minimum food and milk consumption of the rural household. Pyrethrum was not specificially competitive to enter any of the optimal plans in the tea and HALTG zones. An increased supply of operating capital led to the dominance of the dairy enterprise in

all zones. Parametric linear programming analysis was used to derive a supply function for milk in order to determine the pattern of smallholder milk production response to alternative prices of milk and capital. The supplies of milk generated at different levels of milk prices and capital were used in a regression analysis to derive a continuous supply function for each zone. Point elasticities were computed from the fitted functions. The supply of milk was more responsive to increases in operating capital than to increases in milk prices. The supply elasticities with respect to milk prices were 0.67 for the HALTG zone, 0.18 for the tea zone and 0.38 for the coffee zone. The corresponding elasticities with respect to changes in operating capital were 1.88 for HALTG zone, 1.52 for the tea zone and 1.61 for the coffee zone. All the elasticities were calculated at the mean. All the farmers in the province do not respond at the same rate.

The consumption of milk and milk products is widespread in Kenya. Milk is a part of the traditional diets of nearly all Kenyans. The majority of small farmers and pastoralists have always produced some milk for consumption and for sale. Milk consumption is only a luxury for the very poor and in areas where cattle keeping is impracticable. Milk is very important nutritionally for the children who get priority in milk consumption within the family.

There is very little data concerning the informal market and the analysis was devoted to commercial demand. The price and income elasticities of domestic demand of milk were determined by fitting a demand equation using time series data for the 1962-1975 period. The data used in the analysis were restricted to the formal market and

the time period was 14 years, 1962-75. The R^2 of the fitted equation was high suggesting that independent variables explained a high proportion of the variation in demand for milk. Point elasticities with respect to milk price and income were computed and found to be -0.65 and 1.18 respectively. The domestic demand for milk is price inelastic but is elastic with respect to income. The analysis of demand also used income elasticity estimated derived from the 1968-69 Household Budget Survey for Nairobi, Mombasa and Kisumu. Since the data were limited scenario analysis was also used.

The annual domestic demand for fluid milk was projected to grow at 5, 7 and 9.5 percent for the 1978-1985 period, allowing for varying growth rates of population and income. The annual domestic demand for dairy products was projected to increase at 5 percent for the same period. The total domestic requirements of liquid milk to meet the demand for fluid milk and milk products were compared with the supply projections for the same period. An assessment was then made of Kenya's ability to maintain self-sufficiency in milk and milk products.

If the low growth rate (5%) of domestic demand prevails over the 1978-85 period Kenya will remain self-sufficient in milk and milk products and substantial milk supplies would be avaialble for export. However, expanded exports would become a heavy burden for fluid milk consumers. If, on the other hand, the high growth (9.5%) of domestic demand prevails imports would be required by 1984. Given the erratic nature of Kenya's weather imports could be required earlier should dry weather occur prior to 1984.

Policy Implications

According to the performance measures used in this study the KCC and Mariakani Milk Scheme have been progressive in producing substantial quantities of high quality dairy products such as pasteurized milk, butter, various powders, ghee etc., and packaging them in convenient sizes. On the whole the products sold are those desired by the consumer. The only problem is the limited choice of fluid milk. The only fluid milk available from the KCC is standardized at 2.3 percent butterfat. Whole and skim milk are not available except in the form of dry powders. The availability of these products only in powdered form restricts the choice of consumers who may be willing to pay for them in liquid form. The supply of fluid skim milk could be important in urban areas sicne the price of half a litre of milk has exceeded the price of the standard bottle of soft drinks for the first time since 1977.

An increase in nutrition knowledge should help consumers make use of pasteurized milk. The widespread practice of boiling pasteurized milk lowers the nutritive value of milk and negates the purpose of pasteurization. Overall the various participants of the milk subsystem have largely been rational. The producers, for instance, have increased milk production in the wet season when the costs of production are low and have reduced supply in the dry season when costs are high as a result of the uniform pricing system.

Government administered prices have not been efficient. Efficiency in pricing cannot be achieved without flexibility which permits (a) seasonal variation of producer prices to account for variability in costs of production (b) spatial variation in prices in

order to promote efficient allocation of resources, and (c) frequent revision of the producer prices to ensure adequate incentives for farmers and revision of consumer prices to ensure reasonable consumption of milk and to facilitate efficient operations for the KCC. The setting of both producer and consumer prices without careful analysis of KCC operational costs and overhead creates financial problems for the KCC and does not allow it to perform efficiently. The established price must be realistically related to production costs and to consumer demand. The KCC operations have not been as efficient as they could have been given the pricing problems. The KCC has also not exploited fully the potential efficiency that could be derived from the national organization of dairy plants. The Mariakani Milk Scheme suffers a substantial over capacity which lowers efficiency of its operations. Some co-operative societies are efficient in terms of low costs of operation, high quality products and high pay-out to the members. Other co-operatives have serious problems in marketing of dairy products. The problems include high costs of handling a small volume of products, low pay-out to members, inadequate training and misappropriation of funds.

There is an urgent need to reduce the extreme seasonality of milk production in order to reduce surpluses in the flush season. The elaborate system of quota pricing that existed prior to 1970 ensured adequate supplies in the dry season but is not feasible today given the large number of smallholders who produce milk for sale. A higher producer price for milk in the dry season, however, could be effected without quotas. Prices paid to farmers should be made on the basis of a clearly stipulated and well understood formula

relating the KCC milk intake to sales of fluid milk and manufactured products. A guaranteed dry season bonus could be coupled with a floor price for all seasons and an ex-post payment depending on the proportion of fluid milk that is marketed in the dry season. When milk is scarce in the dry season a high proportion is sold in the fluid form which is more remunerative to the KCC and hence farmers could be paid more. By contrast, in the wet season a high proportion of milk intake is manufactured and sold in this less lucrative form. The weighted average of fluid and manufactured products would approach the minimum price during the wet season. Since the industry operates on a pooling system this pricing system is feasible and implies a reintroduction of a net realization pricing system.

