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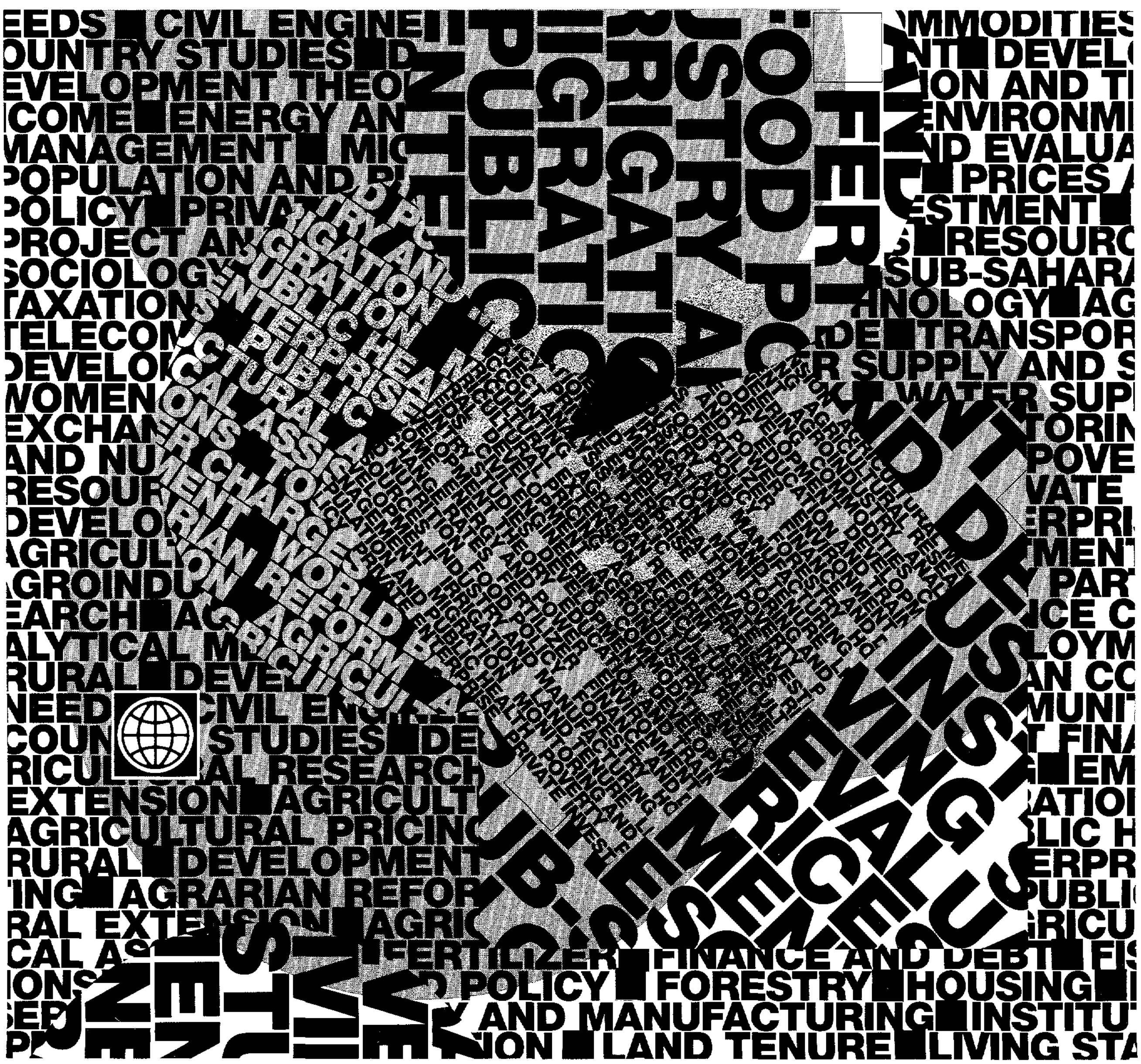
Dairy Development in Sub-Saharan Africa

A Study of Issues and Options

Michael J. Walshe, John Grindle, Arend Nell,
and Marc Bachmann



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ABSTRACT

Rapid population growth and urbanization is creating a strong demand for milk in Sub-Saharan Africa (SSA) and the majority of countries have the potential to meet the growing demand by developing their domestic resources.

This study provides an overview of dairying in SSA and discusses the principal constraints to development as well as the experience gained from some earlier initiatives. It analyzes the main biological, technical, economic and institutional issues, and summarizes the opportunities and options for future dairy development. Appropriate strategies and policies are suggested and estimates are made of the investment requirements to meet future demand for dairy products. Some implications for donor agencies are also considered.

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PREFACE

This paper presents the results of a study by the Agriculture Division of the Technical Department, Africa Region, the World Bank. The study is part of a broader program of research to identify future directions for livestock development and resource management in Sub-Saharan Africa. It is intended to provide guidance for all those working in livestock planning for Africa in the World Bank, in other donor agencies, in NGOs and in the countries. The study and its review have been closely coordinated with FAO, ILCA, ILRAD and other bilateral donors working with dairying in the field. The Irish, Dutch and Swiss Consultant Trust Funds supported the study by contributing funding for consultants to undertake field work, review the literature, produce working papers and assist in the report-writing and review.

The short to medium term prospects for economic growth in Africa depend critically on expanding the production of agriculture and livestock. The volume of dairy imports more than doubled during the 1970s and reached US$705 million in 1980, but they have since fallen (to US$536 million in 1987) under the influence of higher world prices and more realistic exchange rates. This study shows that more than half the countries in Sub-Saharan Africa -- with about three-quarters of the human population -- have substantial potential for dairy development. The areas include most of the Eastern region, a large part of the Southern region and parts of Nigeria. The potential in much of Central and Western Africa is limited by the prevalence of tsetse and trypanosomiasis in the humid and subhumid agro-ecological zones.

The study describes the evolution of dairying in Africa and deals with the growing market's opportunities for development. It deals with the physical, technical, economic, social and institutional constraints and recommends appropriate strategies for tackling them. The challenge now is to implement these strategies so that widespread smallholder dairy development can improve the welfare of farmers in the short to medium run -- and become a catalyst for sustainable economic growth in the long run.

Ismail Serageldin
Director, Technical Department
Africa Region, World Bank

ABBREVIATIONS

AI	-	Artificial Insemination
AFS	-	Australian Friesian Sahiwal
AMZ	-	Australian Milking Zebu
CBPP	-	Contagious Bovine Pleuro-pneumonia
CCPP	-	Contagious Caprine Pleuro-pneumonia
ECA	-	African Alternative Framework to Structural Adjustment Programs
F1	-	First Filial Generation
GDP	-	Gross Domestic Product
IDF	-	International Dairy Federation
ILCA	-	International Livestock Center for Africa
ILRAD	-	International Laboratory for Research on Animal Diseases
LDC	-	Livestock Development Center
PPR	-	Peste des Petits Ruminants
SSA	-	Sub-Saharan Africa
SMP	-	Skim Milk Powder
TDN	-	Total Digestable Nutrients
WFP	-	World Food Program

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ANNEXES:

SUMMARY AND CONCLUSIONS

1. This study provides an overview of dairying in Sub-Saharan Africa (see map) the principal constraints on development and experience with some earlier initiatives. It analyzes the principal biological, technical, economic and institutional issues and summarizes the opportunities and constraints in different areas. Appropriate policies are recommended, and estimates are made of the investment requirements to meet future demand for dairy products. Finally, some implications for donor agencies are considered.

OVERVIEW OF DAIRYING IN SUB-SAHARAN AFRICA (CHAPTER I)

2. The livestock subsector accounts for about 18% of agricultural GDP in SSA, with milk contributing 20% to 25% of this (an estimated $1.75 billion in 1987). Reported milk production (excluding camels) has increased at an average annual rate of 2.5% over the period 1970-88, but (with few exceptions) this has resulted from increased numbers of animals rather than from higher productivity. The Eastern Region accounts for three-quarters of reported production, with Sudan alone accounting for one-quarter. It is estimated that cattle provide 56% of total milk production, sheep and goats 23% and camels 21%.

3. Dairy products supply under 2% of calories and almost 4% of protein in the average human diet in SSA, and they account for an estimated 11% of food production by value. Average per capita consumption has fallen from 30 kgs (whole milk equivalent) in 1970 to 27 kgs in recent years; this ranges from 56 kgs in the Eastern Region to 9 kgs in the Central Region. These variations are a direct consequence of different production levels, only partly offset by net imports. It is estimated that 90% of consumption is in milk form, fresh or soured, with relatively little production of dairy products -- mainly cheese, butter and ghee. Only a small proportion of total production enters formal marketing channels (as low as 10% in Nigeria, Sudan and Tanzania).

4. The volume of imports of dairy products more than doubled during the 1970's. Imports accounted for almost a quarter of total consumption by the early 1980's, but they have since fallen back significantly. Depressed world markets and overvalued exchange rates ensured that imported products were relatively cheap, despite the imposition of high import duties in some countries. Dairy product food aid accounted for about 6% of total consumption on average, but for some countries it provided from one-quarter (e.g., Benin and Ghana) to one-third (e.g., Rwanda and Somalia). Supplies of food aid have now fallen to under half the peak levels of the mid-1980's.

5. Much of the investment in the livestock sector (other than in indigenous animals) over the past two decades has been financed by foreign aid, but this aid, at just over 1% of the annual value of output, was too small to have a significant impact. The designs of livestock projects were often grandiose and unrealistic, especially considering the scarcity of qualified and experienced staff. Management has been the single most important factor governing the success or failure of dairy projects, whether

at the farm, institutional or national level. The emphasis of some donors has now shifted from a one-sided technocratic approach to livestock management to an integrated approach to agricultural development, in the context of appropriate market regimes and pricing policies.

PRODUCTION SYSTEMS AND THE EVOLUTION OF DAIRYING (CHAPTER II)

6. Five livestock/milk production systems are recognized and described: pastoralism, agro-pastoralism, mixed-farming, intensive dairy farming and peri-urban milk production. The potential to increase milk output from pastoralist and agro-pastoralist systems is limited; only seasonal surpluses are available, and the costs of collection, processing and transportation are high. Mixed and intensive dairy farmers in rural and peri-urban areas have more control over their inputs and have the potential to increase milk production per cow, per farm and per unit. The unit cost of supporting services (e.g., input supply, animal health and marketing) will decrease as milk production increases.

7. The normal evolution of dairying in Africa has been markedly influenced by the colonial experience and its aftermath. The influence has been negative insofar as the emphasis shifted from smallholder dairy development to large commercial farms -- initially expatriate but later mainly parastatal. The positive legacy is the specialized dairy breeds introduced, the research and demonstration on dairy production and management and the establishment of input supply, artificial insemination, extension and milk collection services. Few African countries, with the notable exception of Kenya, have been successful in switching emphasis to smallholder dairy development and combining the relevant parts of the pre-independence experience into strategies aimed at smallholders.

8. In Africa, liquid raw milk can be distributed by the farmers themselves or by private vendors at very low cost because labor is cheap. In contrast, the costs of processing and distributing milk in (imported) containers are high and are not competitive except in the limited high-income markets where consumers can afford this luxury. Pasteurization is not essential for public health reasons since consumers in most parts of Africa generally boil raw milk before it is consumed; otherwise they consume sour or fermented milk. Chilling, pasteurization and/or other processing can be justified only if milk has to be transported long distances to city markets from remote milk-shed areas.

9. The principal opportunities for dairy development arise from a growing market (due to population growth and urbanization), a large livestock population and related husbandry skills. The principal constraints result from the environment (physical and economic) and from technical and social/institutional problems. The technical constraints include feed and nutrition, genetic structure, animal health problems, management at all levels, water shortage and the availability of appropriate technologies. Undue reliance has been placed on transferring technology rather than generating it within Africa. Support services and institutions are particularly weak. There are large seasonal fluctuations in production while demand is relatively constant.

LIVESTOCK RESOURCES (CHAPTER III)

10. Local cattle breeds are well adapted to the tropical environment, but their genetic potential for milk yield is too low to support investments in commercial dairying. Crossing with exotic breeds is widely practiced in order to increase the potential without running the risk of disease and other risks associated with the use of imported breeds. However, the proportion of the total cattle herd in Africa that has been significantly affected by deliberate genetic change is probably less than 3%. Improvement of the genetic potential of the cattle can increase production, but only where feed production, animal health services and the management skills of the farmers have also been improved. A shortage of suitable dairy animals is a major constraint on dairy development in most countries.

11. To obtain the best performance, the genetic potential of the cow should be about 30% above the yield level that the production environment can support. On this basis, the following types of animals (genotypes) are recommended for dairying in different production environments:

- high production (over 4,000 kgs): pure dairy breed or 75% cross;
- medium production (3,000 to 4,000 kgs): 50-75% dairy cross or synthetic;
- low production (1,500 to 3,000 kgs): 25-50% dairy cross or synthetic breed; and
- very low production (under 1,500 kgs): 25% dairy cross, native breed or synthetic breed.

12. The design of a breeding program involves many elements, including:

- the role and function of imported breeding stock;
- the roles to be played by natural mating and/or artificial insemination (A1);
- the design of an effective AI service;
- the role of heifer and bull production farms;
- the design of a selection/breed improvement program; and
- the development or strengthening of agencies to undertake these tasks.

13. Although experience to date with services in many African countries has been negative, AI must continue to play a key role since upgrading would otherwise be very slow. It is a legitimate public sector function to invest in the initial establishment and demonstration of the service, but once this is done there should be full recovery of operating costs from the users. The establishment of an AI service is an adaptive research function that

should be entrusted to the national research agency. The agency should have subsequent responsibility for producing semen, training inseminators, and assisting in the design of delivery systems and in problem-solving, but the the agency should not have a mandate to run the general AI service. The delivery of the service to farmers should be left to their own organizations, to private veterinarians or to private inseminators.

14. In addition to low milk yields, traditional production systems are characterized by low calving and weaning rates, high mortality, late age at first calving and long calving intervals. Poor performance on these traits is directly related to the low prevailing levels of nutrition and management; thus considerable improvement is possible in a relatively short period. Feasible reductions in age at first calving and in calving intervals could increase milk production and calf numbers by up to 50%.

FEEDS AND FEEDING (CHAPTER IV)

15. Nutrition is a more significant constraint on increasing milk production in SSA than is the genetic potential, but there is a strong interaction between "dairy merit" and the economics of feeding. Natural pasture is the principal source of roughage, but it is inadequately nutritious and would rarely support milk yields of over 3 to 4 kgs per cow per day; cultivated forages can sustain yields of up to 8 to 10 kgs under good feeding and management conditions.

16. In arid areas, with rainfall of less than about 400 mm/year, there is no cost-effective technology at present for improving dry matter production or quality. Leucena and some stylos can make an important contribution to feed production where rainfall is 400 - 600 mm. For areas with rainfall between 600 and 800 mm, a number of improved grass strains and forage legumes are available, but there is limited experience with them under African conditions. In the rainfall belt between 800 and 1,200 mm, the options include improved grasses, pasture legumes, and tree legumes and shrubs; they are likely to be introduced mainly on mixed crop/livestock farms. There is good potential for forage production in the humid and sub-humid zones, where the rainfall is in excess of 1,200 mm, and particularly in the highland zone.

17. Concentrate feeds for dairy animals are less expensive and less difficult to procure than those for pigs and poultry as they do not require such high energy and high-quality protein ingredients. In practice, about one kg of concentrates will be required per incremental kg of milk; thus the economics of concentrate feeding calls for a milk:meal price ratio greater than one. At present the ratio is much greater than this in most countries. Concentrate feeding to animals with adequate dairy merit is a viable proposition.

ANIMAL HEALTH (CHAPTER V)

18. The distribution of tsetse flies, the vector of Trypanosomiasis, has played a major role in the distribution of livestock in SSA (e.g., only 4% of the milk is produced in the humid zone, which covers 18% of the land area). The milk production potential of trypanotolerant cattle is low, so

their role in commercial milk production systems is limited. The use of insecticide-impregnated screens now offers a cost-effective, non-polluting and flexible method to control tsetse flies. It also enables farmers to participate in control schemes. Some combination of trypanocidal drugs and tsetse control will be needed to protect dairy animals. Regular vaccination against Contagious Bovine Pleuro-Pneumonia (CBPP), Foot-and Mouth Disease and Rinderpest is also essential.

19. Ticks are found in all areas of SSA that are suitable for livestock production, but new control techniques (e.g., simplified acaricide treatment by pour-on formulations or slow-release implants) are being developed. Protection against the principal tick-borne diseases is now available through premunization (by artificial infection and treatment), but it is not yet applied on a large scale. The availability of an immunization procedure against East Coast Fever, in particular, should open up possibilities for increased milk production, but the technology is still complicated and expensive to deliver.

20. The safest way of controlling pathogens in dairy products is through proper heat treatment of the milk and prevention of contamination thereafter. This need not involve an expensive process like pasteurization but simply boiling by the processor and/or consumer. In fermented products, the survival of pathogens is affected not only by heat but also by other factors (e.g., acidity, control of temperature during manufacture and storage, salt concentration and maturity of product).

21. Animal health services represent an estimated 80% of the budgets for all livestock services. Because of externalities and economies of scale, governmental involvement in the funding, enforcement and supervision of mass vaccination campaigns is necessary and justified. Unlike preventive care, curative services are predominantly private goods. In other words, the value derived from a clinical or curative veterinary visit goes almost entirely to the owner of the livestock. Milk producers in particular will have the necessary income and the greatest incentive to avoid lost production from disease. The privatization of veterinary services can take place either through individual practice, farmers' associations or formal cooperatives.

COLLECTION, PROCESSING AND MARKETING (CHAPTER VI)

22. Modern dairy development and milk processing did not evolve gradually in SSA from the traditional systems, but dual (formal and informal) systems developed. Past efforts to improve dairy supplies and processing have focused largely on the establishment of large-scale centralized plants to meet the liquid milk demand of urban dwellers. Because of low milk production levels, inadequate collection systems, and unattractive prices for locally produced milk (relative to subsidized or free imports), these plants have relied heavily on imported materials for reconstitution and recombination to meet the market demands.

23. Liquid milk is usually the preferred, and most profitable, product, but the combination of hot, humid climates, poor hygiene on the farms and difficult transport conditions leads to rapid deterioration of milk quality in rural collection systems. The small milk quantities produced, seasonal

supply and poor infrastructure in many parts of SSA make such collection systems difficult to operate and uneconomical. Thus the stimulation of efficient on-farm or village-level processing offers a better approach to dairy development in many areas. Depending on the products to be manufactured, plants based on relatively simple equipment can cope with a daily milk intake of up to 1,500 to 3,000 kgs; the management of such plants is likely to be within the capabilities of local communities.

24. At current international prices, the landed price (CIF) of the raw materials for recombination is equivalent to 25 US cents per kilo of milk; internal transport, handling costs and an allowance for losses add another 5 cents. This brings the total costs to 30 cents per kilo, double that of two years ago. The increase is correspondingly greater for countries that have devalued in the meantime. Even if world prices were to fall to half their current levels, the import parity price would still be of the order of 17 cents, but there would be a substantial premium (25% to 50%) for fresh milk. Thus a local milk price of 20 to 25 cents (converted at real exchange rates) per kilo would be consistent with long-term world prices.

25. Capital and operating costs of milk collection and processing are substantial. The investment cost (including collection and other support facilities) in large-scale facilities is $100 to $150 per kilo of installed capacity, but the level of capacity utilization is often low. At moderate levels of utilization, the processing/marketing costs would be on the order of 15 to 20 cents. Thus a margin of around 75% over raw material costs would be required. The processing margins of parastatal dairy plants have often been tightly squeezed, ostensibly to protect consumers, but with the ultimate effect of creating losses that required public funding.

26. Parastatal companies, which provide most of the large-scale processing capacity in SSA, face the same problems as other public enterprises (e.g., political interference in management decisions). The dairy subsector would be an obvious candidate for selective privatization since it is clearly a nonsocial service and nonstrategic sector. Management has also been a recurrent weakness in cooperatives because of technical shortcomings and confused objectives (social and commercial). It would be better in many cases to allow less formal communal institutions to evolve, as has happened in local food processing and brewing, for example.

27. Appropriate training is even more important for dairying than for other agricultural processing activities because of the perishability of the products and the resulting hygiene risks and marketing problems. Future development in processing implies a shift from traditional methods to new science-based technologies, but this can be a step-wise process, building upon existing techniques and skills. Since traditional milk processing and marketing are carried out by women in many parts of Africa, training must be made available to them and must respond to their needs.

DEVELOPMENT POTENTIAL, PRIORITIES AND SUPPORT REQUIRED (CHAPTER VII)

28. Given the poor prospects for growth in per capita incomes, FAO projections indicate that average consumption levels of dairy products will remain at around 27 kgs (whole milk equivalent) until the end of this

century. However, the annual increase of 15 million in the human population will generate a demand for an extra 400 million kgs of milk each year; some part of the 2 million tons of imports might also be replaced by local consumption. The bulk of the increased demand will be in urban areas, but it will continue to be a relatively low-income market, requiring simple (but safe) products at low prices. The principal demand will continue to be for fluid milk, much of which will be supplied through informal channels.

29. Over half of the countries in SSA, accounting for about three-quarters of the human population, have substantial potential for dairy development. The natural development of the industry has been distorted in recent times by the dumping (or donation) of dairy products at highly subsidized prices and by overvalued exchange rates that further depressed prices of imported products. The large adjustments in exchange rates in recent years, combined with developments on the world market, have made imported products either very expensive or unavailable, thus favoring substitution by local production. However, there are few areas in SSA where an Operation Flood approach to dairy development could be successfully applied since the milk volume is too low to support an elaborate marketing and processing structure.

30. Policy often has not been coherent, exchange rate policy has overridden sector-specific policies; consistency is needed in relation to import policy and the pricing of imports, including food aid. There is little argument on either strategic or distributional grounds for government interference in the marketing or pricing of locally produced dairy products. Human health and hygiene standards are clearly of major importance, but they are best addressed through prevention and education rather than regulation.

31. Dairy development requires a long lead time (10 to 20 years), to improve husbandry, nutrition and processing, to disseminate improved stock on a widespread basis and to build up viable and sustainable support institutions. The initial emphasis must be on the expansion of milk production and on developing small-scale local processing and trade in dairy products. Experience in most parts of the world has shown that milk production, in view of the labor and personal attention required, is best suited to smallholders.

32. Inadequate and inefficient support services have been major constraints on dairy development, which requires not only additional inputs but also increased knowledge and improved management capabilities. Within the framework of a unified extension service, it is still necessary to provide intensive support for particular high-value commodities, and milk is one of them. Livestock Development Centers (LDCs) have proven to be one appropriate institution for concentrating support services and farmer training. Producers should subsequently take over the responsibility and funding of the services, but they must first build up their own institutions (e.g., farmers' associations and cooperatives).

33. The dearth of reliable information on existing dairy industries, especially in the large informal sectors, highlights the need for area-specific studies on production and consumption patterns and local collection/processing/marketing systems. There is a large reservoir of

scientific and technical research that African countries can draw upon and adapt to their own unique circumstances. What is now required is adaptive research, taken through to the development and pilot project stage, and with the full participation of farmers in the formulating of priorities and the monitoring of performance. Research priorities have been identified for the different components; one research station should be given responsibility for dairy research, from production through processing to marketing.

34. In order to keep pace with demand, milk production will have to grow by some 0.5 million tons per annum. This will call for additional on-farm investment (mainly in improved livestock) of $300 million per annum. On the assumption that most of the increased output will be handled by the informal sector, the investment required in processing/marketing will rise to over $40 million per year when existing capacity is fully utilized. In addition, investment on the order of $160 million per annum will be needed in support services. Thus total investment would be around $500 million per annum, with an import content of 25% to 30%. External sources might provide up to $180 million (including monetized food aid of at least $30 million); the remaining two-thirds ($320 million) would come from the farmers themselves, local financial institutions and governments.

35. Dairying in SSA is worthy of donor support as an integral part of rural development. If implemented on a smallholder basis with dispersed local processing, it can generate widespread incomes and employment. Over 100,000 full-time equivalent jobs could be created in production and processing and many more in support services. As the emphasis switches to a decentralized approach, based on smallholders and local processing, the "process approach" to project design will be more appropriate than the traditional "blueprint approach." Given the lack of basic data (especially on markets) in many cases, it will often be necessary to start with pilot projects. There is a need to draw together the lessons of experience from past projects for the benefit of the African countries and the financing agencies.

I. OVERVIEW OF DAIRYING IN SUB-SAHARAN AFRICA

Introduction

1.01 The origins of dairying -- milking livestock as a source of human food -- are lost in antiquity. Dairying is the underlying basis for pastoral systems worldwide where nomads traverse rangelands in search of feed and water for their livestock (cattle, camels, sheep and goats). Unlike farming peoples, pure pastoralists did not grow crops but relied entirely on their animals for food and clothing. Pastoralism flourished on Sub-Saharan Africa's rangelands, which although harsh are either free from or less afflicted by major human and animal pests and diseases (e.g., mosquito/malaria, tsetse/trypanosomiasis) than are areas of higher rainfall.

1.02 Dairying is a biologically efficient system that converts large quantities of inedible roughage to milk, the most nutritious food known to man. It is a more efficient and intensive system, in terms of nutrients and protein production for human consumption from a given area or quantity of feed, than is beef or sheep farming. As human populations on fixed land resources increase, pressure increases to utilize the land more efficiently. In addition, the income elasticity of demand for dairy products remains high over a wide range of incomes. Thus the market grows steadily as societies develop. Where conditions are suitable, dairying is preferred to beef production since it makes more efficient use of feed resources and provides a regular source of income to farmers. It is also much more labor intensive and supports substantial employment in production, processing and marketing. However, milk production often requires the introduction of new breeds of cattle, as well as increased levels of inputs, improved management, curative veterinary services and good marketing facilities. Thus intensive dairying is confined to areas with good infrastructure close to major markets, but less intensive forms, such as dual purpose (milk and beef) systems, can develop in other areas.