The possibility of introducing a spatially differentiated price should be reexamined along the lines of the recommendations of the Kibaki Commission. There is ample precedent (by KCC) and economic justification for producer prices that vary over space. The benefits are likely to outweigh the advantages of the present pricing system.

Current pricing of milk only requires a minimum content of 3.5 percent butterfat. There is no incentive to produce milk of a higher butter content. A basic price could be paid for milk of 3.5 percent butterfat content with an additional payment for a higher percentage or a deduction for milk below 3.5 percent. While the problem of testing for butterfat content is recognized, the butterfat content could be tested on a sample base in conjunction with other qualitative tests. In the long-run payment on the basis of protein content or solids not fat (SNF), should be considered since protein is the major deficiency in local diets.

The domestic demand for fluid milk is price inelastic. This rationalizes the practise of maintaining high fluid milk prices to subsidize manufactured dairy products. Milk pricing tends to favor producers at the expense of consumers. The degree of exploitation of fluid milk consumers by producers through the KCC remains a controversial issue given KCC's monopoly powers. However it is fairly obvious that present policy limits the consumption of milk by low income consumers and by the nutritionally vulnerable group--especially young children.

There is a need to expand the domestic demand for milk and to ensure an adequate supply in all seasons except during periods of drought when imports may become necessary. During the normal dry season shortages could be obviated by proper marketing arrangements such as sales of UHT milk derived from the wet months and increased output resulting from higher prices being paid during the dry season. The KCC could also explore the possibility of supplementing the available supply with reconstituted milk. Since the demand for fluid milk increases slightly during the dry season, increased sales during the dry period could lead to increased returns. The increased returns could then be used to subsidize manufacturing activities during the flush season (inter-seasonal subsidy). The possibility of a government subsidy on milk for school children might be examined.

The results of milk the supply response analysis for the Central Province showed positive elasticities with respect to milk prices in the three zones and suggest the magnitude by which the price of milk could be manipulated to achieve milk production. Smallholders are responsive to price incentives targets. The producer price of milk

should be related to the prices of competing products such as maize, wheat and pyrethrum. Seasonal considerations aside, the present level of milk price appears satisfactory but greater flexibility in pricing is required. Instead of following the present policy of adjusting producer prices every three to four years the author recommends an annual review of producer milk prices and annual price adjustments if necessary in order to generate an adequate supply of milk to meet domestic consumption and optimize exports. Since higher prices for producers imply high consumer prices and reduced consumption the trade-off of alternative price levels must be taken into account. Exports are also a source of valuable foreign exchange but without government subsidy the greater the volume of exports the higher will be the consumer prices in order to recoup losses from exports. A reasonable level of exports must be maintained to ensure fair prices for consumers and self-sufficiency in times of adverse weather.

The results indicated that an increase in operating capital has a high potential for increasing milk production because it was shown that the milk supply response elasticities were higher with respect to changes in operating capital than to changes in price. This suggests that credit policy should be carefully designed to provide operating capital and to complement pricing policies.

Historically Kenya has exported milk to the East African countries but with the collapse of the East African community Kenya is now exporting milk to the middle East, Ethiopia and Djibouti. If the domestic demand for milk grows slowly Kenya will have a large potential export surplus and it will have to aggressively search for

international markets. Kenya could ill afford costly subsidies for the dairy products. However, if Kenya does not subsidize dairy exports like France does in Mauritius, she will lose the market. The value of foreign exchange generated from dairy exports must be related to the real cost of domestic resources. If the domestic demand expands by 9.5 percent per year milk exports will be eliminated by 1984. Given the great uncertainty in weather some surplus production of milk will have to be planned in order to ensure adequate supplies for domestic consumers. The Kenya government policy of self-sufficiency in dairy products implies that some exports will be produced during periods of good weather.

A comprehensive policy for the dairy industry must address itself to pricing, marketing and production policies and institutional reforms. It is now recognized that sound marketing (and pricing) is necessary but not a sufficient condition for improved performance of a sub-system. Empirical studies of supply relationships of farm products in many countries indicate that changes in product prices typically (although not always) explain a relatively small proportion of total variation in output over a period of years (75). Short-run changes in supply are influenced by the weather and disease outbreaks, while long-run changes in supply are attributable to such factors as changes in technology. These and other factors that enable farmers to produce more are referred to as supply shifters. In a review of agricultural policies in developing countries Krishna concludes that the price variable is much less important than non-price factors--the shifter variables in supply functions (39, p. 516). The important components of a comprehensive dairy development program

for Kenya are as follows: the first relates to improved management and feeding. Improved pastures should be integrated with fodder crops and credit should be provided for the purchase of feedstuffs. The second aspect relates to the control of enzootic diseases, particularly tick-borne diseases in order to reduce mortality rates and hence the risks of keeping improved cattle. The third aspect pertains to artificial insemination service for the improvement of genetic potential of the national herd. Artificial insemination should be expanded as a part of a comprehensive dairy program. It is unlikely to succeed if enzootic diseases are rampant, husbandry practices are poor and a market for milk is unavailble. The fourth consideration is extension. An effective extension effort must be an integral part of a comprehensive dairy development stragegy. The fifth aspect is favorable prices for producers and fair prices for consumers. A large amount of research over the past 25 years has demonstrated that favorable prices can accelerate the diffusion of innovations, absorption of new inputs, utilization of idle capacity and institution adjustments. The producer price should be high enough to provide incentives for producers and vary spatially and seasonally. The consumer prices should not be too high to restrict consumption unnecessarily.

Areas for Further Research

This study illustrates the problems of estimating production, consumption and supply response in a developing country. One of the major problems relates to inadequate data. The cattle figures used in this study were based where possible on previous surveys,

large-scale farm reports and sample census reports on small-scale farms. In other areas they were based on informed judgments of livestock experts. Similar problems were encountered concerning milk yields per cow. It is therefore recognized that the projections are very likely subject to error and hence it is not claimed that they will coincide exactly with actual values that will be realized in the future.

There is an urgent need for improved data regarding size, composition, growth and productivity of the national herd. Improved statistical reporting service is needed in order to facilitate the analysis of the livestock sector. The milk production cost relationships for both the wet and dry seasons require further analysis in order to provide a guide to the establishment of a seasonally differentiated price. Improved data for rural and urban demand for milk and milk products is also required. These data could be generated by regular budget studies.

Other limitations of the study concerns the formulation of the LP models in the estimation of the supply response. The production of food crops (maize, beans, potatoes) was assumed to occur in pure stands rather than in mixtures. Other simplifying assumptions were perfect knowledge of prices, inputs, technology, and outputs and that the farmers' goal are to maximize profits. To the extent that these assumptions may not hold, the producers actual decisions may differ (sometimes markedly) from those indicating as optimal. The assumption of mobility of resources implying that they could be moved freely from one enterprise to another within the combinations specified in production plans may not hold unless the adjustment

period is very long. The land devoted to crops such as tea or coffee for instance, may not be available for other enterprises. On the other hand, it will be fairly easy to increase or reduce the size of the dairy herd by buying and selling cows. The computed supply elasticities were limited to the Central Province of Kenya and no valid probability or statistical statements could be made because the data do not meet the required assumptions of normality and independence. The use of the elasticities required caution and subjective judgments. They cannot be generalized to another area unless it duplicates all physical, economic and institutional constraints of the study area. This calls for replication of similar research in other areas in order to get a comprehensive knowledge of smallholder milk supply response for facilitating formulation of dairy policies. Some of these problems are associated with any synthetic method.

An important area of study that was not considered has to do with the locational aspects of the dairy plants and the associated aspects of optimization with respect to assembly distribution costs, plant costs and economies of scale. In addition to inflationary costs, there are allegations of shortcomings in KCC's management which are yet to be disproved and there are serious problems in the creameries. A careful study including costs, margins, profits and services rendered by the KCC should be made. This is perhaps the most urgent empirical investigation of the dairy industry.

Nonetheless this study provides many insights into the milk subsystem of the Kenyan economy. Further analysis and updating of the study can only improve its usefulness in developing government policy for the industry. The results are offered as a contribution

to improved performance of the subsector and the author hopes to continue studies in this area so that further improvement can occur.

APPENDICES

APPENDIX I

EXPLANATION OF ABBREVIATIONS USED IN LP MATRIX

APPENDIX I

Table 1A--Explanation of Abbreviations Used in LP Matrix

Resources (Rows)		
Row No.	Abbreviation	Complete Heading
1	LAND	Land in Hectares
2	OPCP	Operating Capital in Shs.
3	FLAB2	Family Labor in Cycle 2
4	FLAB3	Family Labor in Cycle 3
5	FLAB4	Family Labor in Cycle 4
6	FLAB5	Family Labor in Cycle 5
7	FLAB6	Family Labor in Cycle 6
8	FLAB7	Family Labor in Cycle 7
9	FLAB8	Family Labor in Cycle 8
10	FLAB9	Family Labor in Cycle 9
11	FLAB10	Family Labor in Cycle 10
12	FLAB11	Family Labor in Cycle 11
13	FLAB12	Family Labor in Cycle 12
14	FLAB13	Family Labor in Cycle 13
15	FLAB14	Family Labor in Cycle 14
16	PRMLK	Supply Milk
17	PRCOF	Supply Coffee
18	PRHMZ	Supply Hybrid Maize
19	PRLMZ	Supply Local Maize
20	PRPOT	Supply Potatoes
21	PRBEN	Supply Beans
22	BROPC	Supply Credit
23	CNMLK	Consume Milk
24	CNHMZ	Consume Hybrid Maize
25	CNLMZ	Consume Local Maize
26	CNPOT	Consume English Potatoes
27	CNBEN	Consume Beans
28	TCNSM	Total Subsistence Consumption

Table 1A. (Continued)

Activities (Columns)		
Column No.	Abbreviations	Complete Heading
1	HRL2	Hire Labor in Cycle 2
2	HRL3	Hire Labor in Cycle 3
3	HRL4	Hire Labor in Cycle 4
4	HRL5	Hire Labor in Cycle 5
5	HRL6	Hire Labor in Cycle 6
6	HRL7	Hire Labor in Cycle 7
7	HRL8	Hire Labor in Cycle 8
8	HRL9	Hire Labor in Cycle 9
9	HRL10	Hire Labor in Cycle 10
10	HRL11	Hire Labor in Cycle 11
11	HRL12	Hire Labor in Cycle 12
12	HRL13	Hire Labor in Cycle 13
13	HRL14	Hire Labor in Cycle 14
14	PRMLK	Produce Milk
15	PRCOF	Produce Coffee
16	PRHMZ	Produce Hybrid Maize
17	PRLMZ	Produce Local Maize
18	PRPOT	Produce English Potatoes
19	PRBEN	Produce Beans
20	SMLK	Sell Milk
21	SCOF	Sell Coffee
22	SCHMZ	Sell Hybrid Maize
23	SLMZ	Sell Local Maize
24	SPOT	Sell English Potatoes
25	SBEN	Sell Beans
26	CNMLK	Consume Milk
27	CNHMZ	Consume Hybrid Maize
28	CNLMZ	Consume Local Maize
29	CNPOT	Consume English Potatoes
30	CNBEN	Consume Beans
31	BROPC	Borrow Operating Capital