1.03 Although science and technology have transformed traditional dairy farming over the past half century in the developed world, this transformation is at an early stage in SSA. In Africa dairy development is more difficult because the constraints and problems are more severe. However, the potentials and opportunities are there, and the current economic climate is much more conducive to indigenous production than in the past. This report analyzes the biological, technical, agricultural, economic and institutional aspects of dairy development in Africa; the actions required to increase milk production, which is the main challenge, are outlined.

International Context

1.04 Africa accounts for just over 2% of world milk production, the bulk of which is produced in Europe (East and West), Asia and North America. The principal exporters of milk products are the EEC, New Zealand and the United States, with the European Community typically accounting for up to half of the total. Only about 5% of world milk production is traded internationally. Thus world prices are highly vulnerable to small changes in either supply or demand in the principal producing areas. High guaranteed support prices for domestic producers in many industrialized countries, combined with controls on imports and subsidization of exports, have distorted international trade and prices.

1.05 The high guaranteed prices and advances in technology have led to the rapid growth of milk output in many countries, while demand has stagnated or even declined. Large surpluses became available for export, often at highly subsidized prices, and world prices remained low for much of the past two decades. The introduction, and progressive tightening, of milk quotas in the EEC has led to a two-thirds reduction in the export surplus. Similar measures in the United States further reduced export supplies, as did drought in New Zealand and the United States. The result was an initial trebling of world prices followed by a fall-back from those high levels. For example, world prices of skim milk powder (SMP) rose from under $600/tonne (f.o.b.) in 1985 to around $2000 in early 1989 and fell back to $1650 in early 1990.

1.06 In the medium to long term, milk yields in the industrialized countries are expected to increase because of lower feed costs and technological changes. There may also be some relaxation of production controls in the EEC and United States, while the price support programs are maintained. Thus supplies are expected to increase substantially, while domestic demand stagnates. Offsetting pressure could come from increased demand in the developing countries (including the oil exporters). In addition, the continuing shift away from butter production toward cheese could lead to slower growth in skim milk powder production and upward pressure on prices. On balance, another cycle of lower prices is projected for the early 1990's. However, current trade negotiations should lead, in the long term, to an international trading regime for dairy products that involves lower subsidies, freer trade and higher world market prices. Simulations of the effects of total trade liberalization in dairy products (World Bank 1986) indicated that export volumes could treble and world prices could rise by two-thirds.

Livestock Output

1.07 The output of the livestock subsector (excluding draught power and manure) accounts for about 18% of the agricultural GDP in Sub-Saharan Africa (valued at $7.7 billion in 1987). Milk makes up 20%-25% of this, thus contributing around $1.75 billion. In effect, livestock production leads to a number of joint products: milk and meat, plus draught, manure, hides, etc.

1.08 Estimates have also been made of the economic value of draught and manure. The table below summarizes the relative contributions of different outputs to the gross value of livestock production. Milk accounted for 15% on average, ranging from 9% to 17% in the different regions.

Table 1.1 Relative Contributions to Livestock Production

(Percent of Gross Value of Output, 1975)

Region	Meat	Milk	All Other
Eastern	38	17	45
Western	56	11	33
Southern	58	9	33
Central	79	12	9

Source: Anteneh, et al, 1988.

1.09 Data on the contribution of different livestock products to net farm income are scarce. Except for small samples of farms, few reliable estimates are available for output prices and production costs. The Kenyan experience shows that milk can be a major contributor to farm income. For the smallholders in the Dairy Development Project, the dairy enterprise contributed some 57% on average of net farm income in 1986/87. For Kenyan farmers as a whole, milk sales earned almost as much income in 1987 (K Pounds 62 mln) as maize sales (K Pounds 68 mln). Livestock products can make an important contribution to farm incomes even in intensive cropping areas; they account for 30%-40% (depending on the enterprise) of farmers' net incomes on the Gezira irrigation scheme in Sudan.

Production of Dairy Products

1.10 The number of cattle, sheep, goats and camels in each country/region in Sub-Saharan Africa are summarized in Annex 1 and the milk production figures in Annex 2. These estimates are derived from FAO statistics, which depend upon the data collected in each country. Since the bulk of milk production in most countries of Sub-Saharan Africa is for subsistence consumption or for informal local markets, reported figures must be regarded as rough estimates rather than measured quantities. Estimates of the production and consumption of milk from smallstock are particularly unreliable, while data on camel's milk are not normally available. (FAO production figures are for cows, sheep and goats only; the figures for camel milk have been calculated from the animal numbers and a widely used estimate of average production). It is estimated that sheep and goats produce around 23%, camels 21% and cattle 56% of total milk production (Annex 2).

1.11 According to FAO figures, production of fresh whole milk (excluding from camels) in Sub-Saharan Africa increased at an average annual rate of 2.5% over the period 1970-88, to reach almost 10 million tonnes. (Camels would contribute an additional 2.7 million tonnes, at the rate of 200 kgs per head -- equivalent to some 1600 liters per lactation, over and above calf requirements). The high growth rate reported for sheep milk (Table 1.2) appears to result more from changes in data collection than from real changes in production.

Table 1.2 Milk Production, 1970 and 1988

Source	1970	1988	Growth Rate (%)
Cows	4961	7061	1.8
Sheep	369	1197	5.8
Goats	1031	1739	2.1
Total	6361	9997	2.5

Source: FAO Production Yearbooks.

1.12 Although individual countries have recorded high rates of growth in the volume of milk marketed, this must be attributed in many cases to a change in marketing channels (e.g., from informal or subsistence marketing to commercial) or to recovery from drought or political upheaval. Total reported production in Kenya and Malawi, which are regarded as success stories, increased by less than 1.5% per annum over the period 1970-88, but the volumes marketed through official channels rose sharply. Although the volume of milk marketed in Zimbabwe grew rapidly in recent years (by 7% per annum on average), total reported production has only now regained the 1970 level. In Tanzania, total production fell by one-third over the same period. In contrast, the reported production figures for Ethiopia, Nigeria, and Sudan show average growth rates ranging from 2.0% to 3.3%, but marketed volumes did not increase substantially.

1.13 The Eastern region (9 countries) includes only 30% of the human population but accounts for three-quarters of all reported milk production (Table 1.3). On the other hand, West Africa (16 countries) has over 40% of the population but produces only 15% of the milk. The Southern region (11 countries) and Central region (8 countries) account for almost 30% of the population and only 10% of milk production. Sudan alone contributes over one-quarter of the recorded milk production, while other significant producers are Somalia, Kenya, Ethiopia, Tanzania, Uganda, Nigeria and Zimbabwe.

Table 1.3 Milk Production by Region/Country, 1988
('000 MT)

	COWS	SHEEP	GOATS	TOTAL	%
EASTERN	4959	1053	1410	7422	75
Of which:					
Sudan	1750	580	530	2860	29
Somalia	550	378	640	1568	16
Kenya	1015	29	82	1126	11
Ethiopia	814	66	95	975	10
Tanzania	448	-	63	511	5
Uganda	378	-	-	378	4
WESTERN	1071	141	294	1506	15
Of which:					
Nigeria	360	-	-	360	4
SOUTHERN	720	-	13	733	7
Of which:					
Zimbabwe	225	-	-	225	2
CENTRAL	311	3	22	336	3
Of which:					
Angola	148	-	-	148	1
Total	7061	1197	1739	9997	100

Source: FAO Production Yearbook 1988.

Demand for Dairy Products

1.14 For the subcontinent as a whole, livestock products supply 5% of total calories in human diets -- 20% for countries such as Somalia and Sudan -- and 15% of total protein; they provide around one-third of dietary calcium. On average, dairy products supply just under 2% of calories and almost 4% of protein. However, given the high money value of these products (resulting in part from their high nutritional value), they account for an estimated 11% of food production by value (Mbogoh 1984). In rural areas consumption of milk and milk products is heavily influenced by livestock ownership/herding, but in urban areas, in particular, the principal determinant of consumption levels is income. For example, in Zambia, the Food Strategy Study (1982) estimated that the high-income groups, comprising 30% of the population, consumed about 65% of the dairy products available.

1.15 The aggregate demand for dairy products in Sub-Saharan Africa increased steadily during the 1960's and 1970's. The consumption of milk and milk products grew at an estimated 2.1% per annum (Mbogoh 1984). The demand growth resulted from rapidly rising populations, urbanization and some increase in per capita incomes. The income elasticity of demand for milk was estimated to be about 0.8, but it varied from 0.5 for the Sahel countries to 1.1 in Central Africa. In general, expenditure on dairy products constitutes a small part of total household expenditure; for example, it is around 2% for urban areas in West Africa (Seyoum 1988). In some countries, government policies fueled demand through consumer subsidies and the overvalued exchange rates that encouraged cheap imports from depressed international markets.

1.16 Average per capita consumption of dairy products remained relatively stable at around 30 kg per annum during the 1970's, but the proportion supplied by imports increased from 9% to 23%. Since then imports have been cut back (to around 18% of total supply in 1987), with Nigeria alone accounting for most of the reduction. At peak, imports accounted for around half of total consumption in West and Central Africa, over a quarter in the Southern region and less than 10% in the East. The wide variations in consumption levels between the different subregions (from 56 kgs in the East to 9 kgs in the Central region) are a direct consequence of different production levels, only partly offset by net imports. Production and consumption levels per capita have fallen in most regions in recent years, as illustrated in Table 1.4 below.

1.17 More detailed information is available on consumption patterns in West Africa, as the result of a study by ILCA (Seyoum 1988). This material is summarized in Box 1.1.

Table 1.4 Production, Net Imports, and Consumption, 1970-87
(Kgs per capita)

Region	Production	Net Imports	Consumption
EASTERN			
1970	59.1	1.2	60.3
1980	50.6	4.4	55.0
1987	53.8	2.3	56.1
WESTERN			
1970	14.3	3.7	18.0
1980	12.2	9.6	21.8
1987	8.1	5.1	13.2
SOUTHERN			
1970	20.0	5.0	25.0
1980	15.8	6.3	22.1
1987	13.0	6.2	19.2
CENTRAL			
1970	7.1	2.0	9.1
1980	5.6	4.6	10.2
1987	4.8	4.4	9.2
ALL SSA			
1970	27.0	2.8	29.8
1980	22.9	6.8	29.7
1987	22.2	4.3	26.5

Source: 1970 and 1980 figures from Mbogoh 1984;
1987 figures calculated from FAO data on same basis.

Box 1.1 Consumption of Dairy Products in West Africa
(Based on Seyoum, 1988)

Milk consumption levels (Kgs per head) in the different ecological zones were estimated as follows for the period 1983/85.

Average Milk Consumption (Kgs), 1983/85

	Urban	Rural	All
Arid	30	55	34
Semi-arid	32	12	16
Sub-humid	27	8	14
Humid	22	6	11
Highlands	58	6	9
Average	26	13	16

Consumption patterns followed production patterns, with drier areas having the highest per capita consumption levels and moister areas having relatively low levels. Although little more than one-quarter of the population was in urban areas, they accounted for over 40% of total consumption and absorbed up to 90% of imports in many countries. Imports supplied an average 45% of dairy consumption in the region but 61% in Nigeria, 74% in Gambia, 85% in Ghana, and 90% in Ivory Coast. (Imports have since fallen by over 40% and now supply one-third of consumption on average, and around 30% in the case of Nigeria).

The average share of household expenditure devoted to dairy products was approximately 2% (or 5% of total expenditure on food). A range of local surveys did not reveal any increasing share as incomes increased, thus indicating that income elasticities of demand are less than one. It was estimated that about half of domestic liquid milk production was consumed as fresh (by pastoralists and people living in dry areas), while the other half was consumed in sour form (mainly by people in urban areas of the moister zone and in rural areas of the dry zone). Butter, cheese and cream consumption was restricted to particular localities and/or ethnic or income groups. There appeared to be a switch from sour milk towards fresh milk as incomes increased and towards processed products at relatively high income.

Fermented milk is popular in both dry and moist areas but all fermented foods are becoming expensive delicacies because they cannot be produced on a commercial scale or in large enough quantities. Yoghurt or sour milk offers good prospects for development in both dry (rural and urban) and moist (mainly urban) areas.

Supply and demand projections indicate significant shortfalls in the humid and sub-humid zones, resulting mainly from urban demand.

Markets and Products

1.18 For most countries in Sub-Saharan Africa, only a small proportion of local production enters formal marketing channels. This proportion is as low as 10% in Nigeria, Sudan and Tanzania but rises to 25% in Kenya and 60% in Zimbabwe. Production and marketing of dairy products in the "modern" subsector are organized along the same lines as in developed countries. Since production in the traditional subsector is primarily geared toward meeting family requirements, the amounts of surplus milk and dairy products available for sale are small and show pronounced seasonal fluctuations.

1.19 Many countries have established large-scale, often parastatal, processing and marketing enterprises that have monopsonistic and monopolistic powers over both the domestic and external trade in dairy products; examples include Burundi, Malawi, Mali, Niger, Somalia, Tanzania, Zambia, Zimbabwe. Nigeria has a mixture of private and government plants; Sudan has a number of mixed-ownership operations, while Kenya Cooperative Creameries have a virtual monopoly on processing and marketing in that country. In addition, official price controls have been imposed in the majority of countries, often setting both producer and consumer prices.

1.20 Although formal monopolies exist, there is active competition from the informal sector in all countries. The informal sector can virtually ignore official price controls and can easily evade hygiene and quality standards. Since the margin between producer and consumer prices can be low in the traditional markets (because producers often sell directly to the final consumer), relatively low consumer prices can still mean high returns to the producer. An ILCA survey suggested that the ratio between traditional and official prices fluctuated between 1:1 and 3:1 in some West African countries (e.g., Ghana and Nigeria) and between 3:2 and 2:1 in Sudan, Mali and Tanzania (Mbogoh 1984). Governments have often been slow in responding to changing cost structures by revising official prices to keep in line with the prices on informal markets.

1.21 Irrespective of the marketing channel, an estimated 90% of consumption in all areas is in milk form, fresh or soured, with relatively little production of dairy products -- mainly cheese, butter and ghee (Mbogoh, 1984). (Sour milk is as widely consumed as fresh milk, and more so in rural areas; in addition to its improved keeping quality, it does not give rise to intolerance problems since the lactose is no longer present.) Similarly, almost three-quarters of imports (in terms of whole milk equivalents) consist of milk powder, a further 15% is condensed/evaporated milk and only 12% is milk products (mainly butter and cheese). Thus the bulk of the demand is for relatively simple products for direct usage. For example, in Zimbabwe it is estimated that over 70% of milk sold is for tea whitening.

Imports

1.22 Commercial imports of dairy products rose in value from $43 million in 1960 to $113 million in 1970 and peaked at around $700 million in the early 1980's. (At that time, they absorbed around 5% of total export earnings from agricultural, forestry and fishery products.) West Africa accounted for 50% to 60% of total imports for much of this period, with Nigeria alone taking 40% in 1980. The volume of imports (in liquid milk equivalents) increased from 0.8 million tons in the early 1970's to a peak of 2.2 million in 1981 and fell back to 1.9 million by 1987. The reduction is almost entirely due to imports to Nigeria, which declined by around three-quarters. Ivory Coast is now the largest importer, although it also has cut back. Ten countries have consistently accounted for some two-thirds of total imports by value in recent years (see Table 1.5).

Table 1.5 Dairy Imports - Selected Countries, 1970-87
($ Million)

	1970	1980	1987
Ivory Coast	8.0	82.7	74.7
Nigeria	19.5	282.9	69.1
Angola	3.6	25.9	34.1
Reunion	3.5	25.1	34.1
Senegal	5.3	18.7	33.1
Sudan	2.0	6.6	30.2
Mozambique	2.5	6.3	24.2
Zaire	8.6	18.6	21.0
Mauritania	0.7	19.6	20.5
Mauritius	2.3	18.5	19.6
Sub-total	56.0	504.9	360.6
Total SSA	103.8	705.1	536.3

1.23 Population growth (over 3% per annum), urbanization (8% growth in cities and towns) and an improvement in per capita incomes (at least for some groups) strongly influenced demand. There is little information on domestic prices, but the ready availability of cheap supplies on international markets fueled the import demand. Despite the imposition of high import duties in many cases (up to 50% on processed products in Nigeria), overvalued exchange rates ensured that imported products were still relatively cheap. However, it was the availability of foreign exchange that made importing possible in the 1970's; its scarcity forced the retrenchment in the 1980's. (Kenya and Zimbabwe are the only net exporting countries in Sub-Saharan Africa, but the quantities they export are small.)

Food Aid

1.24 The principal dairy products are skim milk powder and butter-oil that can be recombined to form liquid milk. The quantities supplied have fluctuated considerably, depending mainly on emergency situations. Donations of skim milk powder (SMP) peaked at 113,000 tons in 1984 and fell back to 38,000 tons in 1988 (FAO 1989). The United States, the principal supplier to Africa, accounted for 70% of SMP and 33% of other dairy products in 1986; the EEC accounted for 20% of SMP and 35% of the other products. On average, food aid provided about 6% of total dairy products consumed in the early 1980's, but for some countries (e.g., Benin, Ghana and Sierra Leone) it provided about one-quarter and for others (e.g., Lesotho, Somalia and Rwanda) around one-third (Von Massow 1989).

1.25 The World Food Program (WFP) provides butter oil and dried skim milk free to governments, which in turn sell them to dairy plants. The funds generated are then invested in activities to help local farmers increase their milk production. The aim is eventually to replace the food aid commodities. The products are recombined and toned with fresh milk for sale to consumers. Projects in 14 countries in Sub-Saharan Africa have accounted for over one-quarter of the WFP's total expenditure on dairy products. India received a similar level of support. In recent years dairy projects have been supported in Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Tanzania and Uganda.

Box 1.2 EEC Food Aid

Food aid emerged as an outlet for community surpluses in the early 1970s; at their peak donations of these commodities accounted for less than 5% of EEC supplies but for up to 25% of exports. The annual levels of commitments were stabilized at 150,000 tons of SMP and 45,000 tons of butter oil in the late 1970s. The bulk of these products went to Asia (mainly India, Pakistan, and Bangladesh) and to Egypt; in recent years less than 10% went to Sub-Saharan Africa.

Even before the sharp reduction in EEC surpluses, a policy decision was made to cut back on food aid in dairy products. This move reflected management considerations and widespread concern about the developmental and nutritional effectiveness of the uses of these commodities (Clay, 1985). Thus, the proposed quantities for 1989 (94,000 tons of SMP and 25,000 tons of butter oil) were some 40% below the levels of the early 1980s and would barely meet long-term commitments, e.g., to Operation Flood. The decision to cut back indicates some degree of autonomy from agricultural surplus disposal in food aid policy making within the EEC; thus, regardless of the evolution of surpluses, EEC dairy products are unlikely to be provided in substantial quantities as food aid in the future.

Impact of Imports

1.26 The availability and quality of price statistics are very poor for most African countries, and it is therefore impossible to quantify the impact of dairy imports on domestic price levels and production (Von Massow 1989). The general effects to be expected are depressed domestic prices and disincentives to local production, especially where the price of food aid products was not related to local producer prices. However, the effects may be confused or compounded by other Government policies (e.g., control of milk prices at uneconomic levels or subsidization of processing plants through donor funding).

1.27 Imports can have positive effects when properly channeled in the context of coherent development policies. Where production is scattered and inadequate, dairy imports can help create infrastructure (including processing facilities) and stimulate demand at the same time. As in the Indian "Operation Flood," food aid can be sold locally to generate funds for dairy development. Processing plants in countries as diverse as Nigeria, Mali and Tanzania depend almost totally on imports for their continued operations. In other cases, imports are required to overcome the seasonality of production (see Chapter 2), thus contributing to the satisfaction of consumer demands and improving the capacity utilization of processing plants and marketing systems. Imports also may be used to extend existing supplies; adding skim milk powder (and water) to high fat milk produces a balanced standardized product. The resulting low-cost product may be particularly attractive to low-income groups (e.g., Malawi). In the case of food aid, the products may be destined for particular target groups with special nutritional requirements (e.g., the school milk scheme in Kenya).

Experience with Dairy Development Projects

1.28 Over the decade 1975-85, the value of donor assistance to the livestock subsector averaged $80 million per annum, with public sector investment from domestic sources estimated at only 25% of this figure (Anteneh et al. 1988). It is not possible to separate out the dairying component. The principal investment has been by producers in the form of increased livestock numbers. The estimated investment at the production level is summarized below. Similar estimates are not available for investment in processing/marketing facilities.

Table 1.6 Annual Investment in Livestock Sub-Sector, 1975/85
($ Million, 1985 Prices)

	1875	1985
Producers		
In Livestock	310	370
Other (10% of above)	30	40
Sub-total	340	410
Donor-financed	140	90
Other Public	30	20
Total	510	520

Source: Anteneh, et al, 1988.

1.29 The overall capital:gross output ratio in the livestock subsector is between 3.5:1 and 5:1, but with modern dairy enterprises it is in the region of 2:1 (Anteneh et al 1988). Up to 80% of investment (excluding land) tends to be in livestock.

1.30 The record of livestock development initiatives in Sub-Saharan Africa has been generally disappointing. In many cases, national policies were not appropriate since they led to overvalued exchange rates and other distortions at the macro level and to excessive interference, especially in price-setting and regulation, at the micro level. All too many development projects emphasized the direct transfer of inappropriate technologies rather than building on existing production systems and developing local capacities and technologies. The designs of livestock projects were often grandiose and unrealistic, especially considering the scarcity of qualified and experienced staff. Too little attention was paid to social and institutional factors. Institutions set up to provide credit and production inputs have often been neither financially viable nor sensitive to producers' needs. In many cases, donor agencies failed to provide firm but flexible supervision of projects. The experiences of some donor agencies are summarized below.

World Bank

1.31 Rural development projects in Africa have a very mixed record. Half of all audited projects over the period 1965-1986 were judged to have failed (World Bank 1987). Direct Bank involvement in dairying has been limited, but a number of interventions have provided indirect support (e.g., area development, credit, extension and livestock projects with veterinary components). In addition, sectoral and structural adjustment loans, which addressed issues such as overvalued currencies (and thus cheap imports) and excessive regulation, have helped create a suitable policy environment for development in the long term.

1.32 Specific dairy projects (or components) have been undertaken in Ethiopia, Kenya, Tanzania and Zambia. The Ethiopian dairy project was seriously impeded by the major political changes and did not lead to any significant increase in milk production; thus the expanded processing capacity was underutilized. On the other hand, the dairy components of three smallholder credit projects in Kenya were highly successful. It had been expected that only 15% of loans would be for dairying, but in practice Kenyan farmers used 85% of the funds for this purpose. The dairy component of a subsequent integrated project was not successful, in part because the design underestimated the weakness of the implementing agencies, including cooperatives. The Tanzanian project supported mainly large-scale parastatal farms and processing factories. Serious management problems were experienced on the farms, leading to low production coefficients and high costs, while the smallholder component was seriously constrained by a shortage of grade cows. The Zambia project initially envisaged the participation of 1,800 smallholders, but it had to be drastically revised; a scaled-down project involving about 150 farmers performed satisfactorily. Management has been the single most important factor governing the success or failure of dairy projects, whether at the farm, institutional or national level (Walshe 1987).

1.33 FAO has been one of the principal supporters of livestock (including dairy) development in Africa. Its initial focus was on specific technical problems, but the emphasis then changed to an integrated approach. The FAO is now concentrating on smallholders and on local processing (see Chapter 7). Many bilateral donors (especially Denmark, Finland, the Netherlands, Sweden and Switzerland) have supported dairy projects. With the exception of the Netherlands, the donors have not published overall reviews of their experiences; there is a need to make this material more accessible (see Chapter 7).

Netherlands

1.34 A review of 23 livestock projects, two-thirds of which were in Sub-Saharan Africa, was carried out by the Operations Review Unit of the Dutch bilateral program (Anon 1987). It did not cover the meat and milk processing sector nor the large dairy food aid program. The development of the country's involvement in livestock activities was seen as a learning process comprising four phases. The first phase, the large-scale supply of Dutch dairy cattle, came to an end in the 1970's when it was found that the animals were generally unable to adjust to local conditions and were particularly unsuited to the needs of small farmers. In the second phase, the Netherlands became involved in establishing and equipping large-scale modern dairy enterprises, the management of which proved to be a stumbling block.

1.35 It was gradually realized that the import-dependent activities of the first two phases were inappropriate. In the third phase, aid was increasingly targeted to the small farmer. The view taken of cattle also changed. The fourth phase put greater emphasis on the diversity of functions of cattle for local people (e.g., not just as milk producers but also as sources of animal power and manure). A more integrated approach was developed in which livestock activities were seen in the context of mixed farming systems, while the role of women in husbandry, processing and marketing was increasingly taken into account. In general, it was found that women's role declined with increases in the scale and intensity of livestock farming.

1.36 The overall conclusion was that the activities investigated had not so far produced very positive results. However, it was argued that the great importance of cattle, and of livestock in general, to the national and local economies of developing countries implied a need for a livestock component in virtually all development cooperation activities in rural areas. A new policy on livestock production has been adopted in which the emphasis has shifted from a one-sided technocratic approach to livestock management to an integrated approach to agricultural development. Individual livestock activities are to be placed in the context of market regimes and of the natural environment. This policy shift implies reduced support for large dairy farms, veterinary laboratories and AI schemes and the deployment of fewer experts. Improved roughage supplies are seen as a precondition for the genetic improvement of livestock and their effective protection. The provision of credit facilities for small farmers is increasingly being used as a way of promoting livestock activities. The farmers' cooperative is seen as the most suitable form of organization, provided there is a reasonable level of literacy and local governments permit at least a minimum of autonomy.