APPENDIX II

TECHNICAL CONSIDERATIONS IN INCREASING MILK PRODUCTION UNDER AN INTEGRATED DAIRY PROGRAM

APPENDIX II

TECHNICAL CONSIDERATIONS IN INCREASING MILK PRODUCTION UNDER AN INTEGRATED DAIRY PROGRAM

The appendix considers the technical and organizational aspects of dairy production and measures to increase milk production. It is recognized that marketing and pricing reforms are necessary but not sufficient conditions for improving the performance of the milk subsystem. An integrated approach is therefore necessary for the expansion of dairy production. Such a comprehensive approach requires that progress be made simultaneously on many fronts, including marketing and pricing, dairy breeding, nutrition, establishment and enclosure of pastures, disease control, extension etc. It has been shown that improved breeding alone can bring about an increase of three percent per annum of the total milk supply (26). Thus it is not only a question of increasing the numbers of dairy cattle on the land. It is also a matter of intensification by getting better quality and higher yields from the existing cows.

The priority measures to increase dairy output include artificcial insemination, management, feeding, pasture improvement, disease control and improved extension services.

Artificial Insemination (AI)

An effective AI program must be considered an integral part of a strategy for developing the dairy industry. Presently only 40 percent of the dairy herd is under AI. The other 60 percent is served by bulls some of which are low grade and are contributing to the down-grading of the national herd (50). In addition, only a paltry 1 to 2 percent of the zebu herd is reached by AI, hence the scope of expanding the AI program is very wide.[1] Although improved genetic potential may not be the principal variable explaining differences in performance between farms, it could be a major source of productivity growth in Kenya. It enables the small holder and large-scale farmer to develop a good quality breed while eliminating substantial costs incurred if quality bulls were kept to serve the entire herds. In addition, AI will overcome the problem of disease transmission, particularly venereal diseases such as trichomoniasis, vibriosis and epivaganitis. The major problem of AI concerns the efficiency, reliability and distribution to the farmer and his environment, including his ability to recognize oestrus and to take the cow for insemination, and the problems of getting the cow to the inseminator which may entail a long walk through tick-infested areas (26). These problems will mean prolonged calving intervals with concomitant reduction in yields in the long-run. Poor roads, vehicle breakdowns, improperly preserved

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[1] In some areas it is no longer a question of acceptance of AI but on of satisfying demand. In 1971 the charges for insemination were reduced from Shs 10 for up to three inseminations to 1 shilling per insemination. The subsidy involved may be discerned by the fact that average cost per insemination for all Provinces of Kenya was Shs 14.80 in 1970 and Shs 32.74 for Kiambu District for 2.2 inseminations per pregnancy. In 1973 it was Shs 10.63 per insemination in all provinces.

semen, poor insemination techniques could accentuate the problem. In 1976, there was an average of two inseminations per conception (50) which represented a major improvement from 2.5 inseminations per conception in 1968. Further increase in the non-return rate would mean that many more animals would be reached. AI should replace bulls wherever possible and should incorporate an effective progeny testing as a continuous check of the performance of the progenies.

Pastures, Fodder Crops and Feeding Improvements

Better management and effective feeding are warranted if the genetic potential of grade cattle and cross-breds is to be exploited. Improved animals and calves that are not properly fed are likely to present problems of fertility and yield maintenance and at times may even be less productive than the zebu stock.

The large-scale farmers own larger herds and the income derived from the dairy enterprise is large enough to warrant investment in grass leys and inputs such as feeds.[2] Culling eliminates the animals of low productivity. Many smallholders and settlement farmers have to struggle with low incomes and do not cull effectively. Even when AI improves the genetic potential they are unable to purchase feeds to make the most of their animals. The consequent tendency to overstock further reduces output levels.

The problem of low productivity per cow is related to poor quality pasture since few farmers operate an effective supplementary feeding program using concentrates. A majority of farms tend to suffer a

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[2]Some of the new owners of large-scale farms are having problems because grass leys are not being properly looked after.

shortage of feed in the dry season which is also accentuated by irregular calving intervals. In the dry season pastures cannot satisfy maintenance requirements of the cow leave alone production. the grass is high in crude fibre and low in protein. Even in the flush season when the pastures are luscious and grass often high in protein content, the moisture content of the grass is high and the dry matter content low so that the animal reaches satiety without adequate dry matter intake for maintenance and production. Supplementary feeding must therefore be provided for the high producers.

The most common grasses in the highlands is Kikuyu grass (Pennisetum clandestium) and star grass (Cynodon spp.) which occur naturally or are planted from splits. In the large scale farms Rhodes grass (Chloris guiana) and Guinea grass (Panicum maximum) are common in planted leys. Nandi grass (Setaria anceps) also occurs naturally in some parts of the highlands. There are some well managed pastures and leys in Nakuru, Uasin Ghisu and Trans Nzoia but there are also cases of poor management of Rhodes grass that make such pastures unproductive and uneconomic. In the medium and low potential areas Hyperrhenia grasses and Themenda triandra grow among acacia bushes.