II. PRODUCTION SYSTEMS AND THE EVOLUTION OF DAIRYING

Ecological Zones

2.01 The options for milk production in SSA are defined by the agro-ecological zone, the livestock production system and the tsetse challenge. There are five agro-ecological zones (see map) based on the number of plant growing days and temperature (Jahnke 1982):

- Arid zone : growing days below 90
- Semi-arid zone : growing days from 90 to 179
- Sub-humid zone : growing days from 180 to 269
- Humid zone : growing days 270 or more, with hightemperature and high relative humidity
- Highlands zone : growing days 90 to 365; over 1,500 m above sea level; ranges from semi-arid to humid but average temperature below 20°C during the growing period.

2.02 The distribution of land, ruminant livestock populations and milk production by ecological zone is shown below for the late 1970's.

Table 2.1 Land, Livestock, and Milk by Ecological Zone (%)

Zone	Land	Livestock	Milk
Arid	37.3	30.4	42.2
Semi-arid	18.1	27.3	21.4
Sub-humid	21.7	19.2	14.7
Humid	18.5	5.9	3.9
Highlands	4.4	17.2	17.8

Source: Jahnke, 1982.

Thus the zone with the harshest climate, the arid zone, is the most important for milk production because of its comparative advantage for livestock, but little of this milk is marketed. The human population is concentrated in the humid, sub-humid and (to a lesser extent) highland areas.

2.03 In the arid zone, pastoral range-livestock systems predominate and milk is the main product. Milk has an important subsistence value, providing 50% or more of total calories in some cases. The market or exchange value of dairy products also may be a significant component of pastoral income. Milk production in pastoral societies is marked by a strong seasonal influence on yield; thus surpluses are available only at certain seasons. As the zones become more humid, the cropping potential increases, and more intensive feeding regimes become possible. The crop-livestock systems, however, are increasingly subject to tsetse challenge. The sub-humid zone of West Africa offers good opportunities in the medium term because of its reasonable potential for forage production, comparative freedom from tsetse fly, lower cultivation pressure on the land and a relatively large cattle herd (ILCA 1988). In the highlands, tsetse flies are largely absent; the crop-livestock production systems are characterized by high densities of people and livestock, and milk is an increasingly important product. The individual land tenure that prevails in many of these areas facilitates the development of intensive feeding systems, and the population concentration provides a ready local market.

2.04 Because many urban centers/populations are concentrated in humid and sub-humid zones, they are a considerable distance from the traditional cattle-keeping areas. (In West Africa, some 75% of the urban population lives in the humid and sub-humid areas.) For example, in Nigeria, only 4% of the cattle herd is in the southern states where the bulk of the human population is concentrated, and there is a distance of 500 to 600 kms between the large urban areas and the zones with high potential for milk production.

Production Systems

2.05 The following livestock/milk production systems are recognized.

- Pastoralism. Pastoralists are livestock owners who exploit natural grasslands mainly in the arid areas with their herds of camels, sheep, goats and cattle. Pastoralists and their herds are continuously on the move looking for fresh grazing areas; most are transhumants, having permanent homes in an area with a more favorable rainfall. Milk is the main source of food for pastoralists.

- Agro-pastoralism. Agro-pastoralists are sedentary farmers who cultivate food crops both for subsistence and for sale. Their livestock feeds on communal grazing land, fallow land and on crop land after the harvest. Livestock are used for draught, milk production and savings. Shifting cultivation is a common practice associated with this system.

- Mixed-farming. Food or cash crop cultivation is the main agricultural activity. Farm size is usually small (1 to 5 ha), with a moderate to high cropping intensity. Maintenance of soil fertility is one of the main problems. Livestock are kept for draught, utilization of crop residues, improving soil fertility and providing additional income in the form of milk or meat.

- Intensive dairy farming. These farmers use part or all of their land to cultivate fodder crops for their dairy cattle and in addition they usually feed purchased concentrates. They may also use part of their land for food or cash crops. The dairy animals cannot be used for draught, but manure is used for growing fodder and other crops; milk is a major source of farm income. Intensive dairy farming is mainly by small farmers who use family labor, but it also includes large parastatals and commercial farmers who employ hired labor.

- Peri-urban milk production. This system has developed around cities and towns that have a high demand for milk. The main feeds are agro-industrial by-products that are available in the cities (e.g., brewery waste, oilseed cakes) and cultivated fodder crops or crop residues. Although dairy production can sometimes compete with vegetable production for land, it also can support the production of horticultural crops by providing manure. Milk is often traded directly to the consumers in the city and is the major source of income for the farmers.

The main characteristics of the five systems are summarized in Table 2.1.

Table 2.1 Some Characteristics of Different Dairy Production Systems in Sub-Saharan Africa

	Pastoralism	Agro-pastoralism	Mixed farming	Intensive dairy farming	Peri-urban milk Production
Farmers' priority	Milk production livestock numbers	Subsistence meat/milk production, drought	Drought soil fertility, milk/meat production	Sale of milk	Sale of milk
Farmers' attitude	Aversion of risk	Aversion of risk	Spreading of risk integration	Cash income	Cash income
Species	Camel, sheep, goat, cattle	Cattle, sheep, goat	Cattle	Cattle	Cattle
Feed resources	Communal grazing,	Communal grazing crop residues	Crop residues, cultivated fodder, communal grazing	Cultivated fodder, purchased concentrates	Purchased roughage and concentrates
Farmers' mobility	Mobile	Sedentary	Sedentary	Sedentary absent	Sedentary
Type of enterprise	Extended family	Smallholder extended family	Smallholder	Smallholder commercial farmer parastatal	Smallholder commercial farmer
Surplus milk	Seasonal	Seasonal	Mainly seasonal	Continuous	Continuous
Yield/cow/day (kg)	0.5 - 1	0.5 - 1	1 - 5	5 - 15	5 - 15
Surplus/farm/day (kg)	1 - 5	1 - 5	2 - 10	5 - 20 (smallholder)	5 - 30 (smallholder)
Land area/animal (ha)	5 - 10	2 - 5	0.5 - 2	0.5	0 - 0.5
Milk density (kg/sqkm/day)	2 - 5	5 - 10	30 - 50	250	250
Inputs used	Veterinary services (vaccinations)	Veterinary services (vaccinations)	Veterinary services, feed, minerals, extension, credit	Concentrates, breeding services, credit, extension, training, veterinary services	Concentrates, purchased roughage, breeding services, credit, extension, training, veterinary services
Main constraints	Land tenure system, animal nutrition, animal health, low milk density	Land tenure system, animal nutrition, animal health, low milk density	Animal nutrition, infrastructure, marketing, knowledge of crop/livestock integration, extension/training	Animal nutrition, genetic potential/breeding, infrastructure/marketing extension/training	Animal nutrition, genetic potential/breeding, infrastructure/marketing extension/training
Potential for commercialization	No/very limited	No/limited	Yes	Yes	Yes

Potential for Commercialization

2.06 The potential for commercializing milk production depends to a large extent on the location and production system. In the pastoralist system production per unit area is low and highly seasonal because of the rainfall pattern and related feed availability. Pastoralists have little or no control over the feed resources and consequently few opportunities to commercialize, apart from improving animal health. Few inputs are used, and the cost of production is very low. The range-lands are already being used to capacity, and pastoralists are being progressively restricted by the expansion of sedentary farming. The collection of milk for processing is difficult due to the mobility of the producers and the limited surpluses available after family subsistence requirements have been met. Surplus milk in any quantity is available only during the wet season; it is bartered or sold to nearby crop farmers or villagers as the herds move.

2.07 Agro-pastoralists also have limited control over their principal feed resources -- common grazing land and crop residues. Milk production fluctuates with the seasonal availability of feed, while collection is almost as difficult as in the pastoralist system. Although they may be closer to urban markets than the pastoralists, agro-pastoralists are not in a position to supply sizable quantities on a regular basis. The feed supply can be improved by saving grazing areas, planting tree legumes or establishing fodder banks for dry season feeding, as demonstrated by ILCA research in Nigeria. Farmer organizations (pastoral associations) need to be established to take advantage of this new technology. There is little scope for increasing production or sale of milk under pastoralist or agro-pastoralist systems, but there is some potential for seasonal production of stable products (e.g., ghee and white cheese).

2.08 The role of cattle in the mixed farming system is primarily for draught and maintenance of soil fertility, but also as savings/insurance. Milk production is of secondary importance. Private land ownership, prevalent in the mixed farming system, allows for improved feed production in the form of storing crop residues, fodder crop cultivation and planting of fodder trees. Milk production can be improved without affecting the primary functions of the animals for draught and manure. Dairy production in the mixed farming system is attractive since it offers the opportunity to diversify operations, to spread risks and to provide a regular income. The size of the surplus can, in many cases, justify the establishment of supporting collection and processing infrastructure. In this system the production and sale of milk can be stimulated by the establishment of a collection service and by payment of good prices for milk. Even if organized collection is not available, farmers can oftentimes sell direct to consumers and milk vendors if regulations barring the sale of milk do not constitute an unsurmountable hurdle. Good examples of mixed farming milk production systems are found in Kenya (see Box 2.1 below).

Box 2.1 Smallholder Dairy Development in Kenya

Initial situation:

- infrastructure, e.g., research institutes, herdsbooks, and marketing geared for large-scale farms.

Government policy is focusing on smallholder dairy development:
- individual land ownership to allow for fodder production and tick control;
- cash crop production to generate finance for dairy development;
- credit based on land title;
- livestock services: veterinary service, A1, milk collection, etc.

Dairy Development Project since 1980: Introduction of a zero-grazing package through an intensive individual extension program, supported by a monitoring unit and an adaptive research unit. Main focal points:
- cultivating fodder crops, mainly Napier grass (0.4 ha per cow);
- construction of cattle sheds (cubicle housing):
- use improved (grade) dairy cattle;
- improved management.

Results up to 1988: 2600 farmers registered, many are organized in zero-grazing clubs.

Project results (69 recorded farms):	1986/87
Average number of cows per farm	2.5
Hectare (Napier) per cow	0.28
Annual yield per cow (kg)	2635
Yield per day of lactation (kg)	8.7
Price per liter milk sold (Ksh)	3.85
Receipts per cow (Ksh)	8084
Recurrent expenditure per cow (Ksh)	3053
Surplus per cow (Ksh)	5031

Key to success for smallholder dairy development in Kenya:
- basic infrastructure and dairy experience;
- intensive extension and farm support program;
- on-farm feed production;
- financially attractive enterprise.

2.09 In the intensive dairy farming system, farmers produce their own roughage and purchase additional concentrates; they are commercially oriented and prepared to invest in their own enterprises. If the milk price is attractive, these farmers will respond to extension, training and improved marketing. Examples of the intensive dairy farming system are found in Kenya and Zimbabwe in particular.

2.10 Peri-urban dairy farmers rely mainly on purchased feed. They are commercially oriented and will respond to improved technical, input supply and marketing services. Examples of peri-urban milk production systems are found around most cities (e.g., Addis Ababa, Bamako, Dakar, Dar es Salaam and Khartoum). The dairy development projects in Kenya and Tanzania also have peri-urban components.

2.11 The potential to increase milk output from pastoralist and agro-pastoralist production systems is very limited. Only surplus milk can be extracted during the rainy season. The amounts marketed will depend very much on the cost of collection, transport and processing. Mixed and intensive dairy farmers in rural and peri-urban areas have more control over the inputs, and their improvement will result in increased milk output. Consequently, there is more potential to increase milk production per cow, per farm and per unit area in these systems, and the unit costs of the supporting services (input supply, animal health services and marketing) will decrease as production increases.

The Dairy Farmers

2.12 Pastoral herds typically average about 40 to 50 head of cattle and are managed by household heads. Most animals belong to the men and their sons, but a few belong to wives and daughters. The men are responsible for managing herd welfare and organizing access to pasture, water and health care; most of the actual herding is done by boys. The men also control the quantity of milk extracted and the amount left for the calves. The milk is allocated to the women in the household, and each woman decides how much milk is kept for the family and how much is sold. Selling dairy products is, for example, a main source of income for Fulani women in Nigeria (Waters-Bayer 1986). Among nomadic groups women are frequently responsible for milking. Among the pastoralists and agro-pastoralists many variations in cattle ownership and management responsibilities are found that depend on social and cultural factors. In general, the men control the quantity of milk available for sale or consumption, and the women control the amount consumed by the household as well as the quantity processed and sold. A conflict of interest between menfolk and women is not uncommon; the men are anxious to allocate as much milk as possible to calves to ensure strong stock, reduce mortality and expand herd size, while the women are anxious to ensure that sufficient milk is available for consumption by the family and the largest amount possible for sale.

2.13 In mixed farming systems livestock are kept on small family farms. Men are usually responsible for land preparation (ploughing) and women for planting and weeding. Women are also often responsible for a major share of the livestock work such as feeding, watering and milking. Milk sales could, in many instances, provide a regular year-round cash income for women and dairying a suitable income-generating activity for female-headed households. Ownership and responsibility for undertaking different kinds of work between family members vary considerably from place to place. In the Kilimanjaro region of Tanzania, for example, dairy husbandry is the responsibility of women; they cut and collect fodder, milk the cows and market the milk. In the Kagera region, however, women do not traditionally tend dairy cattle; livestock keeping and firewood fetching are considered men's work, and women with dairy cattle have to depend on hired labor. The owners of dairy cattle in intensive dairy farming systems and in peri-urban systems are mainly small farmers, but businessmen and retired civil servants who depend, wholly or partly, on hired labor are also common. Livestock ownership and labor responsibilities vary as does the distribution of benefits from dairying.

Evolution and Scale of Dairy Farming

2.14 In Europe, India and North America, farmers milked their cows, as they do in Africa, for limited barter or sale to their neighbors. In time, the demand for a year-round supply of liquid milk expanded with the growth of towns and cities; specialized dairy farms were established to meet this demand. Up to about 50 years ago, dairy farmers in Europe and elsewhere sold raw milk to consumers or vendors who distributed it to households, but two factors contributed to the demise of this system. First, public health authorities emphasized pasteurization (although untreated milk from licensed herds could still be sold), and the growth in the number of home refrigerators made distribution in bottles and other containers through stores and supermarkets convenient for the consumer. Second, as incomes increased, the milkman could not command a satisfactory income because the quantity he could deliver from door-to-door was restricted.

2.15 The failure to appreciate that neither of these two factors applies under most African conditions has been a major impediment to dairying in Africa. Liquid raw milk can be distributed by the farmers themselves or by private vendors at very low cost because labor, which is the main cost, is relatively cheap. In contrast, the costs of processing and distributing milk in containers are high and are not competitive except in sophisticated markets where consumers can afford the luxury of purchasing packaged, processed milk. (The informal milk distribution system in Khartoum, where donkeys are used as pack animals to carry two 20-liter milk cans, is a good example.) Furthermore, pasteurization is not essential for public health reasons because in virtually all parts of Africa, as elsewhere in the tropics, raw milk is boiled before it is consumed. Under the prevailing conditions in most parts of Africa, this practice is less risky than relying on pasteurization and hygiene, which may be faulty. At any rate, sour milk is a relatively safe and highly acceptable product in most African countries. Chilling or pasteurization can be justified only if milk has to be transported long distances to city markets from far away milk sheds (as is the case with Operation Flood in India).

2.16 The normal evolution of dairying in Sub-Saharan Africa has been markedly influenced by the colonial experience, which has had both positive and negative consequences. The colonial strategy placed complete reliance on large commercial farmers to meet the growing demand in cities and even to provide a surplus for export. The institutions and services that were established closely copied Western institutions that had evolved over a long period in response to economic growth, urbanization and technological changes at factory and farm levels. Institutions (parastatals, cooperatives and dairy boards) were designed to serve large colonial farmers and not to foster and serve the needs of smallholders. The Kenya Cooperative Creameries and the dairy produce boards in Zambia and Zimbabwe are good examples of such institutions.

2.17 After the colonial period the negative attitude to smallholder development was exacerbated by two unjustified policy decisions. First, a decision was made that colonial dairy farmers (e.g., in Zambia) would be replaced by parastatal dairy farms. Where colonial farms did not exist (e.g., in Tanzania and Ethiopia), dairy development would be based primarily on parastatal or state farms. It was argued that the skills and management capabilities needed for successful dairying could be replaced or developed under a parastatal structure, but it is now clear that this approach was mistaken. The problems experienced by dairy parastatals are similar to those experienced by all parastatals -- inadequate management, political interference (e.g., concerning milk prices), low productivity and poor financial performance. Second, governments were encouraged to rely on reconstituting cheap imports (donated or purchased at low world market prices and distorted exchange rates) to meet the growing urban demand. Thus sophisticated milk processing plants, often funded by donor agencies, are to be found in many major cities. The familiarity of the industrialized countries giving technical assistance with the intensive dairy model, and the ready supply of equipment from the commercial sector, reinforced the newly independent countries' tendency to build large-scale facilities under government control.

2.18 Although the colonial legacy was negative in terms of its influence on the policies that governments followed (even after the colonial era) and on the culture and outlook of the dairy institutions that were established, it had many positive aspects. For example, specialized dairy breeds were introduced, and research was undertaken on dairy production and management (e.g., grass and forage production, animal nutrition, crossbreeding and animal health). Input supply services, artificial insemination, and extension and milk collection services were also organized in a number of countries. Colonial farmers showed what could be achieved with improved dairy stock and good management under African conditions. It is regretable that few African countries, with the exception of Kenya, have been successful in switching their emphasis to smallholder dairy development and combining the relevant parts of the pre-independence experience into strategies aimed at smallholders.

2.19 Small family farms -- with low input, capital and foreign exchange requirements, and depending mainly on family labor -- represent a more sustainable form of dairy development than large-scale parastatals. Thus a strategy for dairying in Africa must focus on smallholders and must be designed to utilize and mold existing institutions and resources to this end. Although aspects of the development strategy will vary from country to country, depending on climatic, agro-ecological and market conditions, the essential elements should be common to all countries. Once these elements are fully understood and taken into consideration, a country can design a dairy development strategy to suit its own conditions and needs.

Constraints on Dairy Development

2.20 The principal constraints result from environmental (physical and economic), technical and social/institutional problems. The physical environment presents severe challenges in many parts of Africa. Because of poor soil fertility and scant, unreliable and markedly seasonal rainfall, feed supplies fluctuate widely in terms of both quantity and quality. Indigenous cattle (and other livestock) have been selected for their survivability rather than their productivity. Thus marketed output is relatively low. Moreover, underdeveloped infrastructures (e.g., roads), distant markets, and high temperature/humidity leading to rapid spoilage can render surplus milk production in pastoral or other remote areas virtually unmarketable.

2.21 Over the past decade in particular, the international economic environment has not been conducive to successful dairy development. Declining real prices on world markets, combined with the trade and food aid policies of developed countries, resulted in intense competition from imported products. This was exacerbated, in some cases, by overvalued exchange rates and by the attempts of many governments to keep retail prices down. At the same time, attempts by donors and governments to interfere in marketing systems have widened the gap between producer prices and retail prices, except where subsidies have been introduced (Anteneh et al. 1988).

2.22 During the past two decades, much of the investment in the livestock subsector (other than in indigenous animals) has been financed by foreign aid. At just over 1% of the annual value of output, foreign aid was too small to have had a significant impact, however. Insufficient recurrent expenditure on Government services has probably been a more serious constraint than shortage of investment (Anteneh et al. 1988). Much of the increase in real expenditure per animal has been rendered ineffective by the rising share of staff costs in total costs, at the expense of essential nonstaff costs such as veterinary drugs, materials and transport. More numerous and more expensive staff have tended to become less effective because of inadequate operating budgets.

2.23 Technical Constraints. The technical constraints include genetic structure, feed and nutrition, health and disease problems, management, water shortage and appropriate technologies. The proportion of Sub-Saharan Africa's total cattle herd significantly affected by deliberate genetic change is probably less than 3% or 5 million head (Anteneh et al. 1988). Thus the genetic structure has evolved largely as a result of natural selection influenced by environmental factors. Natural selection has been for survival under high disease challenge and fluctuating feed and water supplies, rather than for high levels of production. This is reinforced by social institutions (particularly land tenure) that encourage competition for scarce feed and water resources, rather than adjustment of herd size. Bos taurus (i.e., European) dairy cattle appear to have a genetic potential for milk production roughly twice that of the indigenous Bos indicus. However, in the tropics they fail to produce adequately, or even to survive the multiple challenges of climatic stress, new diseases and parasites and poor nutrition. (The livestock resources and their improvement are considered in Chapter 3.)

2.24 Native pastures, crop residues and browse are still the major feeds for the vast majority of African livestock, in spite of experimental evidence showing strong responses to supplementation of various kinds. Enclosing natural pastures, oversowing pastures and rotational grazing have failed almost totally in pastoral areas; major research efforts have not led to viable solutions. Sown forages have been adopted in mixed farming areas where they could be used for milk production with crossbred animals, since they were then competitive with food or cash crops. The use of agro-industrial by-products and the improvement of crop residues and native grasses by treatment (e.g., with urea) have been adopted in some areas; they do not compete for land, unlike forage crops. (Issues relating to feeds and feeding are considered in Chapter 4.)

2.25 Modern technology has reduced some disease risks, but animal health problems still constitute a major constraint. For example, trypanosomiasis is a serious problem over 46% of the surface area of Sub-Saharan Africa, leading to high mortality, reduced productivity and high prophylaxis or treatment costs. Internal and external parasites can be important causes of low productivity and high mortality, and there are often significant interactions between nutrition, disease and reproductive performance. Technical solutions to some health problems are available (e.g., control of internal parasites) but at a relatively high cost. For other problems (e.g., streptothricosis), new technology may be the only way to improve productivity substantially (see Chapter 5).

2.26 Although poor management may be caused as much by a shortage of labor at critical times as by ignorance or inefficiency, there are often significant gaps in livestock-owners' knowledge, especially about causes of disease and new technical possibilities. The development of dairy production at the smallholder level requires changes in management methods because husbandry standards for local stock usually lead to failure if applied to improved stock. Any dairy development strategy must therefore involve improvements in the knowledge and management skills of smallholder producers. The productivity of herds with apparently equal access to the same feed and water resources and equal exposure to the same health risks can vary markedly; this may be due to differences in management practices not yet properly identified.

2.27 There is a lack of appropriate technical packages for both milk production and processing. Available technologies are often inappropriate for African conditions because they are capital intensive, import dependent and do not take account of local constraints. Undue reliance has been placed on transferring technology rather than generating it within Africa. The adaptive research needed in a continent with such a wide range of agro-ecological conditions and farming systems has been underestimated. There has been underinvestment in adaptive research in livestock projects compared with other agricultural projects.

2.28 Although data indicating expenditure on livestock-related research are not readily available, the total for Sub-Saharan Africa is estimated to be on the order of $70 million per annum or 1% of the estimated value of output (Anteneh et al. 1988). National research capacity in most countries is not yet adequate to generate the required flow of new technology, and in many cases researchers lack adequate operating funds to be fully effective. The International Livestock Center for Africa (ILCA) is strengthening its partnership with national agricultural research systems through applied and adaptive collaborative research, and by providing more training opportunities and better information services. Its priority target groups are mixed crop-livestock smallholder farmers and agro-pastoralists. In the short term, efforts will be concentrated in the high-potential semi-arid, sub-humid,

humid and highland zones. In addition to work on feed resources, genetic potential and trypanotolerance, a major research topic will be the development of simple milk processing techniques to promote the marketability of dairy produce (ILCA 1987).

2.29 Institutional Constraints. The principal institutional constraints include land tenure, marketing facilities, and support services at all levels. Land tenure has been identified as a constraint in a number of studies, where common ownership was seen as inhibiting the adoption of improved techniques. However, common forage properties are common because they are cheap and because there is insufficient interest or opportunity to improve them. Where technical or other changes (e.g., urbanization) reduce benefits from common resources, privatization occurs rapidly (e.g., with crop residues). The role of the State may well be less important than local politics since tenure is often governed by local custom.

2.30 Marketing institutions have suffered either from neglect or direct government interference (e.g., the establishment of new parastatal substitutes or competitors). Many dairy development projects in the region have been launched prior to any serious evaluation of the type of marketing system that would best handle the resulting marketable surplus. Such projects have usually been accompanied by the establishment of public organizations with responsibility for collection, processing and marketing (and sometimes also for input supply). This was considered to be the best means of ensuring that the interests of producers and consumers would be safeguarded; the performance of parastatals in most cases does not support this view. The nature and performance of dairy marketing systems in Sub-Saharan Africa are not well understood and much additional work is required in this area.

2.31 Support services and institutions are particularly weak in Sub-Saharan Africa. With few exceptions, traditional livestock production systems use little inputs, besides natural forage or crop residues, herding labor and livestock. A partial exception to this are veterinary services where the method of service delivery has changed little over several decades. Para-professionals are now a feature of livestock projects in about 20 countries, and use of professionals in the private sector is increasing. The delivery of other inputs has not been developed, partly for lack of economic demand and partly because appropriate organizational forms have not been devised. Thus AI services are generally weak, and more appropriate delivery systems are needed. A shift toward dairy development requires more support from advisory services and more effective links with research services. On-farm advice on animal husbandry and fodder crops and demonstrations and training courses are also needed. The main constraint on providing good advisory services in animal husbandry has been the limited number of advisory staff with appropriate training and experience in farm management. Farmers are reluctant to follow advice on good husbandry practices unless they are convinced that taking the advice will lead to significant, and sustainable, increases in productivity and income.

2.32 Sometimes left to animal health departments or to commodity-oriented parastatals, livestock development has been inadequately incorporated into the general planning of the agricultural sector. In some countries, responsibility has been shifted around (e.g., from the agricultural department to a separate livestock department). This spasmodic approach has been inimical to the desirable continuity of planning personnel, methodology and policy.

Opportunities for Dairy Development

2.33 The principal opportunities result from a growing market, which is already heavily dependent on imports in many cases, combined with an existing large livestock population and related husbandry skills. Since the market expansion results mainly from population growth rather than from income increases, it is largely a dispersed market for basic, low-cost products; there is also a small, concentrated market for more expensive products among high income urban groups. This dual market structure contributes to the development of a dualistic production structure: a small "modern" sector and a large traditional sector. A stratified dairy industry could be developed to harness the potential of the different areas and to satisfy the separate markets.

2.34 Sub-Saharan Africa has a number of advantages in dairy development. First, livestock owners traditionally milk their animals, and dairy products are an important part of local diets. Thus no cultural or social impediments to dairying exist. (Lactose intolerance does not preclude consumption of limited quantities of fresh milk; fermented products do not contain lactose.) In virtually all parts of the region where the tsetse challenge is manageable, indigenous cattle are plentiful; their current low yields can be transformed by better breeding, feeding and management. Second, the transformation that took place in Europe in the beginning of this century, with the application of technology to peasant farming, is now only beginning in many parts of Africa. As a late starter, there is considerable potential to benefit from advances elsewhere and to catch up rapidly. Third, labor costs, which are significant in relation to dairying, are extremely low (although seasonal labor shortages do exist).

2.35 When labor is cheap, or family labor with a low opportunity cost is available, forage production, harvesting, feed storage, feeding and milking can all be carried out manually. Smallholder manual systems are appropriate under African conditions because they are much less capital intensive and risky than large mechanized systems. They do not need the specialized housing, equipment or support services (e.g., milking machine testing, maintenance and cleaning, and mastitis control) that are essential on large mechanized farms. In the developed world, capital investment in buildings and farm mechanization was justified by increasing labor costs and the exodus of farm labor from agriculture -- factors that are not yet significant in Africa. An investment, for example, in machine milking cannot be justified except at much higher labor rates than those prevailing at present.

2.36 Finally, there is a strong and growing demand for milk and milk products, which has had a marked effect on milk prices and the profitability of dairy farming. High producer prices for milk are now the norm around virtually all towns and cities because imported products have been either insufficient or too expensive to compete with local milk producers. It is not uncommon for dairy farmers to sell their milk at US$0.20 to $0.30 equivalent per liter (assuming currency conversions at real exchange rates). High milk prices are a powerful incentive to farmers to purchase improved dairy stock and/or to upgrade their animals and to improve their feeding and management.

III. LIVESTOCK RESOURCES

Introduction

3.01 Climate is an important but not an insurmountable constraint on dairy development in Sub-Saharan Africa. The feeds that are available and the animal diseases that are prevalent are largely governed by agro-ecological zones. Tropical climates have deleterious effects on the performance of improved dairy breeds. High temperatures (exceeding 27°C), combined with high humidity (over 80%), depress feed intake and milk production. Where temperature exceeds 27°C for 6 or more hours per day, the feed required for daily maintenance of cows may be as much as 15% greater than where temperatures are lower (McDowell 1983). Tropical forages have substantially lower feeding value than temperate climate ones. Lactation yields of 4,000 to 5,000 kgs can, for example, be supported with minimal supplementation in temperate regions, but yields of about 1,500 kgs are the maximum that can be achieved on improved tropical pastures under rainfed conditions without concentrate supplementation.

Choice of Genotype

3.02 Probably less than 3% of the total cattle herd in Africa (fewer than 5 million head) has been significantly affected by deliberate genetic change (Anteneh et al. 1988). The superior milk production capabilities of European breeds (Bos taurus) and the heat tolerance and disease resistance of the indigenous zebu types (Bos indicus) are widely recognized. Bos indicus cattle are well adapted to the disease and nutritional constraints in their tropical environment. As well as having a high degree of heat tolerance, they are much more resistant than Bos taurus to ticks, tick-borne diseases, trypanosomiasis and foot-and-mouth disease. In addition, they probably digest food more efficiently at low feeding levels and have the ability to select higher quality diets when grazing coarse tropical pastures; they also have the advantage of being able to lower their metabolism during droughts.

3.03 However, the potential for milk production is poorly developed in the zebu and even specialized zebu dairy breeds like the Sahiwal and Red Sindi appear to have only about one-half the milk production potential of Holstein-Friesians, for example. Although the genetic potential for milk yield of most of the indigenous cattle is too low to support the investment required in commercial dairying, they will remain the principal source of milk in low potential areas. Since the milk production potential of the indicus and taurus breeds differs by about 100%, there is a substantial amount to be gained by crossbreeding. (Note that the sophisticated selection schemes in the industrialized countries are producing milk yield increases of only about 1% per annum.) In addition to the additive difference between the two breed groups, their first crosses (F1) profit from a heterosis effect of about 30% (Cunningham 1989). In general, the first generation cross is well adapted to the African environment, performs satisfactorily and is acceptable to farmers. However, the risks are much higher than with the local breeds, and the crossbreds do need an improved feed supply, better management and adequate health care.

3.04 The continuation of the upgrading process would eventually result in problems similar to those encountered with the use of pure improved breeds. The optimum proportion of Bos taurus genes is on the order of 50% to 75%; upgrading beyond 50% has given variable and often disappointing results (Cunningham and Syrstad 1988). However, there are practical difficulties in stabilizing the cross at an appropriate level. A rotational crossbreeding program would exploit the heterosis effect to the maximum, but such a system is complex and difficult to sustain in the absence of an efficient AI service. Thus most taurus-indicus crossbreeding programs for milk production eventually concentrate on the objective of creating a synthetic breed (Cunningham 1989). The best known synthetic dairy breeds are the Australian Milking Zebu (AMZ), the Australian Friesian Sahiwal (AFS), the Jamaica Hope, the Karan Swiss and the Sunandini (in Kerala).

3.05 The design and implementation of breeding programs are, to a large extent, a public sector responsibility that farmers cannot undertake initially without strong government commitment and support. The importance of a well-designed program becomes apparent when one considers the long time needed to upgrade indigenous cattle -- 10 to 12 years to upgrade a farmer's herd to F1 status and about 20 years to reach F2 status. To succeed the breeding program must have a clearcut objective (that is, be focused on the genotype that is desired at the end of the upgrading process).

3.06 The choice of the appropriate genotype (breed or species) and breeding should be based on the yield level a specified production environment can support (McDowell 1985). For optimal performance, the genetic potential of the genotype should be about 30% above that possible with the projected nutrition level; this reserve is recommended so that the animal can respond to subsequent improvements in feeding. If the genetic potential is more than 50% above the level of production that the environment will support, then low calving rates and major health problems will be experienced.

3.07 On this basis, the following types of animals (genotypes) are favored for dairying in different parts of Sub-Saharan Africa.

High production environment. If the resources (climate, feeding, disease control and management) can sustain a lactation yield greater than 4,000 kgs per cow, pure European-type dairy breeds or 75% purebred crosses should be used. Friesians will be the favored dairy breed in most cases.

Medium production environment. If resources can sustain a yield between 3,000 and 4,000 kgs, the preferred type of animal should be a 50% to 75% European-type dairy cross, or a suitable synthetic breed.

Low production environment. If the resources can sustain a yield between 1,500 and 3,000 kgs, the type of animal should be 25% to 50% dairy cross (European-type) or a synthetic breed.

Very low production environment. If resources can sustain only a yield of less than 1,500 kgs, then there is little justification for upgrading; the productivity of the local breed could be improved through systematic selection and controlled breeding.

Because the livestock management capability and commitment of the individual farmer significantly shape the local production environment, the most suitable breed may vary from owner to owner.

Livestock Resources

3.08 Local zebu dairy breeds are mainly found in Ethiopia, Kenya, Niger, Nigeria and Sudan. The Kenana and Butana breeds in Sudan have potential milk yields of about 1,000 to 1,500 kgs with improved feeding and management; their combined numbers are about three million head. The White Fulani breed, which is common in Nigeria and elsewhere in Western Africa, has a potential yield of about 600 to 1,200 kgs per lactation. The Boran is common in Ethiopia, Kenya and Somalia and has a potential yield range of about 450 to 1,800 kgs per lactation, depending on the local strain. The main zebu dairy breeds that have been introduced into Africa are the Sahiwal and Red Sindi from India and Pakistan. The zebu dairy breeds can be used to upgrade the genetic potential for milk production of the local cattle from the present low levels to about 1,000 to 1,500 kgs. Synthetic breeds, although found in Sub-Saharan Africa, are not of great importance at this stage. Performance records for some zebu breeds found in SSA are summarized in Table 3.1.

Table 3.1 Performance Records of Selected Breeds

Breed	Age at 1st calving (months)	Milk prod. per lactation (kg)	Length of lactation (days)	Fat (%)	Calving interval (m)	Source
Red Sindi	30-43	680-2268	270-490	4.0-5.0	13-18	(1)
Sahiwal	37	1306-1840	277-286	5.2	N.A.	(2)
White Fulani	36-48	635-1225	190-360	5.0-7.5	12-15	(1)
Boran	36-52	454-1814	139-303	4.1-6.8	11-14	(1)
Kenana	47	1282-1581	244-289	4.5	N.A.	(3)
Butana	44	1581-1775	261-283	4.5	N.A.	(3)
Ndama	27-72	150- 270	150-300	6.5-7.0	14-42	(1)

Sources: (1) Williamson and Payne, 1978.
(2) Meyn and Wilkins, 1974.
(3) FAO, 1987a.

3.09 Although the vast majority of cattle are indigenous zebu types, European dairy breeds have been imported and crossed with local cattle. A measure of expected performance of Friesian, Brown Swiss and Jersey F1 crosses with Bos indicus, derived from the results of cross-breeding trials, is given in Table 3.2.

Table 3.2 Performance of Friesian, Brown Swiss, and Jersey F1 Crosses with Bos Indicus

F1 Crossbred	Age at first calving (months)	Milk yield (kg)	Lactation length (days)	Calving interval (days)
Friesian	33.4	2165	341	429
Brown Swiss	35.3	1921	337	435
Jersey	32.4	1737	326	412

Source: Cunningham and Syrstad, 1987.

Friesian crosses give the highest milk yields, but the Jersey crosses have advantages in fertility and milk composition (i.e., high fat content). Where milk volume is valued, rather than total solids, Friesian crosses would generally be preferred.

3.10 Tropical Bos taurus cattle native to Africa are the small shorthorned cattle of West Africa and especially the N'dama, which is found in Guinea and adjoining countries. The N'dama and some other breeds are relatively tolerant of bovine trypanosomiasis and are regarded as an important genetic resource for this reason. Their potential for milk production is relatively low, but average production levels of 400 kgs per lactation (with a maximum of 900 kgs) have been recorded by ILCA under village conditions in the Gambia. The Azarwak in Niger is also considered to be a good dairy breed.

Breeding Program

3.11 The first objective of a breeding program from the farmer's point of view is efficient reproduction (i.e., short calving intervals and regular lactations). The longer term objective is that of genetic improvement, related to the market and production conditions. In some areas (e.g., parts of Sudan, where a potential of 1,000 to 1,500 kgs already exists), the local breeds may have as much genetic potential as can be exploited under current or projected levels of nutrition and health care. However, if production is to be increased significantly, upgrading will be one essential component of development programs. The absence of effective breeding programs is a major constraint on dairy development in most countries in Sub-Saharan Africa. Such programs should take into consideration the following issues: the role and function of imported breeding stock and the means of importation; the respective roles of natural mating and/or artificial insemination and the design of an effective A1 service; the role of heifer and bull production farms; the design of a selection/breed improvement program; the development or strengthening of institutions to undertake these tasks and a clear definition of each institution's responsibility.

Importation

3.12 It is expensive to import purebred dairy breeding animals. Thus such importations, as a general rule, should be kept to a minimum. When all the costs are taken into consideration (e.g., for inspection, assembly, quarantine, disease certification and transport), good quality in-calf grade heifers can cost about US$2,000 to $2,500 per head. A case can be made for importing 4 to 6-month old dairy calves in certain cases, since transport costs are cheaper and these calves adapt better to the disease challenge. As a rule, profitable dairy farming cannot be based on a policy of importing the entire dairy herd, even in high resource environments, because the investment is too high and the disease risks too great. Consequently, importations of live animals should be confined to the small numbers needed to sustain a well-designed breeding program. In comparison with embryos and live animals, high quality semen is usually available at low cost, and the disease risk is minimal. Embryo transfer can have a role in very limited circumstances and only when the technology has developed further.

Artificial Insemination (AI)

3.13 With few exceptions, Al services in Sub-Saharan countries are either not available to farmers (except in name), or are so unreliable that farmers cannot take the risk of using them. An attempt has been made to transpose a model and technology from industrialized countries, at an advanced stage of development, to developing countries, where conditions are completely different. In developed countries, the AI service is an integral part or adjunct to a sophisticated national or regional dairy herd improvement program. It enables a small number of proven sires with superior genotypes, selected under a sophisticated breeding program, to be used to the greatest possible extent. Since the rate of genetic gain in a population of dairy animals is directly related to the selection intensity, a large number of inseminations per bull is important because it means that only a small number of stud bulls are needed and only a few highly selected animals have to be added each year to the teams of AI sires.

3.14 Under African conditions a large number of inseminations per bull is not necessary because the emphasis, in most cases, should be on grading up through crossbreeding and not on genetic improvement within a breed. Progeny testing of sires is not necessary or recommended in most situations (McDowell 1983). The semen of Friesians, with a milk potential of about 8,000 kgs is readily available at low cost in many industrialized countries, but production conditions will rarely support yields in excess of 3,000 kgs. Thus imported semen should not be widely used at farm level, but will be necessary for the production of F1 crosses. Local crossbred bulls, from outstanding dams, can then be used to provide fresh semen on a large scale.

3.15 Most AI services in Africa have been heavily influenced by donors and use sophisticated liquid nitrogen technology and equipment copied from developed countries. Liquid nitrogen is frequently not available, the equipment cannot be maintained, and there is inadequate foreign exchange to purchase the spare parts, chemicals and materials that are not available locally; thus the service is not sustainable in most cases. Frozen semen is not needed once the number of inseminations per bull is reduced; simple technology based on fresh semen is all that is required at this stage. Fresh semen technology was used in all countries in the past and is currently used effectively in New Zealand and China (although the sophisticated New Zealand technology is not appropriate in Africa).

3.16 The difference in labor costs between developed countries and African countries is great. It can cost 10 to 20 times as much to employ an AI technician in the developed world, thus the number of inseminations per operator must be high; a small fraction of that number would still ensure cost-effectiveness in Africa. On the other hand, motorized AI services in Africa incur high transport charges, because it is not possible to achieve a high number of services where dairy herds are small and scattered and where roads and telephones are inadequate. Motor cars and 4-wheel drive vehicles are not cost-effective for inseminators, who must rely on lower cost alternatives, e.g. bicycles or motorbicycles, or travel with the milk collection service.

3.17 Efficient institutions capable of developing and managing AI services are not in place in most African countries, and it is generally entrusted to the national or regional veterinary and/or livestock service. It thus becomes an adjunct to a bureaucratic service which is already lacking the resources and funding needed to discharge its primary functions. The operating costs of the service are either not recovered or only partially recovered because governments are anxious to stimulate AI usage. An attempt is often made to provide a country-wide service even when it is obvious that it should be confined to areas where the service is warranted by the density of farms and the potential for dairy development. Thus it is perhaps not surprising that AI services are generally highly subsidized, badly managed, grossly inefficient and of little or no interest to farmers who are unwilling to rely on a service which exists only in name.

3.18 In Kenya, a good artificial insemination service was built up with Swedish support. A mobile service of small cars made daily rounds and animals on heat were offered by smallholders for insemination in road crushes. In this way, a large number of local stock was upgraded, while agricultural shows, herd books of dairy cattle and milk recording schemes kept the breeders of good dairy stock very active. Later, in the seventies and eighties, shortage of funds led to the replacement of cars by motorcycles, and recurrent budgets were reduced. By degrees the effectiveness of the service dropped, and it came to a standstill in more remote places. Fees had been very low in relation to running costs of the service; they have recently been raised, but they are still insufficient to cover all operating costs.

3.19 In Zambia, the AI service, milk recording system and herd book have been renovated and are functioning for the large commercial farmers; for smallholders the system is too expensive. In Tanzania, AI is mainly concentrated on heifer breeding units for crossbreeding, and on parastatal dairy farms that can maintain a supply of liquid nitrogen. The supply of semen is partly from local bulls but largely from abroad. Smallholder schemes, such as those in Arusha-Kilimanjaro, are hampered by a lack of nitrogen or transport to reach farms in time.

3.20 Despite these negative experiences, AI can play an important role in the future, but only if services are designed to suit the prevailing conditions. An artificial insemination service is required because genetic upgrading is otherwise very slow, and the number of bulls required is large, yet suitable bulls are generally not available in any numbers. Even if bull usage in an AI service were as low as only 1,000 services per bull per year, one AI bull would replace about 20 for natural mating. As a consequence, the rate of return on AI compared with natural mating is usually very attractive from the smallholder's standpoint, even if no allowance is made for the improved dairy merit of the progeny. There is now ample evidence that farmers are prepared to pay insemination charges that cover the operating costs of an AI service if the service provided is efficient and reliable. It is a legitimate public sector function to establish and demonstrate the effectiveness of an AI service; once this has been done, farmer organizations should be involved in its operation and management, and full cost recovery should be implemented.

3.21 The initial establishment of an effective AI service is an adaptive research function that should be entrusted to an agency with a clearcut mandate to undertake R & D for the development of the dairy industry in a particular country. Several arguments for this approach follow:

(i) Under SSA conditions AI cannot yet be regarded as a routine service; considerable work is still needed to develop appropriate technology, to train staff, to implement pilot approaches and to analyze the results (financial as well as technical);

(ii) The success or failure of AI cannot be isolated from other aspects of reproductive physiology (e.g., problems related to heat detection, nutrition, disease and herd management). The research service is the most likely source of the professional and technical staff required for backstopping and training;

(iii) Location in the research service would also ensure that AI is closely linked with the professional animal geneticists involved in choosing suitable genotypes and designing cost-effective animal breeding and selection programs;

(iv) If fresh semen were used, it would be necessary to locate a small number of AI sires at strategic points around the country. The placement of sires, semen collection and distribution, training and monitoring of the inseminators could be facilitated by fully involving the research service in AI; and

(v) The research agency would be the most appropriate body to operate pilot AI services, which might be used to test and modify new or existing technologies;

3.22 While the research agency could handle technology development, it would not be an appropriate body to manage the direct delivery of the service to the farmers. This should be left to farmers' organizations, private veterinarians and/or private inseminators. The discipline and commitment of the inseminators are the most important factors in determining the success of an AI service, and the inseminators should reap the financial rewards of their efforts. In between the basic R&D and the farmer delivery lie the key functions of semen production and inseminator training, which will probably remain as public sector functions until the service is more widely accepted and a viable private sector emerges. A separate unit within the Research Service or general Livestock Service, but with administrative and financial autonomy, would be the most suitable interim arrangement.

Natural Mating

3.23 Natural mating is by far the most important breeding technique available to dairy farmers in SSA. It is the only option in areas where the cattle density is too low to support an AI service or where the AI service is not reliable. If natural mating programs are to be effective, a reliable supply of suitable bulls must be available. Considerable organization and planning are needed to ensure that supply. Government should play a major role, especially in the early years of dairy development, to ensure that suitable bulls are made available and distributed or sold to dairy farmers. This can be achieved by: (i) identifying and purchasing suitable bulls from private commercial farmers, (ii) organizing (or subsidizing) a limited AI service to produce crossbred bulls, (iii) establishing government-owned and operated bull-rearing farms, (iv) organizing importation of crossbred or purebred bulls and (v) organizing the placement (and sale) of suitable bulls with selected smallholders who would provide a mating service to their neighbors on a fee per service basis.

Heifer Breeding Units (HBU's)

3.24 A major constraint on dairy development is the scarcity of suitable dairy stock for new farmers. The supply of surplus dairy stock from large-scale dairy farms (private and parastatal) is diminishing where government controls keep prices down, at least for the favored few. Governments themselves have tackled the problem through schemes like artificial insemination, heifer breeding units/livestock multiplication units and lately through bull breeding units. Heifer Breeding Units (HBU's) are private or public ranches where local zebu cattle are crossed with temperate dairy bulls either by natural mating or AI; the first crosses (F1's) are reared under an extensive system and sold to interested farmers. For example, Tanzania has opted for producing F1 heifers at government or parastatal HBU's; the results are good at well-managed units with a calving rate of 60% to 65% (see Box 3.1 for details on Kikulula HBU).

Box 3.1 Crossbred Heifer Production at the Kikulula Heifer Breeding Unit in Kagera, Tanzania (12,700 ha)

Technical Performance 1976-1988:

	1977/78	1981/82	1984/85	1987/88
Total Stock Nos.	2708	4568	4388	4223
Breeding cows	793	1870	1585	1545
Calving rate (%)	45	69	49	65
Weaning rate (%)	35	63	44	47
Calf mortality rate (%)	24	11	16	22
Total mortality rate (%)	12	10	12	15
F1 born (M + F)	186	891	423	317
F1 sold (females)	0	452	152	216

Investment, Recurrent Costs, and Income (Tsh)

Total Development Costs 1976-88: Tsh 33 million

	1986 - 88 Average	
INCOME (Tsh 000)		
Sale of crossbred heifers	2,800	
Sale of other livestock	2,600	
Miscellaneous	400	
Total income		5,800
Recurrent costs		4,300
Gross profit		1,500

3.25 These large units require substantial investment and recurrent funding. There is some trade-off between initial investment (e.g., in buildings, machinery and paddocks) and subsequent recurrent costs (e.g., disease control and losses). In addition, foreign exchange may be required for an AI facility and for disease control. A large foundation stock is required to start with and also replacement stock on a regular basis since 10% to 30% of breeding cows are culled or die each year. The offtake is often sold at low government prices that are insufficient to meet operating and replacement costs. This leads to a continuous burden on government or donor budgets. It would be more appropriate to sell crossbred heifers (and bulls) at open market prices to ensure that the operations are viable and self-sustaining.

3.26 In order to ensure the continued successful operation of the breeding farms, the income from sales must accrue to a separate farm account, rather than to central funds. The Batoka dairy cross-breeding ranch in Zambia operates under an EC-financed revolving fund where income is used directly for replacement, operational and also to provide incentives for management performance. Tanzanian parastatal heifer breeding ranches are becoming more self-supporting through market-oriented prices, but the livestock multiplication units under direct government control still suffer from highly subsidized sales and insufficient funds for investment and recurrent costs. Another problem is that the proceeds from parastatal units are often shifted into investments or running costs at other farms because of the larger framework of companies. In addition, administrative problems exist in paying staff for good performance (e.g., related to heat detection, conception rate and numbers of F1 heifers produced and sold).

3.27 Stock improvement from within smallholder dairy schemes is developing in some projects like the Kenya Dairy Development Project (Box 2.1) and the Dairy Extension Project in Kagera, Tanzania. Private sector breeding schemes, with government support through incentives, recording and technical inputs, are effective in other parts of the developing world (e.g., in North Africa) and are now emerging for small ruminants in West Africa. Similar approaches should be developed for dairy cattle in Sub-Saharan Africa through credit and technical support programs.

Production Coefficients

3.28 In addition to low milk yields, all traditional livestock production systems are characterized by low calving and weaning rates, high mortality, late age at first calving and long calving intervals compared with performance levels in developed countries. With these typically low production coefficients, a dairy farmer produces scarcely sufficient animals to maintain his own herd, not to mention generating surplus heifers to expand his herd or sell to new dairy farmers. It must be emphasized, however, that the native cattle are not genetically inferior to European-type cattle for these traits (unlike for milk yield). Poor performance is directly related to the prevailing low levels of nutrition and management. The effect of improvements in production coefficients on milk production and the generation of dairy heifers is illustrated in Table 3.3.

Table 3.3 Effect of Improved Production Coefficients

	Basic	Improved
Age at first calving (m)	36	24
Calving interval (m)	18	14
Lactation yield (kg)	2500	2500
Culling age (years)	9	9
Number of lactations	4	6
Total milk yield (kg)	10,000	15,000
Average number of female calves produced per cow	2	3

3.29 The age at first calving, which is primarily influenced by nutritional status, has a marked influence on the productivity of dairy systems. If, for example, a farmer is raising his own replacements, he will have at least 20% more productive milking animals if the age at first calving is two instead of three years (assuming farm size and feed resources are held constant). If heifers are to calve at two years of age, they will need to be ready for mating at 14 to 15 months. Since there is a direct correlation between the age at puberty and bodyweight, young females will need to be on a plane of nutrition that enables them to reach the required weight targets at weaning, mating and first calving. A calving age greater than 30 months should not be considered acceptable, although 36 months or even 48 months is not uncommon if nutrition and management are unsatisfactory. These levels may be tolerable in low potential areas where grazing is free and there is little, if any, expenditure on supplementary feed. However, if grazing is not free and the farm size is limited, as is typical for smallholder dairy farmers, it is imperative and invariably profitable to achieve good performance targets when rearing dairy heifers. In practice this means that the farmer must adopt good calf-rearing practices, including the control of parasites, and be prepared to purchase and feed supplementary concentrates as required.

3.30 Although calf rearing in the developed world has been transformed over the past 50 years, the technology developed is not available in SSA in many cases or is not applicable. The first major development was the introduction of whole milk replacers, based on skim milk powder and vegetable oils. This enabled whole milk to be replaced in the first few days of the calf's life by a nutritionally equivalent product costing about half the price. Such milk replacers are rarely available in SSA and, at any rate, would not be as appropriate for zebu and zebu crosses because of the necessity to stimulate milk let down by suckling. Suckling is also associated with a lower incidence of calf scours, which can cause high levels of morbidity and mortality if hygiene is unsatisfactory, and it helps to reduce the incidence of mastitis in milking cows (Preston 1989).

3.31 The second major development in calf rearing was the introduction of early weaning calf feeds that enabled calves to be weaned from whole milk or replacer at an early age. The quantity of whole milk fed to the calf can be drastically reduced to about 50 kgs, compared with up to 200 kgs in suckling systems. In most SSA countries the high quality ingredients like milk powder, soya bean meal, minerals and vitamins required to formulate these feeds are either not available or of greater value as human food. Intermediate steps, however, can be taken, such as partial substitution of milk or its supplementation in calf feeding. Thus the formulation of quality calf feeds and the encouragement of their widespread use should be given much more attention in all African countries. Suckling will remain the preferred system in most cases, but unless calf rearing standards are markedly improved to enable heifers to calve at an early age, the rate of expansion of the national dairy herds will be seriously constrained.