To increase productivity of the pastures, the farmers have to regard pastures as crops and take care of them as such. Productivity of such crops can be increased by application of fertilizers especially in high rainfall areas where nitrogen is usually leached, and by including a mixture of grass species whereever feasible. Inclusion of legumes also increase the nutritive quality of forage by providing proteins and also incorporates nitrogen fixing bacteria. Several suitable legumes exist such as centro (Centrocema pubscens), Desmodium

(Desmodium uncinatum, and Desmodium intortum,) etc. The Kenya white clover (Trifolium repens) can be encouraged by suitable management practices such as application small doses of nitrogen.

Certain management practices especially rotational grazing will ensure an efficient cropping of pastures by the dairy animals while at the same time contributing to the control of internal parasites. Rotational grazing allows preservation of excess roughage in form of hay or silage and also facilitates the integration of crops of pastures through rotation. A few small farmers practice zero grazing.

The costs of establishing pastures are very substantial including land preparation, seed purchase and/or costs of fertilizers. While credit for other crops are available those for pasture establishment are not. One of the most common complaints of farmers was the almost ubiquitous lack of credit for pasture and fodder crops.[3] This is accentuated by the fact that credit for feed is also not readily available.

Fodder Crops

Fodder crops are attractive because they ensure high quality forage in the dry season thus permitting a regular level of nutrition during the dry months of the year and a steady production of milk. Since feeds generally represent a major share of the cost of production, the expansion of milk supply in the dry season will depend on a low cost means of feeding such as grass, fodder crops and silage. This type of feeding regime could raise milk yields, increase carrying capacities and reduce feed costs.

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[3]Personal communication, Deputy Head Planning Division, MOA.

Despite these advantages few farmers grow fodder. A majority of farms therefore continue to suffer from a shortage of dry season feed with the consequent reduction in yields. Napier grass (Pennisetum purpereum) is the most common fodder among smallholders. By products such as sweet potato vines, banana stems and maize stover are also used. Other grasses such as giant Nandi grass (Setaria splendinda) are also grown in its own right and as a by-product of soil conservation along terraces. In the large-scale farm areas maize is grown for silage. Other important fodder crops include lucerne, fodder beets, kale and oats.

Prompted by drastic declines of milk output in the dry season the District Development Committees (DDCs) for the Central Province allocated Shs. 350,000 in 1976 for the promotion of fodder crops and silage making.[4] Other provinces may want to emulate this experiment. There was a total of 28,443 hectares of fodder crops in Central Province in 1975.

Concentrates

Further utilization of genetic potential exceeding 2000 Kg of milk per cow per lactation is highly dependent on supplementary feeding. Natural grazing say Kikuyu grass or star grass cannot provide adequate digestible energy and crude protein to sustain output above 2000 Kg. (71). Even when pastures are luscious they can only meet

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[4]The allocation for 1976 was as follows (thousand shillings): Nyeri 200, Muranga 80, Kirinyaga 46, Nyandarua 89 and Kiambu 125. The Kenya Dairy Board is also planning a package program for improving forage production that will entail provision of credit for pasture improvement (personal communication, executive officer KDB).

requirements for maintenance and the first 4.5 litres of milk. Any further increase will require supplementary feeding. In the tropical parts of Kenya except the highlands the rate of herbage growth is usually very rapid but the forage is of low nutrition value. Thus another reason for supplementary feeding.

Large-scale farmers tend to use concentrates in a consistent manner. Small farmers on the other hand seldom feed concentrates. Some small-farmers use purchased factor waste e.g. brewery waste and pineapple canning waste.

Animal Health and Disease Control Programs

A successful disease control program is prerequisite for the expansion of livestock production and the up-grading of the national herd through AI. In most parts of Kenya except the arid North East enzootic tick-borne diseases are endemic and sometimes epizootic (epidemic). These diseases reduce meat and milk production, undermine the confidence of farmers, and contribute to substantial delays in adoption of grade cattle and up-grading of the indigenous zebu. The mortality losses[5] of grade cattle may impose a financial burden on farmers because 75 percent of AFC loans to small farmers are made for purchase of cattle. Thus disease control must proceed in conjunction with any genetic improvement of livestock.

The control of enzootic diseases in general and the tick-borne diseases in particular, is a Sine qua non for the introduction of

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[5] In some areas of recent grade cattle introduction mortality losses are fairly high and may reach up to 20 percent of the cows per year. (Second overall Evaluation of SRDP, 1976).

grade cattle in an area. The introduction of improved cattle where tick-borne diseases are not adequately controlled is a waste of valuable resources. Most of the contagious diseases are now largely controlled at relatively low costs through vaccination and quarantine. A disease like rinderpest which used to be a scourge of the herdsman has been virtually wiped out. Compulsory annual and free vaccinations are carried out every year against rinderpest and other diseases like anthrax, and blackquarter. The contagious diseases that remain are associated with poor husbandry practices. Some diseases could be reduced by improved husbandry practices especially those ones that are associated with common disorders of lactating cows such as mastitis.

The control of various diseases requires the education and cooperation of the farmer in addition to development funds. This is especially valid for the enzootic diseases where total eradicationis the goal. The existence of improved cattle with higher productivity capacities raises the economic returns to other services and programs such as disease control and clinical services. With these points in mind the problem of tick-borne diseases will now be discussed.

Tick-Borne Diseases

The most serious livestock diseases in Kenya are transmitted by ticks. The major ticks of great concern are the Brown Ear Tick (Rhipicephalous appendiculatus), the Tropical Bont Tick (Amblyomma variegatum), the Blue tick (Boophilous decoloratus) and Riphicephalous evertsi which has red legs. The diseases transmitted include East Coast Fever (ECF) or Theileriasis (caused by Theileria pava) Red Water or Babesiosis (caused by Babesia bigemina), Anaplasmosis

(Anaplasma marginale), Heart Water (Rickettsia ruminantum) and several other diseases. Ticks and tick-bites are also implicated in the spread of spirochaetosis and streptotrichosis which reduce the value of hides.