Camels, Goats and Sheep

3.32 Although cattle account for the bulk of the marketed milk and milk products, the large number of camels, sheep and goats make a significant contribution to total production, especially in the arid and semi-arid zones. The estimates of milk production from these sources (especially camels) must be treated with caution, but available figures indicate that camels contribute about 21% of the total, goats 14% and sheep 9% (Annex 2). Three countries in Eastern Africa (Somalia, Sudan and Ethiopia) account for almost 80% of the camel herd and milk production, with Somalia alone contributing about 50%. Five countries in Western Africa (Chad, Mali, Mauritania, Niger and Senegal) and five in Eastern Africa (Ethiopia, Kenya, Somalia and Sudan) account for almost all of the sheep and goat milk, with Sudan alone contributing almost 40%.

3.33 Camels are important for milk production in the arid zone, especially in Somalia. They are well adapted to a bush/tree-dominated landscape by virtue of their browsing abilities, and they can efficiently utilize resources at a distance (20 to 30 kms) from water sources. The milk yields of camels in Somalia and Sudan are about 1600 to 1900 kgs on average, during a lactation period of 12 to 18 months; the average calving interval is about 24 to 30 months. Since the camel has a longer lactation period than other domestic animals and is probably less seasonal in its milk production, a fairly constant milk supply is ensured (Wilson 1987). Traditional production systems are relatively efficient and, apart from improved health care, there is little prospect that significant improvements will result from new technologies. The comparative advantage of the camel over other livestock is confined to its ability to browse and graze in very dry areas. As grazing and feed conditions improve, camels give way to cattle and sheep; in tsetse-infested browse areas, they give way to goats, which are more trypanotolerant. Consequently, camel milk production systems provide few prospects for further commercialization, but they will remain important for largely subsistence production in the arid areas.

3.34 Goats and sheep also contribute significantly to the subsistence requirements of pastoralists and agro-pastoralists in the arid and semi-arid zones. Goats are predominant in pastoral systems, but the proportion of sheep increases under agro-pastoral and mixed farming systems where crop by-products are more plentiful. The small size, reproductive efficiency and relatively low cost of sheep and goats make them attractive to smallholders with limited feed resources and capital. Flocks regenerate rapidly after drought or disease outbreaks; restocking in these circumstances is handled mainly through traditional lending and herding arrangements, without the need for official credit.

3.35 The East African Nubian goat, the Sudanese Nubian, the Ethiopian Abyssinian and the East African fat-tailed sheep are the main indigenous dairy breeds in SSA. In pastoral and agro-pastoral systems, goats typically yield about 40 to 60 kgs per lactating female (over and above that consumed by the kids); milk yields for sheep are some 25% to 30% lower, although the fat content is substantially higher. Higher yielding goat breeds (e.g., the Saanen and Toggenburger) have been imported from temperate countries and used for crossing, but their contribution to date is relatively small. Intensive small ruminant milk production systems require good disease control, feeding and management. Experience from Western Kenya, where dual-purpose goats were introduced, suggests that farmers may be reluctant to make the investment of time and money required for good results. Sheep and goats will continue to play an important role in the less-favored areas, but cattle will be the preferred dairy animals where feed resources and diseases permit.

IV. FEEDS AND FEEDING

Introduction

4.01 Nutritional factors are the binding constraint on increasing milk production in SSA and in most cases are more important than the genetic potential of the animals for milk. Both quantity and quality aspects are important, and in most cases production could be increased if either the quantity of feed on offer or its quality could be improved. The interaction between "dairy merit" and the economics of feeding is of singular importance. When indigenous stock with a low yield potential are involved, farmers are reluctant to grow improved pastures and/or feed supplementary concentrates because the milk response is small and may not justify the additional cost. Consequently, improvements in genotype and feed supply must be planned to occur simultaneously.

4.02 Two broad categories of feeds can be distinguished: roughages and concentrates. Roughages are relatively high in fiber and low in energy; only ruminants have a digestive system that enables them to digest high fiber feeds. Natural pasture is the principal source of roughage in SSA; other sources include improved pastures, cereal byproducts, rootcrops and pulses, which in aggregate constitute 10% to 15% of the total. Statistics are not available in most countries on the cultivated forage area. An estimate of the quantity of roughage available (other than cultivated forages) is given in Table 4.1.

Table 4.1 Estimate of Dry Matter (DM) Availability from Natural Pastures and Crop Residues in Sub-Saharan Africa

	Area '000 km2	% Land area SSA	Roughage DM kg/ha	Total DM mln tonnes
Permanent pasture	5748	24.7	1000	574.8
Cereals	583	2.5	1000	58.3
Rootcrops	132	0.6	400	5.3
Pulses	99	0.4	500	5.0
Total	6562	28.2	-	643.4

Source: Based on data from FAO Production Yearbook 1987.

The total quantity of dry matter may appear to be sufficient to meet the full needs of about 215 million livestock units (with a current population of about 150 million). But this is misleading. A substantial but unknown amount of dry matter located in heavily infested tsetse areas, is destroyed by burning or eaten by insects. The overall apparent abundance masks the fact that in most cases animals are short of feed (even short of low-quality dry matter) in the dry season.

Natural Pastures

4.03 Natural pastures in most of SSA are inadequately nutritious, even under optimal management and stocking rates, to sustain satisfactory levels of production and health for most of the year. In order to survive, grasses grow rapidly during the rains, but within about two months growth become fibrous. This characteristic growth and development pattern, resulting in the rapid rise in lignin content with advancing age and the consequent decline in digestibility, makes it difficult to supply high-quality materials for grazing animals on a consistent basis. Consequently, milk yields of cattle on natural pastures alone rarely exceed 3 to 4 kgs per cow per day. The quantity of feed available can be influenced to some extent by grazing management, regrowth and the pattern of rainfall, but the overriding quality constraint cannot be overcome except by supplementary feeding. Furthermore, when animals are confined solely to natural grazing and crop byproducts, they are alternately subjected to either feast or famine conditions. During the rainy season, they normally have a surfeit of forage, albeit of restricted quality, while in the dry season both the quantity and quality are severely restricted. In many instances the animals have to rely heavily on crop byproducts for survival until the next rainy season. Ensiling and/or making hay can partially overcome the dry season feed problem, but unimproved pastures cannot be expected to provide more than the basic maintenance requirements of animals in commercial dairy production systems.

Cultivated Forages

4.04 If justified by the milk price and rainfall pattern, the quantity and quality of feed available to dairy animals can be improved substantially by cultivated forages. These can include grass and legumes grown as a component of crop rotations or as permanent pastures, and also fodder trees and shrubs. The feeding value of cultivated forages is far superior to native pastures; in adequate quantity and under good management, they can sustain yields up to 8 to 10 kgs per cow per day. Forage yields are governed by a number of factors including rainfall, soil fertility, fertilizer application, irrigation and the species involved. Under smallholder conditions in Sub-Saharan Africa, grass leys typically yield about 4 to 5 tons per ha of dry matter, napier grass (or similar type pastures) 8 to 16 tons per ha, forage legumes about 3 to 4 tons per ha and fodder trees and shrubs about 1 to 2 tons per ha. Much higher yields have been recorded on large commercial farms or on experimental stations with increased inputs and management. For example, yields of 5 to 15 tons per ha have been reported for planted forage trees on smallholdings in Ethiopia (Robinson 1990, personal communication).

4.05 Maize and sorghum are excellent forages, either as green feed or silage for dairy animals, and they can be economically grown in locations with rainfall in excess of 600 to 700 mm. Their use is sometimes limited by the size of the smallholding and the need to reserve these crops for food production. Furthermore, maize and sorghum are best utilized as silage, but smallholders rarely produce sufficient quantities to justify silage making. Forage grasses and legumes are favored in many instances because they provide a "break" from maize or sorghum in the rotation. There is now ample evidence that forage trees, in alley farming systems, can make an important contribution to feed production on small farms. Alfalfa is an excellent high protein forage that is favored for feeding with maize silage in those parts of the world where conditions are suitable for its production. In Sub-Saharan Africa alfalfa is normally grown under irrigation at high elevations and fed with maize silage (e.g., on large commercial farms in Zambia and Zimbabwe); its use is limited by poor management.

4.06 The potential for improved forage production is primarily governed by the agro-ecological zone, and especially by rainfall; it is also influenced by land tenure, land use rights and farm size. In arid areas with rainfall less than about 400 mm per year where pastoral or agro-pastoral systems are followed, there is no cost-effective technology at present for improving dry matter production or quality by sowing grasses or legumes; responses to fertilizers are too small to justify their use. The best that can be achieved in arid areas is to make marginal improvements and/or to ensure the long-term sustainability of the system by paying more attention to water and range management and agro-forestry. The deleterious effects of overgrazing can be corrected by resting the pasture or adjusting the stocking rate. Therefore it is not a question of technology but one of finding a way to implement grazing control when animals are privately owned and grazing is communally owned. The introduction, or reintroduction, of grass and legume species in overgrazed areas can be achieved by growing small plots in fenced-off areas, allowing the seeds to disperse naturally; this system has been successfully tried in Mali. Crop cultivation poses the most serious hazard in arid areas, and it is usually the main cause of degradation if, and when, it occurs. Where cultivation cannot be avoided, the problems can be ameliorated through the introduction of more sustainable crop/forage livestock systems. There is evidence that Leucaena and some stylos (e.g., Wynn cassia) can make an important contribution to feed production where rainfall is 400 to 600 mm. Range improvement by oversowing at low seeding rates is considered possible (Robertson 1990, personal communication), but its cost-effectiveness needs further study.

4.07 Unlike in arid areas, in semi-arid and sub-humid zones, where rainfall ranges from 600 to 1200 mm, promising technologies do exist for increasing forage production. For the rainfall belt between 600 mm and 800 mm, a number of improved strains of forage grass species (e.g., Buffel and Rhodes) and forage legumes (e.g., Siratro and strains of Stylosanthes) have demonstrated considerable promise. There is inadequate experience with these improved grasses and legumes under SSA conditions, although this is being addressed by the inclusion of forage production components in ongoing livestock projects (e.g., World Bank/IFAD: Ethiopian Fourth Livestock Development Project). Apart from forage legumes, a number of food legumes are available, such as cow peas and groundnuts, whose straw and husks can provide a large amount of feed per hectare.

4.08 In areas with rainfall between 800 and 1200 mm, the technology exists to substantially improve the quantity and quality of dry matter in rangeland pasture areas and in fallows on mixed crop/livestock farms. This improvement hinges on the introduction of improved grasses (e.g., Rhodes, Setaria and Panicum), pasture legumes (e.g., Siratro and Stylosanthes species) and tree legumes and shrubs (e.g., Leucaena leucocephala). Research undertaken by ILCA in the sub-humid zone in Nigeria is demonstrating the value of stylosanthes and forage trees; not only do they produce large quantities of additional forage, but they also substantially increase crop yields (e.g., of maize) when the area under the legume is subsequently cropped. Despite the existence of improved technology, rangeland improvement has been problematic because the forage legumes available could not withstand burning or be maintained in the sward without good management. However, recent introductions, such as Seca stylo and Verano, are reported to withstand annual burning at locations in Ethiopia with 800 to 900 mm rainfall.

4.09 Thus improved pastures have a role, not only on mixed crop/livestock farms, but also on rangeland (through oversowing), although the potential for such rangeland improvement needs considerable study. The adoption of improved pasture technology is expected to be slow in the foreseeable future because of constraints such as limited availability of improved grass and legume seeds, and the need for applied research and extension to demonstrate technical and economic feasibility in farming systems.

4.10 There is a good potential for forage production in the humid and sub-humid zones, where the rainfall is more than 1,200 mm per year. Improved grasses -- such as Guinea grass (Panicum maximum), para grass (Brachiaria mutica) and molasses grass (Melinis minutiflora) -- can be grown without difficulty, as can a number of legumes (e.g., "Centro") and the favored browse tree, Leucaena. In these locations forage quality is the main problem, especially in the dry season when legumes and conserved forages can play a key role. The highland zone has an excellent potential for forage production; depending on altitude and rainfall, a large selection of grasses and legumes with relatively high feeding value can be grown.

4.11 The adoption of improved pasture and forage technology is constrained by a number of factors including:

(i) land tenure arrangements that deny smallholders full ownership rights to grazing and fallow land, but permit uncontrolled access to communal grazing and fallow land, even in high rainfall areas (e.g., in Zambia);

(ii) inadequate applied research and demonstration to adapt the technology to local conditions and to quantify responses and benefits;

(iii) inadequate extension services; and

(iv) inadequate supplies of grass seeds, legume seeds and planting material,or facilities to produce them.

4.12 If governments seriously intend to promote dairy production, they should devote much more attention to applied research on forage production. Extension services should emphasize forage production and utilization as part of their routine work. Sufficient basic technology is now available to make an immediate impact on feed supply by the inclusion in donor projects of well-designed forage components. Provision also should be made for seed production and distribution, as well as technical support services. The World Bank and other donors are now paying increased attention to forage production (e.g., in the Fourth Livestock Development Project in Ethiopia, the Second Livestock Project in Nigeria and the Central Rangelands Research and Development project in Somalia). In view of the diversity of climatic, soil, social and economic conditions encountered in SSA, more pilot projects are advocated. Donors could also help by providing additional assistance to ILCA's valuable research and training programs on forage production and utilization, and to its pasture and forage network for Africa.

Other Roughages

4.13 Apart from native pastures and cultivated forages, maize stalks, sorghum and other cereal straws and food legume hays are the main roughages available in SSA; they are often the main or only source of roughage in the dry season. But because of their low digestibility, which severely restricts the amounts consumed, these roughages are inadequate to provide even maintenance for dairy cattle. Although several techniques have been developed to improve digestibility and intake levels, few if any of these techniques are widely practiced in SSA. Chopping and chemical treatment with ammonia or urea are the most successful techniques employed elsewhere for the delignification of high fiber forages. Chopping is commonly practiced in India and Turkey, and ammonia treatment has been successfully practiced in Egypt and other countries where substantial quantities of straw are available per farm (Creek et al. 1984). Urea application (to generate the ammonia) is considered the treatment of choice for the quantities available to smallholders. Straw treatment offers interesting possibilities in particular locations in SSA, especially on irrigation schemes where substantial quantities of straw are available and cattle are also kept (e.g., in Mali, Senegal and Sudan).

4.14 The conservation of pastures and forages as hay or silage, although practiced on commercial farms, is not generally practiced by smallholders in SSA. Smallholders are at some disadvantage for silage making because the quantities are too small to justify labor-saving equipment and facilities, and it is difficult to maintain wastage and spoilage at acceptable levels when small quantities are involved. The successful introduction of maize silage on smallholder dairy farms in Malawi and the use of molasses for ensiling Napier grass on smallholder dairy farms in Kenya are worthy of special attention. Kenyan smallholders shared equipment and pooled resources to enable silage pits to be filled quickly, a prerequisite for good silage. Despite these isolated successes with silage, it is probable that hay making will prove to be the simplest and most acceptable conservation technique for smallholders. Storing roughage as standing hay is the simplest method of conservation, although the feeding value of the product is very low and dry matter losses are high; it can be justified only for native pastures where the objective is to protect the hay from grazing and burning. The successful development by ILCA of Stylosanthes forage banks in Nigeria is especially noteworthy because it shows that stylo can be stored as standing hay. However, farmers preferred to use it as a survival ration for starving animals, rather than as a supplementary ration for producing animals. Sugarcane has been successfully grown in Mexico and the Philippines for feeding to dairy cattle. Because it can be harvested at any time, sugarcane can contribute to dry season supplementation. Tree legumes can make an important contribution to dry season feed supplies on smallholdings and deserve special attention.

Concentrates

4.15 Concentrates are feedstuffs with a relatively low fiber content, high energy (carbohydrate) and protein levels and high digestibility. In practice, they are usually subdivided into energy and protein feeds; a distinction is made between high-energy and low-energy concentrates and between high-quality land low-quality protein feeds. Maize, wheat, barley and cassava meal are considered high energy feeds; oats, wheat pollard and rice bran are considered low-energy feeds. Soybean and fishmeal are high-quality protein feeds (high crude protein content and high levels of lysine and methionine); cottonseed cake and oilcakes are low-quality protein feeds because the levels of the essential amino acids, lysine and methionine, are low. Concentrate feeds are valued on their energy and protein levels and their protein quality. High-energy and high-quality protein feed ingredients are expensive because of their special value as pig and poultry feeds. They are not essential for dairy animals since these animals can efficiently utilize the whole range of energy and protein concentrate feeds, as well as roughages. Thus concentrate feeds for supplementing roughages and for balanced dairy ration formulation are much less expensive and less difficult to procure in Africa than are feeds for pig and poultry rations.

4.16 Apart from maize, millet and sorghum grains, which are primarily consumed by the human populations, the main concentrate feeds in SSA are cereal bran, oilseed cake, molasses and byproducts from brewing. In 1986/87 SSA produced an estimated 4.7 million tons of cereal bran/pollard (assuming 10% extraction rate) and about 1.2 million tons of molasses (assuming a 35% extraction rate). Furthermore, large quantities of cereal bran/pollard, oilseed cake and meal, and oilseeds were exported, especially from West Africa (see Box 4.1). The total value of feeds exported was about US$163 million, at a time when milk imports amounted to about US$444 million. The quantities exported could produce a substantial tonnage of milk if fed to dairy animals. Although the large milk-importing countries are not always the feed exporters, there is clearly scope in a number of countries to utilize these feeds for import-replacing milk production. Ample concentrate feeds are available to expand dairy production in all four regions, although there is a need to assess the feed supply in each individual country when considering the expansion of dairying.

Box 4.1 Export of Feed Ingredients from Sub-Saharan Africa and Imports of Milk

	Western	Central	Eastern	Southern	Total
Export volume (x 1000 mt):					
Oilseed cake and meal	377	38	90	61	556
Oilseeds	593	4	106	108	812
Bran and other by-products	103	26	12	0.3	142
Est. molasses production: (x 1000 mt)	126	87	430	559	1202
Exported feed expressed in:					
Metabolizable energy (mln Mcal)	1752	151	357	274	2534
Liquid milk equivalent (1000 mt)	1168	100	238	183	1689
Milk production and imports:					
Production (x 1000 mt)	1906	453	8768	642	11769
Imports (x 1000 mt) Liquid milk equivalent)	922	252	555	253	1982
Value of milk imports (US$ mln):	213	82	92	56	444
Value of feed exports (US$ mln):	74	8	60	21	163

Sources: Calculated from FAO Production Yearbook 1987 and FAO Trade Yearbook 1986.

4.17 The best strategy for improving the supply of concentrate feeds is to encourage overall crop production, thereby increasing the supply of byproducts and perhaps generating a surplus of grain for animal feed. A number of countries in SSA (e.g., Sudan and Zambia) have the land resources to produce substantial quantities of feed grains, over and above their food requirements. However, large amounts of forign currency would be required for fertilizers and other inputs. Thus it is unlikely that significant quantities of grain will be available for ruminant feeding in the near future.

4.18 More attention should be given to improving the quality of feed ingredients. The quality of oilmeals and cakes could be improved considerably if the present crushing method of expelling oil were replaced with solvent extraction technology. The grain milling process could also be improved considerably in most countries, and this would result in animal feed byproducts of better quality. Better processing would reduce the fat content of byproducts, which would enhance their storage by reducing rancidity and spoilage. The use of molasses for animal feeding is often constrained by the absence of handling, storage and transporting equipment. Although reliable information is not available, it is frequently reported that large amounts of molasses that cannot be exported or used for beer production are wasted or dumped. Brewery byproducts are bulky and costly to transport and are typically used by specialized peri-urban dairy farmers located nearby, or by feed producers. Other industrial byproducts, such as pineapple pulp, copra meal and citrus pulp, are also suitable as supplementary feeds.

Economics of Feeding

4.19 Three factors profoundly affect the economics of feeding dairy animals: the relative cost of different feeds, dairy merit of the animals and the milk price received by the farmer. Roughages are normally much less expensive than concentrate feeds per unit of total digestible nutrients (TDN). Thus farmers are anxious to maximize their use. In Western Europe, concentrates can be up to eight times as expensive as grazed grass per unit of TDN; the ratio may be even higher in SSA, where indigenous natural pastures are grazed. A large amount of feed is required to maintain a cow, but the share of total feed needed for maintenance declines as the milk yield increases. The result is that a cow producing some 500 kgs of milk per year needs about 2.5 feed units per kg of milk, while the requirement drops to about 0.5 units per kg of milk when annual production reaches 5,000 kgs.

4.20 The incremental milk response to concentrate supplementation is affected in a major way by the cow's ability to substitute concentrates for forage and by its dairy merit, which reflects its ability to convert feed efficiently into milk. Although nutritionists have shown that about 0.4 kg of good quality concentrate feed contains adequate nutrients for one kg of milk, the actual response is much less for cows on pasture or fed roughage ad libitum. Increased feeding of supplements reduces the intake of roughage, but this effect is often overlooked when calculating expected responses from supplementation. For all practical purposes, it may be assumed that the response will rarely, if ever, exceed one to one (1 kg milk per kg concentrates).

4.21 The milk/concentrate price ratio governs the choice of feeds and the optimum quantity of concentrate feed that can be fed in any given situation. For example, this ratio is about 1.5 close to urban centers in Kenya but about 2.5 near population centers in Senegal; as a result, there is higher feeding of concentrates in Senegal. Unless the milk/meal price ratio is greater than one, the economics of feeding concentrates are considered very doubtful, apart from small quantities for special purposes. At present the ratio is considerably greater than one in virtually all SSA countries, and as high as 3 or 4 in many countries. Therefore, the economics of concentrate feeding are attractive if animals, with adequate dairy merit to justify feeding, are available. The ratio has improved dramatically in recent years as a result of increased milk prices. The overall profitability of dairying has increased markedly all over SSA. However, farmers are often unable to purchase adequate amounts of concentrates because supply services are weak or absent. A study of concentrate usage in Kenya, for example, found that there was a decrease from 460 kgs per cow per year to 193 kgs per cow per year, when the distance from the concentrate supply center increased from 1 to 10 kms.

4.22 The adoption of improved feeding practices by farmers is constrained by the following factors:

(a) inadequate applied research and demonstration to quantify responses and benefits;

(b) limited extension and farmer training programs; and

(c) an inadequate supply and distribution system to meet farmers' needs for concentrate feeds; in many cases this is exacerbated by government regulations and controls that hinder or restrict private sector participation in the animal feed industry.

4.23 As already emphasized in relation to forage production, governments need to pay much more attention to applied research on livestock feeds and feeding in general. A similar research and development approach, as well as pilot projects, are called for to quantify and demonstrate benefits to farmers. Donors can play a valuable role by supporting efforts to strengthen applied research on feeds and feeding, and by providing additional resources to strengthen ILCA's research and training efforts in this field.

4.24 There is also a need to strengthen the feed industry at all levels, including the provision of storage and milling/mixing facilities, and to promote private sector involvement. Government should establish the legislative framework and quality standards; the analytical services required for quality control can be carried out by either the research service or the private sector. Macroeconomic distortions may create an incentive for companies to export feed, in order to obtain vital foreign exchange, rather than sell it at home. The design of donor projects should take full account of the broad economic and regulatory framework and consider the project conditions or structural adjustments required for effective interventions in this area.

V. ANIMAL HEALTH

Introduction

5.01 Animal health problems in SSA are closely linked to the environment, management methods and genetic factors related to disease resistance in the animal population. If the major, fatal diseases are controlled through national vaccination campaigns, then the vector-borne and parasitic diseases will be the most common health problems at the level of the individual dairy herd. However, as production systems are intensified, and higher producing animals with at least some exotic blood are introduced, then other disease problems will become more apparent. Animal health problems have a particular impact on milk production since they can lead to the loss of a whole lactation; there is little opportunity for compensatory gain, as in beef production.

5.02 Infectious and parasitic diseases are common throughout the region, but the possibilities and mechanisms of control vary considerably. Vaccination against the principal infectious diseases, such as Rinderpest and Contagious Bovine Pleuro-Pneumonia (CBPP), is required to ensure the animals survive. New techniques have improved the vaccines in many cases and have reduced their costs of production; operating expenses account for most of the cost of mass vaccination campaigns. In small dairy herds, vector-borne and parasitic diseases are the most common health problems, but management problems and/or the high cost of drugs often limit the effective control of these diseases in the field. The strict environmental controls necessary to eliminate these diseases are difficult to achieve under current smallholder conditions.

Tsetse and Trypanosomiasis

5.03 The distribution of tsetse flies, the main vector of trypanosomiasis, has played a major role in the distribution of livestock in SSA (see map). The distribution of dairy production systems and the degree of tsetse challenge for the five agro-ecological zones are shown in Table 5.1.

Table 5.1 Dairy Production Systems and Tsetse Challenge by Agro-ecological Zones

Agro-ecological zone:	Arid	Semi arid	Sub-humid	Humid	High-lands
Dairy production system:					
Pastoralism	++	++	-	-	-
Agro-pastoralism	-	++	+	-	++
Mixed farming	-	+	++	+	++
Intensive dairying	-	-	++	-	++
Peri-urban dairying	-	++	++	+	++
Tsetse challenge	-	+	++	+++	+

Dairy Production System:

- \- production system does not exist
- \+ production system exists under specific circumstances
- ++ production system exists

Tsetse Challenge:

- \- none or very limited
- \+ tsetse in limited areas
- ++ tsetse in 30%-60% of area
- +++ tsetse in over 70% of area

The challenge is most severe in the humid zone, which accounts for less than 4% of the milk produced in SSA, although it includes 18% of the land area. The International Laboratory for Research on Animal Diseases (ILRAD) has estimated that some 50 million cattle, 30 million sheep and 40 million goats are exposed to trypanosomiasis.

5.04 There are three approaches to reducing losses from trypanosomiasis: trypanotolerant cattle, trypanocidal drugs and tsetse control. The milk production potential of trypanotolerant cattle is low, and thus their role in commercial milk production systems is limited to high-risk areas. Trypanocidal drugs are used particularly in areas of low tsetse challenge and/or low livestock density, where tsetse control is less economic. The rotation of drugs in animal treatments is necessary since there is evidence of resistance to every drug now in use; these regimens require thorough observation of the herds and strict management. The use of insecticide-impregnated traps and/or screens seems to offer a cost-effective, nonpolluting and flexible method to control tsetse flies, especially for relatively small areas; for riverine flies, costs can be as low as $0.30 per animal protected. Unlike the large-scale clearance approaches, this method creates the possibility of farmer participation in control schemes, probably on a group basis. However, ILRAD reports that the elimination of the great majority of the tsetse population in parts of the Ivory Coast had little impact on the prevalence of trypanosomiasis (Doyle 1990, personal communication). Thus some combination of trypanocidal drugs and tsetse control will be needed to protect dairy animals.

Ticks and Tick-borne Diseases

5.05 Ticks are found in all areas of SSA that are suitable for livestock production. They act as disease vectors and also directly affect productivity. While indigenous cattle have a high level of resistance to ticks and tick-borne diseases, exotic animals and, to a lesser extent, crossbreds are highly susceptible. The primary control strategy has been to reduce tick numbers using direct methods (dipping, spraying and manual de-ticking) and indirect methods (e.g., pasture burning). New control techniques are being developed; there is the prospect of simplified acaricide treatment by pour-on formulations or slow-release implants; immunization against tick attachment is also promising. To get the full benefit of these new methods, and also of new and more effective chemicals, knowledge of the different tick genera and species will have to be more widely disseminated to farmers, veterinarians and animal husbandry specialists. A viable tick control strategy must also take account of tick ecology, especially the seasonal dynamics of tick populations. Over much of Central and Southern Africa with monomodal rainfall distributions, the important tick species are very seasonal. For significant periods of the year, frequent dipping is not economically justified. The potential returns to the progressive dairy farmer using exotic purebred or crossbred stock are high enough to justify and pay for intensive year-round tick control, but his animals are always at risk. Experience elsewhere (e.g., in Australia) suggests that Zebu breeds and crosses and the use of more tick resistant Bos Taurus breeds (e.g., Jersey) may yield economic benefits to the farmer despite lower milk yields.

5.06 Protection against the principal tick-borne diseases (e.g., Anaplasmosis, Babesiosis, East Coast Fever and Heartwater) is now available through premunization (by artificial infection and treatment), but not on a large scale. Two significant disadvantages of this technique are fragility of the infecting organisms, and therefore problems of distribution, and the need for close supervision after the infection. Current research is expected to lead to effective killed vaccines against Anaplasmosis and Babesiosis in the near future, but no such vaccines are in sight for East Coast Fever or Heartwater. East Coast Fever, in particular, has long been recognized as a major constraint on the development of dairy (and beef) production in Eastern and Southern Africa. In addition to the heavy mortality it causes, especially in European cattle breeds, the disease can affect the productivity of surviving cattle by reducing milk yields and weight gains. Since a relatively safe and effective procedure is now available to immunize cattle against East Coast Fever, milk production should improve. However, the technology is still complicated and expensive to deliver. It may be necessary to develop special centers (public or private) where animals are immunized and subsequently sold. These centers would be similar to the test camps established early this century to provide naturally immune cattle as transport oxen throughout Kenya. For example, calves could be immunized on selected breeding units before distribution to smallholders.

Other Diseases

5.07 Dermatophilosis is a major constraint on the introduction of exotic animals and crossbreds, especially in West Africa where it causes production losses and even leads to death. The incidence is generally related to humidity and to lesions caused by thorns, ticks or biting flies; the reduction in milk yield depends on the length and severity of the attack. There are as yet no fully satisfactory therapeutic or preventive measures, but tick control does result in reduced incidence.

5.08 The incidence of brucellosis, which causes abortions in cows and gives rise to serious human health problems, may be expected to rise sharply with intensification of dairying. An effective, relatively low-cost vaccine is available. Thus heifer vaccination (at least) should be undertaken in all emerging dairy systems. Abortion results in the loss of the calf and the subsequent lactation, which means a substantial loss of income to the farmer; thus vaccination is justified, even at low incidence levels. However, national eradication programs would not yet be justified in most SSA countries. Tuberculosis does not cause significant production losses, but some control measures are required because of the possible human health hazards. The standard control measure is to test the animals and slaughter those affected, but this is obviously expensive. An interim step would be to establish a core of "clean" herds, which would be licenced to supply the major urban areas, as was done in Europe and elsewhere.

5.09 Foot-and-Mouth disease, which is endemic in most parts of SSA, has a major impact on milk production in particular. Suitable vaccines are available, and all dairy animals should be vaccinated on a regular basis (i.e., twice per year for cows). As dairy farming becomes more intensified, other diseases and conditions become more apparent. Among them are internal parasites, mastitis, neonatal diseases and nutritional deficiencies (especially copper and phosphate). Some of these diseases are chronic, and their appreciable economic impact is not immediately apparent; well-designed prophylactic regimes would be cost-effective. Integrated programs are required to control helminths, combining veterinary treatment (anthelmintics) and management approaches (grazing systems); regular deworming of calves and young stock should be undertaken in intensive dairy production systems. There is often a knowledge gap about species distribution and life cycles and the effects of different husbandry and veterinary interventions; applied research and extension are required to close this gap.

5.10 Acute and subclinical mastitis is widespread in smallholder dairy production systems because of poor hygiene, inadequate housing and lack of knowledge as to causes and treatments. Its control depends largely on effective education of farmers regarding hygiene and milking/suckling methods, supplemented by the use of antibiotics in the more intensive systems. In less intensive systems, suckling helps to reduce the incidence of mastitis and is also associated with a lower incidence of calf scours.

Zoonoses

5.11 Some animal diseases can be transmitted to man by consumption of milk or milk products containing the pathogen (e.g., brucellosis and tuberculosis). The control of such milk-borne zoonoses at the source by reducing the occurrence of these diseases in the animal population is an obvious priority, but it will take some time to achieve widespread disease control. In the meantime, the safest way of controlling pathogens in dairy products is through proper heat treatment of the milk and prevention of contamination thereafter. This need not involve an expensive process like pasteurization but may simply require boiling by the processor and/or consumer. In fermented dairy products, the survival of pathogens is affected by heat treatment and other factors: acidity, control of temperature during manufacture and storage, salt concentration and maturity of product (Northolt 1984).

5.12 There is a potential human health problem in some countries regarding residues of acaricides, drugs and/or herbicides in dairy products. For example, in Kenya, samples from bulked consumer milk supplies contained dioxathion (used for tick control) at concentrations of up to 0.35 parts per million (ppm), compared to the FAO tolerance limit of 0.2 ppm. Most countries lack adequate legislation to control contamination, and the scarcity of reliable testing facilities and the largely informal marketing systems preclude effective monitoring in many cases. Thus the problem must be tackled at the source (i.e., by careful selection of the acaricides, drugs and herbicides that are allowed onto the market. The risk to human health from residues must also be weighed against the benefits of improved nutrition and/or higher rural incomes.

Animal Health Services

5.13 Livestock services in SSA still have a strong veterinary bias, and many routine functions are restricted to professional staff. Preventive and curative services are often the responsibility of the government, and there is as yet little involvement of the private sector. Animal health services represent some 80% on average of the budgets for livestock services (de Haan and Nissen 1985). An effective service should spend about as much on other operational costs as it does on personnel, but at least 75% of livestock budgets in most SSA countries is devoted to personnel. The effect of this is that services are often critically short of operating funds for supplies, transport, and travel. Cost recovery is not generally practiced and, when introduced, is often not adequately controlled.

5.14 Because of externalities and economies of scale, government involvement in the supervision and enforcement, as well as in the funding, of mass vaccination campaigns is necessary and justified. However, it should be possible in the long term to subcontract the execution of the actual campaign work to the private sector under the direct supervision of governmental professional staff. Vaccination policies should aim at establishing fees that would at least cover all nonsalary operating costs to ensure sustained financing of future campaigns. Past experience would suggest a cost of $0.30 to $0.40, which would seem to be well within the producer's ability and willingness to pay. Some of the same arguments apply in relation to vector control measures (e.g., tick and tsetse control) since they give rise to private and social benefits. The primary emphasis of government involvement should be on the dissemination of information (extension) and on quality control, rather than on direct management of facilities.

5.15 Unlike preventive care, curative services are predominantly private goods. In other words, the value derived from the service goes almost entirely to the owner of the livestock. This is also the aspect of veterinary service for which producers most readily see the need and are most prepared to pay; milk producers, in particular, will have the necessary income and the greatest incentive to avoid lost production from disease. It is especially in this area that fast responses, which the private sector is best equipped to provide, are essential. The privatization of veterinary services can take place either through individual practice or through farmers' associations (e.g., as in Taiwan) or formal cooperatives (e.g., as in India). One of the arguments raised against private practice in Africa is that it will discriminate against poor producers. However, evidence from Kenya has shown that the level of inequity in the distribution of care decreased when (unofficial) commercial veterinary care was introduced; the number of curative visits increased (up to tenfold) and political and social pressures were greatly reduced (Leonard 1987).

5.16 A substantial part of the basic veterinary work could be carried out by agro-vets, veterinary assistants or livestock extension staff under the supervision of a veterinarian. The staff might be hired by a herders' association or a cooperative, with back-up services (especially diagnostic laboratories) provided by the government. The support given to privatization by the World Bank, the EEC, FAO and other agencies, through the Pan African Rinderpest Campaign and other development programs, could ensure the provision of basic equipment and initial supplies on a revolving fund basis. Although these funds will generate income, it will be in local currency, and foreign currency allocations will be required to allow the associations to purchase drugs and other inputs.

5.17 All dairy projects should have an animal health component to ensure that producers have access to an efficient, reliable veterinary service. This is of particular importance when less resistant crossbred animals are being introduced. The veterinary component should address not only the technical issues, but also the staffing and organization of veterinary services on a sustainable basis. They should take account of the experience to date with privatization and the use of para-professional staff in many locations in SSA.

Animal Health Packages

5.18 Appropriate health packages for cattle, camels, goats and sheep in different production systems and agro-ecological zones are summarized in Annexes 3 and 4.

VI. COLLECTION, PROCESSING AND MARKETING

Evolution of Processing/Marketing Systems

6.01 Milk production in the industrialized countries developed within the past 200 years from being a byproduct of animal production systems geared mainly toward meat and draft to the principal output of the system. This development was influenced partly by technology changes within the sector, but principally by the overall economic development of the countries concerned -- in particular by the growth of incomes and urbanization. The Agricultural Revolution facilitated the improved feeding of animals all the year round and encouraged breed improvement. Subsequent growth in the human population and in incomes generated rising demand for dairy products, while the process of urbanization concentrated the markets and separated them geographically from the producers, thus inducing innovations in collection and processing.

6.02 Initially, two types of milk producers were to be found in Europe and elsewhere: those close to urban areas who sold fresh milk daily, either direct to the consumers or through merchants, and those farther away who processed the milk into butter and cheese. Dairy factories were set up initially (often as cooperatives) to service the latter group (e.g., by reducing labor requirements, improving the quality of processed products and strengthening their marketing position). Fresh milk for the liquid milk trade was sold in its raw form and pasteurization was not widely introduced until after the Second World War; suppliers and traders were licensed and supervised by public health inspectors. The fresh milk producers sold their surpluses to the factories; they discontinued direct sales only after health regulations required pasteurization.

6.03 Mechanization of milk processing began with the invention of the cream separator in the 1870's, but large-scale, capital-intensive methods were not widely introduced until rising labor costs, resulting from industrialization, made them cost-effective. This gradual, endogenous development process facilitated the build-up and handing on of skills and experience largely through on-the-job training, complemented within the past century by more formal training.

6.04 During the second half of the 20th century, industries developed that used milk as a raw material for new products (e.g., baby-food and whole milk replacers for calves). Improvements in technology permitted the dehydration of milk and its separation into whole milk powder, skim milk powder, butter and butter oil. This, in turn, facilitated the transfer of the emerging dairy surpluses over long distances, including overseas. The surpluses resulted from high guaranteed prices in many industrialized countries and necessitated export subsidies for their disposal.

6.05 In Africa, as in other developing areas, modern dairy development and milk processing did not evolve gradually from traditional dairying and milk processing. Rather, dual systems developed (see Chapter 2). Thus most countries have formal systems that cater primarily to high-income urban consumers and informal systems that operate in both the rural and urban areas. The bulk of the milk is consumed in fresh or soured form; only in the vicinity of markets are milk surpluses processed into dairy products having a long shelf-life. Only a fraction of milk production (e.g., less than 10% in Nigeria, Sudan and Tanzania; up to 40% in Kenya and 60% in Zimbabwe) enters the official commercial sector in many countries.

6.06 Past efforts to improve dairy supplies and processing in Africa focused largely on the establishment of large-scale centralized plants to meet the liquid milk demand of urban dwellers. The approach was initially influenced by the emphasis on pasteurized milk supplies for children (e.g., by UNICEF) and by the availability of subsidized (or free) imports of skim milk powder and butter oil. Because of low production levels, inadequate collection systems and unattractive prices for locally produced milk (relative to subsidized imports), these plants have relied heavily on imported materials for recombination to meet the market demand.

Milk Collection and Marketing Options

6.07 The principal problems of most collection systems in Africa include the small volumes supplied, the pronounced seasonality of supplies, dispersed and relatively low-income retail markets, high ambient temperatures, poorly developed transportation systems and heavy seasonal rainfall. The main limiting factor for all systems is the time it takes for the milk to reach the processing unit (or consumer) after milking. If milk is transported in hygienic containers and if it reaches the processing center within two to three hours from milking, its microbial quality will be good without any treatment. A given milk field can then be subdivided into collection areas, each having a radius of two to three hours transport time; the size of such areas will vary considerably, depending on the nature of the terrain and the modes of transport.

6.08 Milk collection systems can be divided into the following four types: small-scale, local marketing of mainly raw milk, either directly by producer or through dealer; small/medium-scale marketing of raw milk over a distance; small/medium-scale marketing of treated milk or processed products over a distance; and large-scale marketing systems.

6.09 In the first system, either producers sell directly to consumers or else middlemen (traders) collect the milk from small-scale producers and sell it in nearby, usually urban, areas. It is a flexible system, using low-cost transport (bicycles, donkeys) that sells loose milk; thus the gap between consumer and producer prices can be relatively narrow. For example, around Bamako in Mali, the traders' margins were 25% to 50% (depending on the season), while the parastatal company required a margin of about 90% (Von Massow 1985). The main disadvantages of the system are the lack of quality control, the frequent adulteration of milk and the resulting poor hygienic quality. However, consumers have learned to protect themselves by boiling the milk and/or incorporating it in boiled products (such as tea), and they can also anticipate adulteration. A further disadvantage is that this system can market only over a limited range, rarely over 30 kilometers. Cows and feed are often assembled close to cities to overcome transport and processing costs; these peri-urban systems are restricted by feed availability and the cost of transporting roughage.

6.10 Marketing of milk over longer distances usually requires a network of collection centers and involves treatment (e.g., cooling or heating); an obvious precondition is sufficient milk to justify the investment and staffing of the facilities required. Producers bring their milk to village collection centers that are under the control of the plant management, dealers, cooperatives or producer associations. The milk is either treated (e.g., chilled or heated) at this first stage or moved directly to a central plant. Chilling centers are a feature of collection systems in many African countries, but especially in East Africa (namely, in Kenya, Tanzania and Uganda). These systems require a reliable electricity supply, continuous availability of spare parts, adequate all-weather roads and competent staff for management and equipment maintenance. In parts of Kenya, as much as 20% to 30% of available milk cannot reach the factories at the height of the wet season (IDF 1986). In many areas milk cooling equipment frequently breaks down because of lack of maintenance and/or spare parts. It is difficult to introduce or maintain proper quality control since current methods to detect adulteration are either not reliable enough or else too complex for use at local collection centers. The standard melthod of measuring the density of milk, to detect adulteration, is unreliable in hot climates with milk of high butter-fat content. Such milk, measured at high ambient temperatures, will show a low density without being adulterated (IDF 1986).

6.11 When producers are located at a distance from the urban market, some form of treatment or processing is needed to overcome the twin problems of perishability and bulk. Small-scale rural milk treatment and product processing units have been successfully introduced in many countries of Asia and Latin America, but they are less common in Africa, with the exception of Kenya. The system generally has two stages: a short leg for the perishable and bulky raw milk and a longer leg for the less perishable treated or processed product. Milk is usually brought to the collection center by the producer, thus ensuring close contact and facilitating quality control. The system does require local processing skills, suitable power and water supplies and adequate roads.

6.12 Large-scale dairy farms will have their own cooling, bulk storage and often transport facilities; otherwise the milk is delivered in cans or collected by tankers owned by the processing company. This system, typical of industrialized countries, is found in a limited number of African countries (e.g., Zimbabwe). In other countries there are isolated "modern" units, usually parastatal farms. The bulk milk system requires high levels of technical and management skills at both the production and processing units and depends greatly on imported technologies.

Local Products and Processes

6.13 Milk is a suitable medium for the growth of micro-organisms and is thus highly perishable. This problem can be countered by a variety of traditional and modern conservation processes. Milk is also a very bulky commodity, and it is costly to transport over long distances; thus its immediate conversion into a less perishable product of lower water content is highly desirable. The perishability of milk also places a premium on technologies that are least susceptible to disruption because of transport or processing plant breakdowns.

6.14 Processing exploits one or more of the solid constituents of milk. Fat is the most valuable component in commercial terms, while milk proteins are most important for human nutrition. A number of relatively simple products can be made locally on a small scale (e.g., fermented milks, butter and cheeses). Skim milk powder and other products involve more complex processes and thus high capital investment.

6.15 The market will determine what types of products are most favored. Liquid milk is always in demand, but in its raw form its shelf life is short. In order to reduce hygiene risks and to gain three to four hours of additional shelf-life, it can be pasteurized, or simply heated to 80oC and cooled to water temperature. The latter procedure is much cheaper than pasteurization or chilling and also eliminates over 90% of the microbial flora, including all pathogenic bacteria. Sterilization, which involves treatment at higher temperatures over longer periods, extends the life and thus the marketing range of milk. Milk treated at ultra-high temperatures, known as UHT milk, can keep for a very long time, but packaging costs are excessive and have a high import content. Flame-sterilization can be done on a small scale, using a sealed container over direct heat, but the process is dependent on an inexpensive and reliable fuel supply. Heat-treated milk can be sold loose, and there should be no presumption that it must be packaged.

6.16 Production of fermented milk is widespread throughout Africa and other traditional cattle-keeping areas; milk is usually allowed to sour naturally without the addition of a starter. Lactic acid fermentation not only improves shelf-life (at least three to five days), but the natural inhibitory substances arising from the process suppress pathogenic bacteria and food poisoning organisms (Kosikowski 1982). Natural fermentations retard the growth of coliforms and Salmonella but do not inactivate Brucella. However, all pathogens are destroyed by boiling, which also improves the texture and firmness of the products. Improved understanding of traditional processing methods could point the way to simple improvements that would render the products safer and the processes more efficient.

6.17 The principal products made from milk fat are butter and butter-oil (ghee). Sour milk can be churned in any watertight vessel of the required volume, but for larger volumes centrifugal separation followed by cream churning is more appropriate. Butter quality deteriorates rapidly at ambient temperatures, but the development of rancidity can be retarded by salting. Butter oil/ghee is produced by evaporating the moisture from butter. If packed in air-tight, light-barrier containers (e.g., tins), dehydrated butter can have a long shelf-life.

6.18 Many cheese varieties can be manufactured using simple equipment and procedures; there is already a tradition of cheese-making in some countries (e.g., Benin, Ethiopia, Senegal, Sudan). Soft white feta-type cheese, cured in brine, and cheddar-type cheese, which undergoes an intensive lactic acid fermentation at an early stage of manufacture, lend themselves very well to village-level processing. A difficult aspect is the preparation and maintenance of starter cultures for controlled fermentation; rennet purchase and preparation can also be problematic. Under typical African conditions, it can be difficult and costly to maintain low temperatures and adequate humidity in curing rooms. Thus it may be better to manufacture cheese for processing, rather than for extended curing. Processed cheese and cheese spreads, packed in artificial sausage casings, keep well in ambient temperatures for several weeks and are marketable without refrigeration. Simple hand-operated equipment, working at atmospheric pressure, has been developed for processing and packaging such cheese.

6.19 On the small luxury market, there are outlets for a wide range of products based on milk fat (e.g., cream, ice-cream, butter and specialty cheeses). There are complementarities between the luxury and basic markets in terms of prices and products. High-priced cream, for example, can subsidize the low-fat fermented milks for which there is a mass market.

Processing Options

6.20 The stimulation of efficient on-farm or village-level processing appears to be a better strategy for dairy development in many areas than the development of large-scale collection/processing systems. The selection of products is influenced by market conditions, milk quantity, technology and consumer preferences. The choice between processing on the farm or at a local center depends on the quantity of milk produced in the area. Allowing milk to ferment naturally is a suitable option for on-farm processing where the quantities accumulated can be small, while the high acidities preserve the other milk solids and improve churnability (O'Mahony and Peters 1987). The equipment used to make butter from sour whole milk is locally available but churning efficiency can be substantially improved by simple adaptations, as demonstrated at ILCA. The butter produced can be sold, salted and preserved, or converted to ghee.

6.21 Small-scale, centralized milk processing reduces labor requirements on the farm, provides a center for the sale of farm inputs and strengthens the marketing capability of individual producers. Depending on the products to be manufactured, plants based on relatively simple equipment can cope with a daily milk intake of 1,500 to 3,000 kgs per day. Cream separators and churns can be operated either manually or by electric motors. ILCA's experience has shown that this equipment is quickly adopted in areas where milk volumes justify its use. Cheese-making is an appropriate option for rural communities that are far from the main roads and do not have sizable local markets for more perishable commodities. Apart perhaps from cheese-vats, most of the tools and equipment required can be made locally, and renewable energy resources can be used. Local communities usually can manage such operations.

6.22 Because of the high prices in the small urban luxury markets and the back-up facilities available there, more sophisticated technologies can be profitably used for this sector. However, the manufacture of milk powder and evaporated milk, which involves complex and expensive equipment, is not likely to present suitable opportunities for most African countries; few, at any rate, would have the milk surpluses required.

6.23 Small-scale pasteurizing plants can be installed for around \$150,000 to \$250,000, for capacities of 3,000 to 7,000 kgs per day. Small-scale processing plants (e.g., for fermented milk) can be assembled for similar unit costs or less. These mini-dairies offer interesting possibilities, but they are yet unproven in difficult conditions, and since they use the same technology as the larger plants, they may incur similar management and maintenance problems.

6.24 To a certain extent, the different technologies are complementary, rather than competitive. The expansion of the formal sector under Operation Flood in India, for example, did not lead to a significant overall loss of employment in the informal sector. The main reason for this was the rapid growth of urban consumer demand that the informal sector would not have been able to meet. New organizations and approaches were required to assemble and deliver milk from farther away. It is also reported from West Africa that fermented foods are becoming expensive because they are not being produced on a commercial scale or in large enough quantities (Seyoum 1988).

Reconstitution of Imported Products

6.25 African processers and consumers have been among the beneficiaries of the subsidized supplies on world markets, but direct competition between cheap reconstituted milk and locally produced fresh milk discouraged the development of local milk production (see Chapter 2). International surpluses have now been substantially reduced, and world stocks of skim milk powder have been virtually eliminated. At the same time, the availability of food aid in dairy products has been greatly reduced; donations to Africa were under 40,000 tons in 1989, compared with over 100,000 tons in earlier years. These trends have major implications for all importing countries, as the relative competitiveness of local producers and processing industries will be greatly improved.

6.26 At international prices as of early 1990 (\$ 1,650 per ton for SMP and \$1,800 for butter-oil), the raw material costs (ex Europe) for recombination are equivalent to 23 cents per kg of fresh milk, giving a landed (CIF) price in Africa on the order of 25 cents. Internal transport, handling costs and an allowance for losses (10%) would add another 5 cents, thus bringing the total to 30 cents per kg just for the raw material (processing and packaging would add at least another 10 cents). This is double the cost of two years ago and the increase will be correspondingly greater for those countries that have devalued their currencies.

6.27 Since collection costs are typically not less than 20% of the costs of raw milk at the plant, a producer price on the order of 24 cents per kg would be equivalent to the current cost of recombination materials. Local production costs are usually well below this figure, at least in smallholder systems. (Producer prices for milk in Africa are typically in the region of 15 to 20 US cents per kg, compared with around 27 cents in India and 35 cents in Europe/North America.) Even if world market prices were to fall to half their current levels, as projected by the World Bank, the import parity price would still be at least 17 US cents. Fresh milk would command a premium price, on the order of 25% to 50% more than reconstituted milk. Thus a local milk price of 20 to 25 US cents per kg would be consistent with long-term world prices.

Processing Costs

6.28 Capital and operating costs of milk collection and processing are substantial. Medium to large processing plants recently planned for Africa have had capital requirements (including collection and other support facilities) of $100 to $150 per kg, depending on the scale and range of facilities. The investment cost per liter of utilized capacity is obviously much higher and can exceed $200 at 50% utilization, thus giving rise to an imputed finance charge (at 10% real interest) of 5 to 6 US cents per kg.