The most serious disease affecting cattle in East Africa is East Coast Fever, a disease which is confined to the coastal belt and the hinterland of East Africa[6] except in the arid North East. Rhipicephalous appendiculatus and A. variegatum do not occur in areas where the rainfall is less than 725 mm. but they survive from sea level to 2500 metres altitude. Rhipicephalous appendiculatus is the main vector of the causitive agent of ECF, Theileria parva, a haemo protozoon. Other ticks will transmit the disease under laboratory conditions but in the field it is clear that they do not do so. The disease is transmitted when an animal which has T. parva in its blood is parasitised by nymphal R. appendiculatus which feed on the infected blood. The nymphs drop off and feed on another healthy cow which will contract the diseases (unless it is already immune like the local zebus). The disease is usually fatal to the grade and exotic stock which have not been exposed to it since birth. A mortality of 90 percent is usual but at times it may reach 100 percent. At present there is no known drug or vaccine which will cure ECF and the only course open to the farmer is an indirect and preventive one through tick control. In calves the mortality is only 20 to 50 percent during the first year and the survivors obtain a long lasting immunity.

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[6] ECF is only found in Southern and Eastern Africa from the Sudan and Ethiopia, South to the Cape Province of the Union of South Africa.

In its only vector R. appendiculatus, the disease is not transovarian, i.e. an effective female cannot transmit the disease through the ovary. There is no carrier state of survivors. In 1973 about 5000 cases of ECF were confirmed by microscopic examination while in 1975 1,087 cases were reported in Central Province alone.

Anaplasmosis is the second most important tick borne disease with mortalities of about 50 percent and decreased productivity of survivors. The primary vector of the disease causing organism, Anaplasma marginale is Boophilus decoloratus. Anaplasmosis and Red Water (Babesiosis) are very similar in their epizootiology and therefore, the two will be treated together. The primary vector of the Red Water disease causing organism, Babesia bigemina, is also the blue tick B. decoloratus. Usually the calves are attacked early in life (the first 6 months or so) and normally the reactions are mild for healthy calves of all breeds. After the disease has run its course, a state of premunity results and cows are carriers of the disease and potential reservoir of infection. Morbidity only tends to reassert itself when animals are under stress (e.g. drought and hence scarce grazing). The animals that escape infection are highly susceptible as adults. Since most animals are premune to both diseases and because Red Water and Anaplasmosis are transovarian in the primary vector only a few ticks need survive to perpetuate the disease. The tick B. decoloratus is more widespread than R. appendiculatus and hence the disease is more widespread. In 1973 11,000 cases of anaplasmosis were confirmed in the country. In 1975 2,302 cases were recorded in Central Province alone. It is estimated that 28 percent

of all AI produced calves die of tick borne diseases.[7]

The Bont Ear Tick, Amblyomma variegatum is the vector of Rickettsia ruminantium, the causitive agent of Heart Water (Rickettsial disease). The disease is fatal to cattle and sheep but fortunately the tick is not very widesperad and hence the disease is not very common in Kenya.

The disease transmission in all ticks is fairly general. Eggs are laid in the ground, hatch into larvae and then attach to a host. The larvae become nympths and the nymphs become breeding adults and after sucking blood the adults become gouged and fall off, lay eggs and then die. The whole process takes several weeks, and may involve, one, two or three hosts depending on the species.

While cultivation or burning of pastures may play a part in tick control, effective tick control is dependent on the regular application of acaricides which may be composed of arsenicals, chlorinated hydrocarbons or organophosphates. The acaricides are administered in water by means of hand sprays,[8] spray races or dips. Dipping is considered to be the most effective and practicable on a wide scale. In addition, dips are the most economical in the use of acaricides.[9]

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[7]The calf mortality rates has serious implications for the rates of upgrading the national herd.

[8]Hand spraying is rather slow, requires a great deal of hard physical labor and water has often got to be carried to the crushes. However, it is practical for the small farmer with a few animals. It may also be very useful whenever quarantines may be imposed and communal facilities inaccessible.

[9]The dips have additional benefits of providing forums where farmers can exchange information with veterinary staff and are also convenient places for clinical services, innoculations, castration of bull calves and AI.

Once dipping programs are initiated they must be sustained otherwise the disease risk will become greater because the animals would have lost the chance to acquire immunity that comes from continuous exposure to tick bites. If sprays or dipping standards decline, the disease susceptible herd could suffer high mortalities.

In addition, a poorly executed or partial control program will expose ticks to doses that are non-lethal and thus contribute to accelerate the development of acaricide resistance in the tick population.[10] Resistance to acaricides has tended to appear wherever acaricides have been used.

To ensure that tick control measures are maintained the government has designed and gazetted certain areas as "Cattle Cleansing Areas." The relevant law makes tick control compulsory[11] with the object of complete eradication of ticks and disease free zones. Virtually all the important grade cattle areas have been gazetted "tick free zones."

Experiences with Tick Control in Kenya

The large-scale farms and ranches have had privately owned and operated dipping programs for many years. Some areas in North East have no appreciable tick problem. In all other dairy cattle areas

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[10] This has already occurred in Australia and some other countries where ticks are resistant to all known acaricides.

[11] As with other mandatory requirements the problem becomes one of enforcing compliance. Farmers found with ticks on their cattle could be prosecuted but such cases are rare or non-existent. Education and persuasion may be a more efficient method than coercion. Also the owners of zebu cattle have no incentive to dip or spray since their animals are largely resistant to tick borne diseases.

tick-borne diseases are endemic. Efforts to control ticks in small-holder areas in the past have been desultory and effective control is a fairly recent phenomenon.

There are about 2,500 dips in the small-farm areas which have been largely built through Harambee (self-help) or co-operative effort,[12] including some grants from District Development Committees (DDCs). Since 1969 and with the aid of Danish Government an additional 600 well constructed and standardized 3,000 gallon dips designed to handle 500 to 1000 cattle weekly have been built in 16 districts at a cost of Shs 20,000 each (26). It is essential that the dip bath be maintained at the proper strength in order to ensure the lethal dose for ticks and hence prevent emergence of acaricide-resistant ticks. Acaricide resistant ticks would be a severe problem and would require changes in other acaricides which may be more expensive than those that are already in existence.

The dips are generally run by dip committees of elected representatives of dairy farmers in each locality. A dip attendant is employed to collect money from farmers either annually or at each dipping. The money collected is used to purchase acaricides and to pay the dip attendant. The cost to the farmer varies but is usually about 25 to 50 cents per cow per dipping. The veterinary staff are expected to monitor dip strength and to investigate ticks for acaricide resistance so as to facilitate the substitution of acaricides.

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[12] Dip construction has generally proceeded at a rapid pace. Where a well-functioning dip exists in an area, there has been great enthusiasm to raise funds for construction of dips in neighboring areas. This represents a genuine awakening of farmers to the problems of tick-borne diseases, administrative exhortation and the provision of matching funds for construction of dips.

Hopcraft et al. (26) report that the increase in the number of dips has resulted in a virtual explosion of the grade cattle in some districts like Muranga, Meru, etc. In others there has been a considerable decline in the reported incidence of ECF and Anaplasmosis. An average decline of 40 percent decrease is quoted in dips financed by Danish aid. The actual decrease might be greater because disease reporting is becoming more efficient with the increased availability of microscopes and personnel.

In some areas adequage dips do not exist and consequently farmers have to rely on individual sprays. In other areas despite the presence of an adequate number of dips, the incidence of tick-borne diseases has been rising instead of declining. The problems of dip management and maintenance[13] are responsible for this. While some county councils have subsidized tick control programs, others have regarded dip collections a source of revenue without purchasing the appropriate amounts of acaricides.

Regular dipping makes the acaricide concentration progressively weaker as the animals remove some of the acaricides. Once the dip bath is under strength a vicious cycle sets in. Even farmers who would like to dip their animals cease to bring their cattle, and since the number of cattle falls, financial problems increase and the dip deteriorates. In some areas veterinary staff do not bother to collect dip samples because they already know beforehand that the

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[13]The main problems in many areas include weak management committees and generally poor organization, a shortage of available funds with which to buy acaricides and misuse of funds or materials by the committees or dip caretakers.

dips are hopelessly under strength.[14] This occurs in defiance of 'Cattle Cleansing Areas' legislation that requires mandatory tick control.

Problems also arise from the success of the dip programs. At the initiation of a dipping program there is a dramatic improvement that manifests itself in rapid growth and gain in weight, less scarred skins, drastic reduction in calf mortality and lactating cows increase milk output. A general improvement in herd health tends to prevail. The improvement in herd performance provides an incentive for an enthusiastic reception of the dipping program and farmers bear the costs of dipping willingly. As the number of ticks decline the farmers tend to lose interest in regular dipping especially when cash is in short supply.

Other problems arise because of differential returns to dipping of zebu and grade cattle. Ownwers of grade cattle and other susceptible stock have a strong incentive to use dips to avoid deaths. On the other hand, owners of indigenous cattle do not have such an incentive since their stock is not equally susceptible and they are therefore unwilling to bear the costs of dipping. The existence of undipped cattle makes it difficult to protect the dipped cattle despite efforts of double fencing. The owner of traditional cattle are being asked to pay the costs while the benefits largely accrues to others. This appears to be an externality problem. The dipping

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[14]For instance, in 1975 a total of 1894 dip tests were carried out in Central Province. Of these 45% were under strength, 42% were over strength and 7.4% were unsuitable outright while a meagre 3.6% were just right. (Annual Report of Central Province, 1975). In 1974 50 percent of all dip samples from all over Kenya that were analysed at Kabete were under strength.

problem has a far greater return in a given area than to the owner by making it possible to introduce grade cattle whereas the indigenous cattle can survive without dipping. In other words a divergence between private and social net marginal returns exists justifying public participation or subsidy. The control of tick-borne diseases is a public good because the entire society benefits from greater milk and meat production and the resultant lower prices than would normally prevail without disease control. To solve the problem of the control, the Veterinary Department should operate the dips and ensure proper concentration of acaricides.[15] A charge could be made or the financing be effected through general taxes or from cesses on milk and cattle sales. It is clear that the financial and managerial problems of tick control are unlikely to be solved by legal compulsion, advice or exhortation.