6.29 Unit costs for all technologies will depend very much on levels of throughput and capacity utilization. Given the seasonality of milk production, high average levels of utilization are difficult to achieve; even with 100% usage in the peak season, it would be difficult to reach average utilization rates of over 60%, unless there was a high level of recombination. Sharp increases in unit costs are experienced when capacity utilization falls below 50%, which is the norm in many African countries. For example, in Nigeria, plant utilization rates in recent years ranged from under 5% to 35% and in Tanzania from 3% to 67%.

6.30 The following figures illustrate the effects of different levels of capacity utilization on the total costs (cents per kilo) of milk pasteurization/recombination (including collection/chilling facilities). The assumed raw material price is 25 US cents per kg -- a producer price of 20 cents (equivalent to import parity at around half the current world prices) plus collection costs of 5 cents. Variable costs include basic packaging, and fixed costs include depreciation; imputed finance costs are as calculated above.

Table 6.1 Milk Pasteurization/Recombination Costs
(cts/kg)

Costs Elements	Capacity Utilization (%) 15%	30%	60%	75%
Raw Materials	25	25	25	25
Variable Costs	8	8	8	8
Fixed Costs	8	4	2	2
Finance Costs	15	10	5	4
Total Costs	56	47	40	39

6.31 With modest levels of capacity utilization, the consumer price could be on the order of 40 to 50 US cents per kg, of which the producer would typically receive half; with higher utilization the margin could be substantially reduced. In Zimbabwe, for example, the producer price in 1988/89 was equivalent to 25 US cents and the consumer price was around 42 US cents, giving a collection/processing/marketing margin of under 70%.

Prices and Margins

6.32 Prices should be determined largely by supply and demand conditions; otherwise black market conditions are created that tend to benefit traders rather than either producers or consumers. Prices must reflect the actual costs of production and processing, while taking full account of the limited purchasing power of most consumers. For example, different kinds of products should be produced for different income groups. Large seasonal fluctuations in supply, and sometimes also in demand (e.g., during fasting periods), must be reflected by variable prices.

6.33 On the other hand, production increases at the farm level are subject to biological time lags and may require large investments in improved animals, housing, and pasture development. Substantial investment is also necessary at the processing level and large scale facilities may not be fully utilized for some time. Both producers and processors must take a long view; thus there is a need for policy stability and a consistent pricing policy to encourage long-term investment. However, the high level of direct government involvement in milk marketing and processing (e.g., price/quality controls) and indirect involvement (e.g., parastatal ownership) has all too often led to excessive price rigidities and distortions. One effect of price and quality controls has been to divert supplies to the informal sector, where such controls cannot be imposed. They have also strongly discouraged investment in production and processing.

6.34 In particular, processing margins of parastatals have often been tightly squeezed, ostensibly to protect the consumer, but with the ultimate effect of creating losses that required public funding. In Zimbabwe, for example, the margin between producer and consumer prices was eroded from over

70% in 1975/76 to a negative figure (i.e., subsidy) by 1983/84; it has since been restored to about 70%. Similarly, the price paid by the Addis Ababa dairy in Ethiopia remained constant for eight years (1976 to 1984). A better policy environment is now developing in a number of countries, leading to more flexibility as regards pricing and other controls.

6.35 In most cases, processing margins are greatly improved by reducing the fat content, which may be 5% or higher in local milk, to around 3%. (Such dilution is usually practiced by the informal traders also.) For example, the Addis Ababa plant standardized from 4.1% to 2.7%, thus reducing its raw material cost by one-third, from the equivalent of 45 US cents to 30 cents per kg. Adding on processing and marketing costs of 44 cents brought the cost to 74 cents, still well in excess of the official retail price of 60 cents (at official exchange rates). As milk production expands and the fat content drops, the potential for dilution will obviously be reduced. Processing margins must reflect this reality.

Institutions

6.35 The most appropriate institutions for processing/marketing of dairy products will be determined to some extent by the market to be served and the type of product preferred. Thus local markets requiring traditional products can usually be served best by local producers and traders. It is only when large quantities, long distances and/or more sophisticated processing are involved that larger-scale institutions are required. At this stage, improved management, additional capital and new or adapted technologies are necessary.

6.36 Parastatal companies provide all or most of the large-scale processing capacity in many African countries, including Ethiopia, Malawi, Mali, Niger, Somalia, Sudan, Tanzania, Zambia and Zimbabwe. Controlled prices and failure to adjust prices in the light of changing costs have led to loss-making operations in many, if not most, cases. Managerial problems have been similar to those identified for public enterprises in general (Nellis 1986), including overstaffing, political interference in management decisions, poorly qualified/trained staff, inadequate incentives for good managers and the incompatibility of civil service procedures with commercial operations. There are now strong indications of policy changes in relation to parastatals in Africa. The "African Alternative Framework to Structural Adjustment Programs" (ECA 1989) argues for a pragmatic balance between the public and private sectors. In particular, it states that selective privatization should be considered "where the State has over-extended itself, particularly in non-social service and non-strategic sectors." The dairy subsector would clearly fall into the latter category and offers substantial scope for privatization. Joint ventures with either local or foreign companies may offer interesting possibilities for improvement and expansion.

6.37 It has been difficult to interest the private sector in largescale processing of fresh milk in Africa, in part because of the small volumes available and the seasonality of supplies. For example, in Nigeria, the only plants handling locally produced milk until recently were those originally established by the government; the private firms were involved only in recombining imported materials. Government policies, in particular price controls and inappropriate exchange rates, have been largely responsible for the reluctance of the private sector to invest in some countries. Additional distortions have been created by donor support (both capital and product donations) directed mainly, if not exclusively, at public sector milk processing. The most important constraints, however, have been the uncertainty of supplies and the limited size of the market; in many cases, the large operations simply could not compete with the small-scale informal sector.

6.38 Cooperatives have played a major role in the development of dairy industries in many parts of the world, and they are frequently recommended as the appropriate institution for dairy development in Africa. In general, cooperatives have shown themselves well suited to undertaking assembly of fairly standard, not very perishable, products for sale on pre-established markets where the price risk is small. They have also been in a good position in many cases to supply inputs, credit and other services. Within the dairy sector in other parts of the world, cooperatives have been more successful in processed products than in liquid milk, thus emphasizing their particular role in areas distant from the market. Management has been a recurrent weakness in cooperatives, not only because of technical shortcomings but also as a result of confused objectives (social vs. commercial). There are particular problems in raising sufficient capital, either from members or from wary financial institutions. Many so-called cooperatives have, in fact, been established by governments (local and donor) and continue to be tightly controlled; in effect, they are barely distinguishable from parastatals. In other cases, they are controlled, not by the members at large, but by dominant local figures and/or self-perpetuating boards. Although there are sound reasons for formalizing co-operatives and applying national legislation to them, it may be better in many cases to allow less formal communal institutions to evolve, as has happened in local food processing and brewing.

Training in Milk Processing

6.39 Appropriate training is even more important for dairying than for other agricultural processing activities because of the perishability of milk and milk products and the resulting hygiene risks and marketing problems. There is already a substantial reservoir of local knowledge and skills related to traditional methods of handling and processing milk. Future development implies a shift from traditional methods to new science-based technologies, but this should be a step-wise process that builds upon existing techniques and skills. Every step will require education and training based on the specific needs of the particular groups involved. In particular, since traditional milk processing and marketing are carried out by women in many parts of Africa, appropriate training should be made available to them. At this level, formal training in classes or specialized centers is neither possible nor appropriate; it should be participatory and on-site, conducted as far as possible by local people with practical experience. FAO is establishing out-reach Dairy Development Training Units as part of its integrated projects (e.g., in Kilimanjaro, Tanzania).

6.40 At the intermediate level, informal and formal training that combines traditional skills with theoretical knowledge is most appropriate. Trainees must be free to attend short courses in local agricultural colleges or dairy research/training centers; training in clean milk production is often best provided by the processors. Participants should be given additional technical and commercial skills to assist them in starting/ expanding milk processing enterprises or so they can work for others in similar businesses. The FAO/DANIDA Regional Dairy Training Center in Kenya offers courses for different target groups, in conjunction with national institutions and ILCA.

6.41 Large-scale imported dairy plants, on the other hand, require totally new skills and intensive training. This training must also combine the practical with the theoretical, and much of it can only be carried out on the job. FAO should support on-the-job training by the dairy industry and the training of milk plant managers and technical staff in colleges and technical schools. Most countries do not have sufficiently large industries to support separate training facilities, but they can make use of regional centers.

Project Conditions

6.42 In the design of donor projects, subcomponents should be included on milk collection and treatment, product processing and marketing. Particular attention should be given to the informal sector which accounts for the bulk of all sales and the sale of loose milk should be encouraged. It is important to ensure that donated products do not disrupt the local market; the FAO/WFP pricing formula should be used by all donors to set the transfer values of their products. Adjustment policies and/or project conditionality should be used to influence the regulatory framework and the macroeconomic policies of particular importance, e.g. exchange rates. Technical and management training should be a key component of all support projects.

VII. DEVELOPMENT POTENTIAL, PRIORITIES AND SUPPORT REQUIRED

The Market Context

7.01 The international market for dairy products is small and dominated by subsidized exports. Thus the resulting prices do not necessarily reflect long-term costs of production. While the deficit countries in Africa and elsewhere should take advantage of cheap supplies when they are available on the world market, the price signals from that market must be interpreted with caution. (These signals have been further distorted in many cases by seriously overvalued exchange rates.) In many countries in Africa, milk can be produced at prices equal to or below those of imported products, especially when account is taken of consumer preference for fresh milk and a willingness to pay a premium price (see Chapter 6). A local producer price of 20 to 25 US cents per liter (at real exchange rates) would be consistent with projected long term world prices. It is the combination of limited supply, inappropriate processing technologies and costly packaging that renders the final product expensive.

7.02 Given the poor prospects for growth in per capita incomes, FAO projections indicate that average consumption levels will remain at around 27 kgs (liquid milk equivalent) until the end of this century (FAO 1987). However, the annual increase of 15 million in the human population will generate a demand for an extra 400 million kgs (0.4 million tons) each year. Any improvement in per capita incomes, especially of the high-income groups who consume the most dairy products, would obviously add to this demand. There is further potential to substitute for some of the annual 2 million tons of imports, but this is limited by some imported products that do not lend themselves to local manufacture. Thus demand is projected to grow by at least 0.5 million tons per year, from the current level of 12 to 13 million tons (i.e., by around 4% per annum).

7.03 Although this market is currently diffuse and scattered, it is becoming increasingly a concentrated urban one. Over 60% of the population increase over the next decade is expected to be in the towns and cities, where per capita consumption of dairy products is highest. In addition to increased production, improved collection, processing and marketing systems will be required to supply these growing markets. However, it will continue to be a relatively low-income market, requiring simple (but safe) products at low prices; only a small minority can afford to pay for highly processed and packaged items. The principal demand will be for fluid milk, much of which will be supplied through informal channels.

Potential for Dairying in Africa

7.04 The natural expansion of dairying in Africa, to satisfy growing urban markets, has been distorted in recent times by two principal factors: the availability of imported dairy products at highly subsidized prices (or free), and overvalued exchange rates that further depress the prices of imported products. The considerable adjustment of the exchange rate in recent years, combined with developments on the world market, have rendered imported products very expensive or unavailable, thus favoring substitution by local production (see Chapter 6).

7.05 A preliminary attempt has been made to analyze and summarize the potential for dairy development in each country and to identify the principal constraints (see Annex 5). Such an exercise is clearly subjective and is based to a large extent on the opportunities offered by existing technologies. Over half of all the countries in Sub-Saharan Africa, accounting for about three-quarters of the human population, have substantial potential for dairy development. They include most of the Eastern region, a large part of the Southern region and parts of Nigeria. The potential in much of Central and Western Africa is limited.

7.06 The widespread prevalence of tsetse and trypanosomiasis is the greatest single obstacle to the development of livestock production, including dairying, in much of the humid and sub-humid zones of Central and West Africa. However, a combination of the new tsetse control technologies and drug treatments (see Chapter 5) should make it possible to expand dairying into new areas. Similarly, the recent developments in the control and treatment of East Coast Fever should facilitate the expansion of dairying in the Eastern and Southern regions. In areas such as the Sahel and Somalia, the principal constraint is feed, and there is no imminent prospect of increasing the carrying capacity. The challenge will be to maintain it. For many countries, especially in Central and West Africa, self-sufficiency in dairy products is neither a desirable nor a feasible objective in the near future. These countries do not have the necessary combination of climate, feed, stock, skills and markets. The heavily populated coastal areas of Central and West Africa are too far removed from the producing areas to allow easy movement of milk or dairy products, and the opportunity costs of local production are high. There is a need to study how the markets of major cities such as Abidjan, Accra, Kinshasa and Lagos might best be supplied.

7.07 Expansion of dairying in Africa is favored by:

(a) an unsatisfied and growing internal market;

(b) indigenous husbandry, processing and marketing skills;

(c) favorable feed:milk price ratios; and

(d) low labor and housing costs.

7.08 On the other hand, expansion is constrained by:

(a) an overall shortage of feed and seasonal fluctuations in its quality and quantity;

(b) widespread livestock disease problems;

(c) indigenous cattle of low dairy merit;

(d) underdeveloped processing/marketing systems; and

(e) inadequate infrastructure and weak service institutions.

7.09 The development of milk production, usually within mixed farming systems, is a natural step in the intensification of agricultural production on an integrated and sustainable basis. Dairying provides a more stable source of employment and income and a better cash flow for the farmer than does most other agricultural enterprises. Since much of the food crop production is for subsistence, the sale of milk and animals is often the principal source of income and of the funds required for investment in increased crop production; thus the available evidence shows a complementarity between livestock and food grain production. Dairying is labor-intensive, but the labor demands can be met at least in part by household members whose opportunity costs are low.

Operation Flood

7.10 The success of the Indian dairy development program, known as "Operation Flood," has led to proposals for its replication in Africa. The principal features of this model are:

- a three-tier structure owned by the dairy farmers through their cooperatives, namely village societies (which collect the milk and provide inputs and services), district cooperative unions (which collect, process and market the milk) and state federations which coordinate marketing and promote dairy development;

- a National Dairy Development Board responsible for project planning and technical advice, and the Indian Dairy Corporation responsible for financing; these organizations have high-level political support and control the import of dairy products;

- donated milk powder and butter oil used to finance the infrastructure for milk production and marketing and not for on-farm investments; and

- most dairy equipment produced in country as a result of the existing level of industrial development and the boost given by Operation Flood.

7.11 Operation Flood was specifically designed to link distant milk sheds with urban markets. Milk production was already relatively high, thus the priorities were marketing and processing rather than production. Producers needed a guaranteed outlet for peak milk supplies, and this could be provided by using the milk powder supplies as a buffer stock in the dry season. Operation Flood has not been successful within a radius of about 100 kms around the big cities , where direct sales to the consumers and high producer prices have made cooperative marketing and processing unattractive.

7.12 The milk density (production per sq km) is roughly 20 times higher in India than in Africa on average. In addition, milk is mainly produced under zero-grazing conditions within the villages so that there is easy access to milk collection, inputs and services. Similarly, dairy training started much earlier in India and on a much larger scale so that a substantial corps of professional staff is available. Milk is also more important as a traditional source of protein, and this has facilitated the development of a "white" lobby.

7.13 There are few areas in Africa where an Operation Flood approach to dairy development could be successfully applied since milk volume is generally too low to support an elaborate marketing and processing structure. The main focus initially must be on increasing production and on improving small-scale processing and trade in fresh milk.

Elements of a Dairy Development Strategy for Sub-Saharan Africa

7.14 Strategic Agenda. The future strategy for sustainable growth in Sub-Saharan Africa sees agriculture as the primary foundation (World Bank 1989). In order to stimulate this growth, all countries will need to create an enabling environment, harness new technologies, build capacities and safeguard natural resources. An enabling environment for agriculture means allowing prices to move flexibly in response to changing market conditions, turning over input supply, marketing and processing largely to the private sector and reducing administrative controls. The core of the strategy must be a determination to improve research management and to link research to the farmer by putting in place management systems for agricultural extension that are more responsive to farmers' needs. Building capacities is a need that runs through all levels to produce better trained researchers, extension agents and farmers and to strengthen rural institutions (such as farmers' associations, cooperatives and women's groups) especially by training managers. These basic principles apply more to dairying than to other parts of the agricultural sector.

7.15 National Policy. The realization of the undoubted potential in many countries will call for appropriate macroeconomic and sectoral policies, as well as institutional support and the generation and dissemination of technical packages for both production and processing. The development of the human resource is a necessary precondition for progress in all areas.

7.16 Policy coherence has often been absent, and exchange rate policy has overridden sector-specific policies, as overvalued currencies favored imports. Real effective exchange rates have fallen sharply in recent years. Thus this distortion has been greatly reduced, if not eliminated. Sharp fluctuations in international prices in recent years have generated confusing signals and illustrate the difficulty of setting optimum tariffs in the face of a highly artificial world market. In order to encourage producers and processors to undertake the long-term investment needed, consistency is required in relation to import policy and the pricing of imports. In particular, food aid imports should not be allowed to undermine the domestic market. Recombination materials should be sold at a competitive price (using the standard FAO pricing formula) and the proceeds used for dairy development.

7.17 Sector-specific policies are often impeded by contradictory incentives to consumers and producers (e.g., trying to keep consumer prices down while also offering adequate incentives to farmers and processors/traders). Dairy products provide valuable nutrition and are preferred foods of large numbers of people. However, they are not basic foodstuffs or strategic commodities in any sense; they are consumed in large part by the wealthier sections of the population. Thus there is little argument on strategic or distributional grounds for government interference in their marketing and pricing. The task of governments should be to facilitate the creation of the economic, institutional, infrastructural and legal environment that stimulates broadly based dairy development.

7.18 Integrated Approach. Dairying is only one component of livestock production, which in turn is an integral part of agricultural production. Thus it can best be developed as part of an integrated approach to the total sector, but in particular geographical areas it may provide the leading edge and the catalyst for agricultural intensification. Dairying will compete with other enterprises for labor and perhaps land, but it will correspondingly benefit from other agricultural developments (e.g., increased crop production giving rise to additional edible byproducts). It can offer additional opportunities for income generation through local processing, which can in turn stimulate further technological development and employment in the area.

7.19 African livestock keepers already have considerable experience of low-input, subsistence-oriented dairy production using local animals and traditional husbandry methods. However, with few exceptions, there is little experience with commercial dairying using improved breeds and where both animal nutrition and health care are designed to produce year-round surpluses for sale. Intensive dairy production requires not only additional inputs but also increased knowledge and improved management capabilities. Since support services of all kinds are relatively weak, their development on a sustainable basis is a major priority. Dairying will, of course, benefit from developments elsewhere in the agricultural sector (e.g., the strengthening of research and extension systems), but the subsector also has special needs over and above the basic services. In this respect it is similar to the high-value crops (e.g., tea) that both require and can support specialist services.

7.20 Production. Most countries should pursue a dual development strategy that promotes the traditional mixed farming systems and the more specialized dairy farms. The scattered traditional sector will mainly serve local markets and provide seasonal surpluses for processing, while the development of more intensive dairying is essential to supply larger urban markets. The strengthening of support services (e.g., extension, veterinary services) and the development of local processing/marketing, must be the priorities in relation to the traditional sector. The intensive units will also require support services, especially research/extension/training, and access to credit facilities.

7.21 Experience in most parts of the world has shown that milk production is best suited to smallholders in view of its labor intensity and the personal attention required. In some countries (e.g., Tanzania, Zambia, Zimbabwe), larger scale (often parastatal) farms account for a substantial proportion of milk supplied to the large milk plants; thus they will have a continuing role. Their output guarantees a minimum supply for the processing/marketing facilities, which can then serve the smallholders whose production level does not yet add up to the critical mass required. The large-scale commercial farms should be an important source of crossbred heifers (as in Kenya).

7.22 A major constraint on the rapid expansion of dairying in most countries is the availability of improved stock. This cannot be resolved only through parastatal breeding farms but requires the full involvement of private farmer/breeders. It is essential that the public sector stock are sold at full commercial prices, so that the development of the private sector is not undermined. Given the biological time-lags, 10 to 15 years would be the minimum realistic planning horizon for upgrading programs.

7.23 Processing/Marketing. Too much of the development in the past has been supply-driven (and heavily donor influenced), rather than demand-driven and determined by the needs of the market. Thus there has been considerable investment in large-scale pasteurizing/recombination plants that often have been seriously underutilized. International agencies and bilateral donors are now shifting their attention to small-scale rural processing, but there is a need for applied research and development of new technologies. This will require the strengthening of regional research/training institutions (e.g., Dairy Technology research at ILCA) in conjunction with national research services and FAO/DANIDA Dairy Training activities.

7.24 With the exception of a few countries (e.g., Zimbabwe), most marketing is carried out by the informal sector, and this is likely to remain the case for some considerable time. An immediate priority is market studies that would cover not only the quantities and types of products preferred but also the operation of existing distribution systems. Human health and hygiene standards are clearly of major importance, but they are better addressed through education than regulation. A diffuse processing/marketing system, operating largely through informal channels, is virtually impossible to police as regards public hygiene regulations. The effect of such controls is often counterproductive since they apply in effect only to the formal sector where they impose extra costs, thus giving a price advantage to the relatively uncontrolled informal traders. Regular monitoring of all supplies through random spot checks is necessary, but it requires organization and laboratory back-up. For the urban supplies, it may be preferable to register and inspect the milk producers, as was done in Europe and elsewhere for long periods.

7.25 Support Services. Many of the services required by dairy farmers are common to all livestock producers (e.g., supply of inputs, extension and veterinary services). Dairying may be distinguished by its level of intensity which both creates new management/nutrition/disease problems and provides an economic incentive and a regular source of income to pay for inputs and services. Milk production will tend to be carried on in relatively accessible areas with a substantial concentration of people and animals. Thus it should be easier to deliver the goods and services required.

7.26 Within the framework of a unified extension service, it is still necessary to provide intensive support for particular high-value commodities, and milk is one of them. This will be the case, in particular, where dairying is being introduced for the first time, or where major changes in the production system are required. In order to reduce the risks and enhance the chances of success for the emerging dairy industry, an integrated approach should be taken to the provision of support services to farmers. Training, extension, inputs and services should be offered as a package. Livestock Development Centers (see Box 7.1) have proven to be appropriate institutions for concentrating support services and farmer training.

Box 7.1 Livestock Development Center (LDC) Serving 1,500 Farmers

The principal functions are training, extension, demonstration, applied research, and services, covering the following areas:

Training
- Induction courses for farmers
- Animal husbandry courses
- Farmers' organization training
- Mobile training in villages

Extension
- Farm planning
- Development of fodder crops
- Conservation of fodders/feeds
- Crop-livestock integration
- Dairy farm management

Demonstration
- Dairy production systems
- Crop-livestock integration
- Extension packages

Services
- Animal health care
- Multiplication and breeding
- Bull and semen distribution
- Seeds and planting material

Possible commercial services
- Sales of concentrates, medicines, seeds, and other supplies
- Marketing of milk and other products
- Access to credit facilities

Facilities and staff required to provide training, extension, and support for around 250 new farmers each year would include:

Facilities
- Farm demonstration units (each of 3-5 cows)
- 10-20 cow dairy training farm
- Hostel for 25-40 farmers
- Lecture rooms, offices, etc.
- Mobile training unit

Staff
- Trainers
- Sector specialists
- Extension agents
- Health and breeding
- Farmers' families
- Laborers

Costs: Depends on scale and possible link with other facilities, up to $0.5 mln for initial investment and $0.1 mln net operating costs.

7.27 Experience from Tanzania and Kenya shows that around 1,000 to 1,500 dairy farmers could be served by a Livestock Development Center (LDC). If they were to sell only 8 to 10 kilos per day each, then annual milk sales would be on the order of 5 million kg at full development, valued at an estimated $1.0 million. The service would require a subsidy for at least the first five years when the number of participants and the level of production are still low. The cost of the centers might be kept down by adding them to existing facilities (e.g., heifer breeding units) There are also opportunities for cost recovery from sales of supplies and charges for services.

7.28 In other parts of the developing world, farmers' associations (e.g., in Taiwan) or cooperatives (e.g., in India) play a major role in providing extension and veterinary services to their members. In Sub-Saharan Africa, producers could similarly take over the responsibility and funding of livestock development centers in due course, but they should first build up their own institutions. (In India, as Operation Flood was extended to states that did not already have milk unions, the state governments established dairy development corporations to promote village cooperative societies and to provide the services until the unions were on their feet.)

7.29 Farmers' Organizations. In many developed and developing countries, the supply of inputs, the marketing of milk and milk products and the provision of support services are handled by farmers' organizations. They also play an important political role by fighting for the interests of their sector and their members (e.g., in relation to price policy, proposed legislation and other government support). Such organizations are weak in Sub-Saharan Africa, where many of the inputs and services are still provided by government institutions. Official government policy often favors large multipurpose cooperatives, which are in effect quite similar to parastatals. Such cooperatives service mainly farmers producing cash crops, while the requirements of dairy producers may be quite different (e.g., daily or even twice daily marketing). Thus there is a strong argument for the development of specialized dairy cooperatives, provided the volume of business is sufficiently high to cover the overheads. For example, in Meru (Kenya), dairy farmers have organized separately and have started collection, processing and marketing with donor assistance.

7.30 Research Needs. There is a dearth of reliable information on existing dairy industries, especially in the large informal sectors. The first requirement is to close the knowledge gap with area-specific studies on consumption patterns and local collection/processing/marketing systems. They should address questions such as consumer preferences for different products and distribution systems (von Massow 1989). This work should go beyond economic surveys to include technical factors, such as the efficiency of processing techniques and the hygienic quality of products. At the farm level, there is a similar requirement for the collection of farm management data, showing the costs and returns from different enterprises. Dairy development projects themselves offer good opportunities for data collection and research.

7.31 There is a large reservoir of scientific and technical research in the more developed dairying regions of the world. African countries can draw upon and adapt this research to their own unique circumstances. Adaptive research must be pursued to the development and pilot project stages. Research priorities in different areas have been highlighted in the earlier sections. Each country with a sizable dairy industry should designate one research center or station specifically for dairying, and it should be given responsibility for all stages, from production through processing to marketing. There is also a clear need to involve farmers' representatives much more in the formulation of research priorities and the monitoring of performance to ensure that the programs respond to their needs.