There is an important problem associated with tick control. This concerns pollution problem and demands greater attention than it has hitherto received. The weekly dipping of cattle in organochlorides, organophosphates, arsenicals etc. has polution implications given the residual toxicity that could last for more than three days on the cow. This may taint milk and thus find their way to the consumer with potentially hazardous results. Adequate monitoring of toxic compound

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[15]This has been accepted in principle and a detailed proposal has been completed. The Kenya Government has launched a K£ 1 million plan to stamp out cattle diseases. The MOA has begun taking over dips in Nyeri, Muranga, Kirinyaga, Meru, Kisii and Kakamega and plans to spend K£ 800,000 on acaricides by the end of 1978. One thousand and thirty dips will be taken over in Phase I and all dips in the campaign areas will be taken by 1982 (Farmers-Voice, official Journal of Kenya National Farmers Union, August 1977. Peter Moll Publishers, Nairobi).

levels in milk and milk products should be maintained and the use of compounds with high residue toxicity should be banned.[16] The KCC in conjunction with the Kenya Bureau of Standards and the Veterinary and Medical Departments should monitor this problem.

Other Diseases

In addition to tick-borne diseases foot and mouth disease constitutes another threat. Outbreaks of the virus disease poses constant problems in many cattle areas. Often strict quarantines are required in attempting to confine the disease to the particular localities wherever an outbreak occurs.[17] In addition, compulsory vaccination campaigns are mounted but at times they may be thrown out of gear by the veterinary staff trying to cope with temporary outbreaks. The problem of ECF and Anaplasmosis and other tick-borne diseases may be exacerbated by outbreaks of foot and mouth diseases. On farms where the disease is absent the farmers are afraid of driving their cattle to the dips lest the animals contract the foot and mouth disease. It may be necessary therefore to maintain individual control measures under cases of such an emergency.

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[16]Some acaricides had to be withdrawn partly because they were becoming increasingly ineffective and also because they were traced in cows and human blood and also in milk.

[17]The Kenya National Farmers Union meeting of April 1977 revealed how very worried farmers were regarding livestock diseases and illegal animal movements . . . the subject of livestock diseases and illegal movements is once more on agenda. There again one knows what the problems and solutions are. The necessary laws exist to deal with the situation but they are not enforced effectively (emphasis mine). And so the whole situation is getting worse and worse and causing great losses to the farming industry and our whole economy. (Kenya Farmer, April 1977, English Press, Nairobi). This also prompted an editorial comment in one of the leading daily newspapers, The Standard (Nairobi) supporting the farmers in their concern.

Trypanosomiasis, the tsetse fly vector borne disease is enzootic in some cattle producing districts. As in ECF no cure for the disease is known to date and only preventive measures directed towards eradication of tsetse flies. Thus routine prophlactic measures are carried out in the highly infected areas. Meanwhile investigation and research on all important diseases continue unabated under the general supervision of Ministry of Agriculture mainly at Muguga and Kabete Research Centers.

Veterinary and Clinical Services

Clinical services to the livestock sector are complementary to the disease control programs that are in existence. By treating individual animals and through provisions of immunizations and vaccinations against diseases, and by helping reduce or overcome fertility problems, calving difficulties etc. clinical services are beneficial to the farmers. The coverage by veterinary surgeons is very thin on the ground but their maximum use and by maintaining effective supervision of the junior staff clinical services could be improved.

A plan to provide clinical centers in the high potential areas where veterinary coverage has been low is undergoing implementation. In 1975 for instance six centers were already operational and three more were scheduled to be completed by mid 1976. The clinics are associated with AI centers and are equipped with a laboratory for the microscopic diagnoses of various diseases, in addition to a post mortem room. The veterinary officer in charge also makes field trips depending on the density of grade cattle. The health services are heavily subsidised and usually vary depending on the complexity

of the problem, on whether surgery is performed, the costs of drugs or vaccines, and on whether a visit is made to the farm.[18] The number of cases investigated may reach 700 per month at the initiation of the service but usually declines to a lower level. The clinics also collect statistics relating to incidence of diseases and other problems.

While some problems exist regarding efficiency of the service, supplies of drugs, timeliness of response etc. none of them appear unassailable. The major hurdles have been overcome and the clinics are proving their worth by providing the farmer a vital service.

Extension

Improved productivity of the smallholder dairy farming requires greater extension contact with farmers. The Kenya government provides extension services through the Ministry of Agriculture.[19] An effective extension service is expensive and difficult to organise because of the large number of smallholders. A variety of methods are employed including visits to individual farms, demonstration or model farms, farm field days, and the use of mass media. Short courses are conducted for farmers in the various Farm Training Centers.

The existing extension service tends to concentrate on the better or more progressive farmers who also seek after extension agents.[20]

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[18] The subsidy element is at times as high as 90 percent. The changes are usually Shs 3, 10 or 30 per cow.

[19] Extension Services account for the largest share of recurrent expenditure of MOA (32, p. 206). There are 5,500 extension workers for about 1.7 million farmers or 1 extension agent to 310 farmers.

[20] See, for instance, Ascroft Joseph et al. (1973) Extension and the forgotten farmer. Bulletin 37, Dept. of Social Sciences, Wagennigen Agricultural University.

As it has expanded it does not appear to have increased in effectiveness. The model farm has also been criticised for being too expensive and for misallocating resource to too few farmers who also get special privileges such as special access to credit and grants. These make the demonstration effects doubtful. The level and adequacy of training of extension agents has also received substantial amount of criticism. The level of competence of the lower echelon need to be upgraded through in-service training. The support services including moral and material support, and supervision has to be beefed up if extension service is to remain a viable instrument of dairy development. The cost of extension could be reduced by relying on mass methods. The 1974/75 Plan calls for a policy of increased emphasis of the methods that involve a large number of farmers (32, p. 206).

Summary

The chapter presented a brief discussion of the factors that need to be considered in the formulation of an integrated program of dairy development. Often there is a tendency to over-emphasize pricing policies while neglecting to consider technological changes, extension etc. An effective dairy development will require integrated policies including animal health and disease control, management, foods, pasture improvements, credit and extension. These were examined in the chapter.

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