7.32 Given the growing demand and the limitations of existing technologies, there is a need to develop new dairy products, processing methods and distribution systems adapted to local needs and capabilities. This calls for a combined research and development approach, up to at least pilot field testing of the technology, assessment of consumer acceptability and derivation of likely production costs. Some work is already under way in these areas, both in international organizations (e.g., FAO, ILCA) and national research institutions, often in collaboration with universities in the industrialized countries. FAO has initiated a major study on the manufacturing procedures for indigenous dairy products, including survey results from more than 100 countries worldwide, and it is also developing simple village processing models. These essential steps must be linked to research work on the ground, which can best be carried out by local researchers. Research institutions should be strengthened through joint research work with similar institutions in industrialized countries.

7.33 Education. There is a great scarcity of qualified dairy extension staff in most African countries. The principal emphasis in certificate and diploma level education is usually on agriculture, with animal production as a special subject or specialization during the final year. The quality of certificate and diploma level training should be strengthened by the introduction of more animal production subjects, such as crop-livestock integration and practical dairy production on smallholder units. At university level, animal production is usually either a specialization within agriculture or veterinary science. The quality of programs at this level could be improved by emphasizing crop-livestock interactions and by covering semi-intensive livestock production systems. More attention should be given to animal production within veterinary programs.

7.34 The future research leaders should receive their undergraduate training at third-level institutions in their own countries. At the postgraduate level, joint research/training programs with institutions in industrialized countries can be highly beneficial, if they are geared toward solving African problems. Such training must be seen as an integral part of investment in dairy development.

Investment Required

7.35 Farm Level. Milk production will have to grow by some 0.5 million tons per annum to keep pace with demand. At an average price of 20 US cents per kg, this additional output would be worth $100 million. With an incremental capital-output ratio of 3:1 on average, this would imply additional annual investment of $300 million, or 15% of the value of net output of dairy products. Up to 80% of this farm-level investment would be in the form of livestock since many of the other improvements would be incremental and created largely through family labor. Credit would be required by most farmers to cover some initial investment in livestock and related facilities, but most upgrading would be carried out by crossbreeding on the farm.

7.36 Processing/Marketing. Only 12% to 15% of milk and milk products enters formal marketing channels at present, and on-farm consumption or informal local marketing will continue to account for the bulk of production for some time. However, increased commercialization is necessary, especially to supply the growing urban areas. In many countries there is substantial underutilized capacity in the formal sector, although rehabilitation of much plant and equipment is required; at a later stage new plants will be needed to cope with rising demand and production.

7.37 The following estimates may be regarded as indicative of long term investment requirements in processing:

(a) Half of the increased production will be handled by the informal sector; one-quarter will be for on-farm consumption by producers and their families, and only one-quarter will enter the formal system (large and small scale).

(b) On the basis of increased output of 0.5 million tons per year, the additional volumes would be 700,000 kgs per day through informal channels and 350,000 kg through formal channels.

(c) Investment requirements in the informal systems are on the order of $10 per kg, while in the formal sector they are on the order of $100 per kg on average (ranging from $50 to $150); rehabilitation costs could be as low as $10 per kg.

Total investment per year would then be as follows:

(a) Informal - 700,000 @ $10 = $ 7 million

(b) Formal - 350,000 @$100 = $35 million

(c) Initial Rehabilitation approx. $7 million.

Thus investment requirements in processing/marketing might rise from around $20 million per year in the short term to over $40 million per year when existing capacity is fully utilized.

7.38 Support Services. Investment is also required in research, extension and training and in the provision of inputs and services (e.g., veterinary service). FAO (Agriculture 2000) has estimated that support investment for agriculture generally is equivalent to some 70% of primary investment. In relation to the dairy subsector, this would imply support investment of over $200 million, of which processing might account for $40 million.

7.39 Total investment in production, processing/marketing and support services would then be about $500 million, with an import content of 25% to 30%; this would require external funding of up to $150 million annually (excluding technical assistance). Current levels of food aid in dairy products are worth about $60 to $70 million, at least half of which could be used to generate local currency to finance investment. Thus, external sources might provide up to $180 million per annum, or just over one-third of the total. The remaining two-thirds ($320 million) would come from the farmers themselves, local financial institutions and governments.

Credit

7.40 It is not within the scope of this report to deal adequately with the issues relating to credit for dairy development. Credit is a constraint, and the problems and issues are similar to those generally encountered with credit for agricultural development. These include:

- weak financial institutions, often owned or controlled by governments, that require continued budgetary support;

- reliance on funds provided by governnents and/or aid agencies for most credit schemes;

- inadequate attention to mobilization of domestic deposits/savings;

- high transaction costs;

- administrative interventions, including arbitrary interest ceilings that are usually well below market clearing rates;

- inadequate legal and regulatory framework to safeguard lenders;

- subsidized and directed credit that often fails to reach targeted groups, thus contributing to misallocation of resources; and

- government and political interventions that exacerbate the pervasive problem of chronic overdues and mounting nonperforming loan portfolios.

7.41 While subsidies may be justified in special cases, as an inducement to farmers to adopt new technologies or to accept commercial risks during a pilot development phase, the subsidies should be transparent and met from special budget allocations to avoid weakening the lending institutions. The availability of credit to meet identifiable demand for dairy development (capital for improved breeding stock, buildings, dairy equipment and pasture improvement) is obviously important.

Employment

7.42 Dairying is a labor-intensive activity at the farm level, with labor typically accounting for over 40% of total costs in smallholder systems. It was estimated that each 6 to 10 kgs per day of additional milk processed in India added one man-day for animal feeding and care, but less intensive (or larger-scale) systems in Africa have a much lower employment content. Thus data from the Dairy Development Program in Kenya indicate smallholder production on the order of 25 kgs per man-day; similar levels were experienced on parastatal dairy farms in Zambia. On the large commercial farms in Zimbabwe, milk production is up to 200 kgs per worker per day. In order to produce the additional 0.5 million kgs required, farm-level employment would increase by some 70,000 each year (on the basis of one unit per 7,500 kgs).

7.43 If improved milk marketing leads to higher milk prices relative to those of home-processed dairy products, a shift from on-farm processing to the sale of milk, with corresponding reductions in employment, is likely. This may be partly or totally offset by increasing employment in milk production since yields are increased and output is expanded. However, incomes from milk and from processed products may be controlled by different family members (e.g., women handling on-farm processing and receiving the income from sales; men controlling the income from fresh milk). Particular attention should be paid in dairy development projects to the distribution of labor and income within the household.

7.44 At the processing level, the choice of technology will have a major impact on the level and type of employment generated. Capital-intensive equipment will generate relatively little local employment, either in its use (200 to 500 kgs per man-day) or manufacture, since it is likely to be imported. Small-scale rural processing would generate incomes from local manufacture of at least part of the equipment required, and the processes would also be labor intensive (100 kgs per man-day). In the informal processing/marketing systems, one person is required per 50 to 100 kgs handled. In the past, the choice of technology was influenced by the ready availability of modern equipment from commercial suppliers (often funded by donors), but also by the distortions in exchange rates and factor prices that favored imported, capital-intensive methods. The future growth in employment in processing and marketing is projected to be on the order of 40,000 full-time equivalents per year, most of it in the informal sector where reasonable incomes could be earned from volumes as low as 50 to 100 kilos per man-day.

Implications for Donors

7.45 Dairying in Sub-Saharan Africa is worthy of donor support as an integral part of rural development. If implemented on a smallholder basis with dispersed local processing, it can generate widespread incomes and employment. Capital investment as such is not the main priority but rather coherent and realistic long-term plans and a commitment by donors and partner countries to the development of the institutions and the strengthening of local capabilities. Quick results cannot be expected since there are biological time lags and a clear need to build up viable institutions; a 10 to 20-year time horizon should be adopted. It is essential to build on the foundations of the existing industry and to develop it through improved processes and technologies.

7.46 Donors should support the efforts of national governments to undertake the long-term planning required. Such plans should be based on realistic projections of supply and demand and should take explicit account of the continuing need for imports in many cases. They should also consider the respective roles of the public and private sectors in relation to primary production, processing/marketing and support services. There will be a need for substantial government support in the early years when institutions are weak and production relatively low. Specific timetables should be drawn up for the gradual withdrawal of support and the transfer of responsibilities to the private sector.

7.47 As the emphasis switches from a centralized approach, with large-scale farms and processing plants, to a decentralized approach based on smallholders and local processing, project design should change. The "process approach," which provides for continual appraisal and evaluation from project identification through completion, will be more appropriate than the traditional "blueprint approach." In addition, given the lack of basic data in many cases (especially on markets) and the need to develop new technologies and institutions, it will be necessary to start with pilot projects. The pressure to increase project size resulting from donor practices should be resisted until there is solid information for project planning and proven approaches/technologies to implement.

7.48 There will be a continuing need for substantial imports of dairy products and for food aid in particular, given the limited production and import capacity of many countries. Long-term commitments should be given by donors so that there is security of supplies while local production is gradually increasing. Donors should facilitate and encourage the competitive pricing of food aid supplies so that they do not disrupt local markets. The institutional arrangements in-country should also be such as to ensure equality of access to supplies to both the public and private sectors.

7.49 The results of past dairy development projects in Sub-Saharan Africa are not easily accessible. There is a need to draw together the lessons of experience for the benefit of the African countries and the financing agencies. Much of the relevant material already exists in-country and/or in donor agencies, but a multicountry effort would be required to assemble it since no single country or donor predominates in this field.

Annex 1
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DAIRY DEVELOPMENT IN SUB-SAHARAN AFRICA

Livestock Population in Sub-Saharan Africa, 1988
('000)

Country	All Cattle	Milking Cows	Sheep	Goats	Camels
Eastern Africa					
Comoros	85	8	10	96	-
Ethiopia	31,000	3,875	23,400	17,500	1,060
Kenya	9,800	2,255	7,300	8,500	790
Somalia	5,000	1,000	13,500	20,000	6,680
Sudan	22,500	3,450	18,500	13,500	2,850
Tanzania	13,500	2,800	4,700	6,600	-
Uganda	3,910	1,080	1,740	2,800	-
Sub-total	85,795	14,468	69,150	68,996	11,380
Western Africa					
Benin	914	116	860	960	-
Burkina Faso	2,809	461	2,972	5,198	5
Chad	4,060	406	2,245	2,245	509
Gambia	300	30	200	200	-
Ghana	1,300	195	2,500	3,000	-
Guinea	1,800	225	460	460	-
Guinea-Bissau	.340	59	205	210	-
Ivory Coast	960	154	1,500	1,500	-
Liberia	42	6	240	235	0
Mali	4,738	474	5,500	5,500	241
Mauritania	1,250	272	4,100	3,200	810
Niger	3,500	530	3,500	7,550	417
Nigeria	12,200	1,220	13,200	26,000	18
Senegal	2,608	260	3,792	1,150	8
Sierra Leone	330	50	330	180	-
Togo	290	38	5,900	1,115	-
Sub-total	37,441	4,496	47,504	58,703	2,008
Southern Africa					
Botswana	2,350	290	220	1,100	-
Lesotho	525	80	1,440	1,030	-
Madagascar	10,600	59	611	1,080	-
Malawi	1,000	95	210	950	-
Mauritius	30	10	7	95	-
Mozambique	1,360	390	119	375	-
Namibia	2,050	169	6,400	2,500	-
Reunion	20	10	3	49	-

Swaziland	650	153	35	320	-
Zambia	2,684	270	80	420	-
Zimbabwe	5,700	143	580	1,650	-
Sub-total	26,969	1,669	9,705	9,569	-
Central Africa					
Angola	3,400	295	265	975	-
Burundi	340	60	350	750	-
Cameroon	4,471	97	2,897	2,906	-
Cent. Afr. Rep.	2,313	45	116	1,159	-
Congo	70	2	64	186	-
Gabon	9	2	84	63	-
Rwanda	660	160	360	1,200	-
Zaire	1,400	8	880	3,040	-
SUB-TOTAL	12,663	669	5,016	10,279	-
TOTAL SSA	162,868	21,302	131,375	147,547	13,388

Source: FAO Production Yearbook, 1988.

DAIRY DEVELOPMENT IN SUB-SAHARAN AFRICA

Milk Production in Sub-Saharan Africa, 1988
('000 MT)

Country	Cow Milk	Sheep Milk	Goat Milk	Sub-total	Camel Milk
Eastern Africa					
Comoros	4	-	-	4	-
Ethiopia	814	66	95	975	212
Kenya	1,015	29	82	1,126	158
Somalia	550	378	640	1,568	1,336
Sudan	1,750	580	530	2,860	570
Tanzania	448	-	63	511	-
Uganda	378	-	-	378	-
Sub-total	4,959	1,053	1,410	7,422	2,276
Western Africa					
Benin	15	-	5	20	-
Burkina Faso	81	-	16	97	1
Chad	110	8	13	131	102
Gambia	5	-	-	5	-
Ghana	11	-	-	11	1
Guinea	42	1	4	47	
Guinea-Bissau	10	1	2	13	
Ivory Coast	19			19	
Liberia	1	1	1	3	
Mali	95	28	33	156	48
Mauritania	96	74	78	248	162
Niger	106	13	130	249	83
Nigeria	360	-	-	360	4
Senegal	94	15	12	121	2
Sierra Leone	17	-	-	17	-
Togo	9	-	-	9	1
Sub-total	1,071	141	294	1,506	402
Southern Africa					
Botswana	101	-	3	104	-
Lesotho	23	-	-	23	-
Madagascar	41	-	-	41	-
Malawi	44	-	-	44	-
Mauritius	25	-	-	25	-
Mozambique	66	-	9	75	-
Namibia	70	-	-	70	-
Reunion	5	-	1	6	-

Swaziland	39	-	-	39	-
Zambia	81	-	-	81	-
Zimbabwe	225	-	-	225	-
Sub-total	720	-	13	733	-
Central Africa					
Angola	148	-	-	148	-
Burundi	21	2	8	31	-
Cameroon	49	-	-	49	-
Cent. Afr. Rep.	5	-	-	5	-
Congo	3	-	-	3	-
Gabon	1	-	-	1	-
Rwanda	77	1	14	92	-
Zaire	7	-	-	7	-
SUB-TOTAL	311	3	22	336	-
TOTAL SSA	7,061	1,197	1,739	9,997	2,678

Source: Cow, sheep & goat milk from FAO Production Yearbook, 1988.
Camel milk production estimated at 200 kg per head (Jahnke, 1982).

ANIMAL HEALTH PACKAGES FOR CATTLE

A. Animal health packages in pastoralist and agro-pastoralist livestock production systems (mainly in the arid and semi-arid areas)

Vaccination	Treatment	Management
Rinderpest (S) CBPP (S/P) Blackquarter (S), combined with Anthrax (S/(Z)) (if present) Brucellosis (DP) Foot & Mouth (DP) Heartwater (S) (if present Hemorrhagic Septicemia (S) (if present)	Blood parasites (tryps, ECF) (S/P) Dermatophilosis (P) Helminths (P) Eye infections (P)	Provision of salt, minerals & Vit.A** (P) Tick control (manual & spraying of the udder) (DP) Strategic worm control (P) e.g. ascariasis in calves and liverfluke if present.

** : Vitamin A deficiency is common in the Sahel

B. Animal health packages for the mixed farming system (mainly in the sub-humid and humid zones)

Rinderpest (S) CBPP (S/P) Blackquarter (S), combined with Anthrax (S/(Z)) (if present) Brucellosis (P/DP/Z) Foot & Mouth (DP/Z) Tickborne diseases (S) (if grade cattle) Hemorrhagic Septicemia (S) (if present)	Blood parasites (S/P) (tryps; all tickborne) Dermatophilosis (P) Helminths (P) Coccidiosis (S/P) (for calves) Mastitis (DP) Eye infections (P)	Provision of salt & minerals (S) (Strategic) tick control (S/P) Strategic worm control (P) (nematodes & possible liverfluke) Tsetse fly control (P) Milking hygiene (DP) Hygiene around abortion (DP)

C. Animal health packages for the intensive dairy farming systems in the rural and peri-urban areas

Require vaccination against Rinderpest (S) CBPP (S/P) Blackquarter (S), combined with Anthrax (S/(Z)) (if present) Brucellosis (P/DP/Z) Foot & mouth (DP/Z) Tickborne diseases (S) (if grade cattle) Hemorrhagic Septicemia (S) (if present)	Treatment should be available for Tickborne diseases (S/P) (those present) Dermatophilosis (P) Helminths (P) (incl. liverfluke) Coccidiosis (S calves) Mastitis (DP/Z) Eye infections (P)	Management practice should include Provision of salt & minerals (S) Strategic tick control (S/P/DP) Strategic worm control (P) Milking hygiene (DP/Z) Clean up abortions (DP) Control of TB - test and slaughter

Key: S = minimum for Survival P = for Productivity
DP = for Dairy Production Z = for Public Health (Zoonose)

DAIRY DEVELOPMENT IN SUB-SAHARAN AFRICA

Animal Health packages for Camels, Goats, and Sheep

A. Animal health packages for pastoralist and agro-pastoralist livestock production systems (mainly in the arid and semi-arid areas)

Require vaccination against	Treatment should be available for	Management practice should include
CAMEL (ONE-HUMPED):	T.evansi (S/P)	Salt & minerals (S/P)
Antrax (S) (if present)		
	Camel mange (P)	Prevention of Hydatidosis (Z by encouraging destruction o organs with hydatid cysts
	Salmonellosis (S/P/Z)	
	Helminths (P)	Vitamin A (P)
GOATS:		
Peste des Petits Ruminants (PPR) (S/if present)	Sarcoptic mange (P)	Provision of salt and minerals (P)
Contagious Caprine Pleuropneumonia (CCPP) (S/if present)	Internal parasites: - Helminths (P) (especially haemonchosis & nodular worm disease)	Strategic worm control (P)
Enterotoxemia (S)	- Coccidiosis (S/P)	Ecto-parasite control (P)
Heartwater (if present) (S)	Eye infections (P)	Controlled breeding (P/DP)
SHEEP:		
Enterotoxemia (S)	Stress pneumonia (S)	Shelter if possible
Sheep pox (S)	Internal parasites: - Helminths (P) (especially haemonchosis & nodular worm disease)	Strategic worm control (P)
		Provision of salt & minerals (P)
	Eye infections (P)	
	Caseous lyphadenitis (P)	Avoid & clean wounds
	Mange (P)	

Key: S = minimum for survival
DP = for dairy production
P = for productivity
Z = for public health (Zoonose)

B. Animal health packages for the mixed farming system (mainly in the sub-humid and humid zones)

Require vaccination against	Treatment should be available for	Management practice should include
GOATS:		
PPR (S/if present)	Sarcoptic mange (P)	Provision of salt and minerals (P)
CCPP (S/if present)	Internal parasites: - Helminths (P) (especially haemonchosis & nodular worm disease) - Coccidiosis (S/P)	Strategic worm control (P)
Enterotoxemia (S) Anthrax (S)		Ecto-parasite control (P)
Heartwater (S) Brucellosis (DP/Z) (Br. melitensis)	Mastitis (DP/Z)	Controlled breeding (P/DP)
	Eye infections (P)	Milking hygiene (DP)
SHEEP:		
Enterotoxemia (S) Anthrax (S)	Stress penumonia (S)	Shelter if possible (S)
Sheep pox (S)	Internal parasites: - Helminths (P) (especially haemonchosis & nodular worm disease)	Prevent protein inanition if possible (S)
Brucellosis (P/DP/Z) (Br. melitensis)		Strategic worm control (P)
	Mastitis (DP/Z)	Provision of salt & minerals (P)
	Mange (P)	Controlled breeding (P/DP)
	Eye infections (P)	Hygienic milking (DP)

Key: S = minimum for survival; DP = for dairy production; P = for productivity; Z = for public health (Zoonose)

DAIRY DEVELOPMENT IN SUB-SAHARAN AFRICA

Indication of dairy development potential of Countries in Sub-Saharan Africa

Country	Land area 000 sq km	Area tsetse infested (%) (1)	Livestock units per sq km (2)	Kg milk per sq km per day (3)	Self-suff. in milk (%) (4)	Feed export as perc. of milk imports (5)	Production constraints: Diseases (6)	Production constraints: Land tenure (7)	Production constraints: Training Ext. demon. (8)	Dairy development possibilities: Potential (9)	Dairy development possibilities: Production Systems (10)
WEST AFRICA											
Benin	111	100	8	0.5	73	2187	++	+	1,2	2	1,4
Burkina Faso	274	77	10	1.0	59	29	+	++	1,2	2	1,2,4
Chad	1259	?	4	0.6	100	300	-	++	1	1	1
Gambia	10	100	25	1.4	29	508	++	++	1,2	2	1,4
Ghana	230	100	6	0.1	24	6	++	+	-	0	-
Guinea	246	100	5	0.5	81	172	++	+	-	0	-
Guinea Bissau	28	100	10	1.3	76	250	++	+	-	0	-
Ivory Coast	318	100	3	0.2	8	56	++	+	-	0	-
Liberia	96	100	1	0.1	7	26	++	+	-	0	-
Mali	1220	19	4	0.5	81	261	+	++	1,2	2	1,2,4
Mauritania	1030	0	2	1.1	77	0	-	++	1	1	1
Niger	1227	3	3	0.7	92	7	-	++	1	1	1
Nigeria	911	85	14	1.1	69	164	++	++	1,2	2	1,2,4
Senegal	192	46	10	1.4	37	125	+	++	1,2	1	1,4
Sierra Leone	72	100	4	0.7	60	91	++	+	-	0	-
Togo	54	100	7	0.4	44	1420	++	+	2	1	4
EAST AFRICA											
Comoros	2	0	59	19.2	71	0	?	?	-	?	?
Djibouti	22	0	6	0.0	0	0	-	?	-	0	-
Ethiopia	1101	9	24	2.9	84	23	-	+	1,2	3	1,2,3,4
Kenya	569	17	16	6.1	98	124	+	+	2	3	1,2,3,4
Somalia	627	5	21	8.5	98	0	-	++	1	2	1
Sudan	2376	17	9	4.1	96	85	+	+	2	3	1,2,4
Tanzania	886	72	13	1.6	90	37	+	+	2	3	1,2,3,4
Uganda	200	57	21	5.0	95	5	+	+	2	3	2,3,4
CENTRAL AFRICA											
Angola	1247	30	2	0.3	77	0	+	+	-	2	-
Burundi	26	100	15	3.3	72	0	+	+	2	2	2,3
Cameroon	469	90	8	0.3	48	54	+	+	1,2	2	1,2,4
Cape Verde	4	0	4	6.8	42	0	+	+	?	?	?
Centr.Afr.Rep.	623	100	3	0.5	96	0	++	+	-	0	-
Congo	341	100	0	0.0	11	0	++	+	-	0	-
Equat. Guinea	28	93	0	0.0	0	0	++	+	-	0	-
Gabon	258	100	0	0.0	4	17	++	+	-	0	-
Rwanda	25	100	24	10.1	84	0	+	+	2	2	2,3
Sao Tome PRN	1	0	3	0.0	0	67	+	+	?	?	?
Zaire	2268	95	1	0.0	11	120	+	+	-	2	-

Country	Land area 000 sq km	Area tsetse infested (%) (1)	Livestock units per sq km (2)	Kg milk per sq km per day (3)	Self-suff. in milk (%) (4)	Feed export as perc. of milk imports (5)	Production constraints: Diseases (6)	Production constraints: Land tenure (7)	Production constraints: Training Ext. demon. (8)	Dairy development possibilities: Potential (9)	Dairy development possibilities: Production Systems (10)
SOUTHERN AFRICA											
Botswana	567	4	3	0.5	74	0	+	-	2	1	3
Lesotho	30	0	20	2.1	49	0	+	+	2	2	2,3
Madagascar	582	0	13	0.2	50	24	+	-	2	2	2,3
Malawi	94	65	8	1.2	89	880	+	+	2	3	2,3,4
Mauritius	2	0	20	37.0	26	0	+	-	?	?	?
Mozambique	784	75	1	0.3	67	51	+	+	2	1	2,4
Swaziland	17	0	28	6.2	88	960	+	+	2	2	2,3,4
Zambia	741	40	3	0.3	84	0	+	+	2	3	2,3
Zimbabwe	387	18	11	1.6	98	1550	+	+	2	3	2,3

Footnotes:

(1) Percentage of land area infested by tsetse fly: data from Jahnke (1982).
(2) Livestock units per sq km: data from FAO.
(3) Kg milk per sq km per day: data from FAO.
(4) Percentage self-sufficiency in milk: local production as a percentage of local production and imports, based on FAO statistics.
(5) Feed exports as percentage of milk imports: feed value of exports converted into milk as a percentage of milk imports.

Production constraints:

(6) Disease situation:
 ++ Serious constraint: tsetse, dermatophilosis, ticks (mainly the humid areas).
 + Constraint: Seasonal tsetse infestation, etc. (mainly sub-humid areas).
 - Diseases cause less problems (mainly semi-arid and highlands).

(7) Land tenure system:
 ++ Communal land ownership, few possibilities to improve feed production.
 + Communal as well as individual land ownership.
 - Mainly individual land ownership
(8) Training, extension, demonstration:
 1. Training, etc., mainly in small-scale processing in pastoral areas.
 2. Development, demonstration, training, and extension of new dairy production systems.

Dairy development possibilities:

(9) Potential:
 0. Potential very low or non-existent.
 1. Very limited potential, mainly tapping existing resources.
 2. Potential in selected areas and for selected markets.
 3. Good potential.

(10) Production system:
 1. Milk collection for processing in pastoral areas.
 2. Development of milk production in mixed farming systems.
 3. Development of rural intensive milk production.
 4. Development of (peri-) urban milk production.

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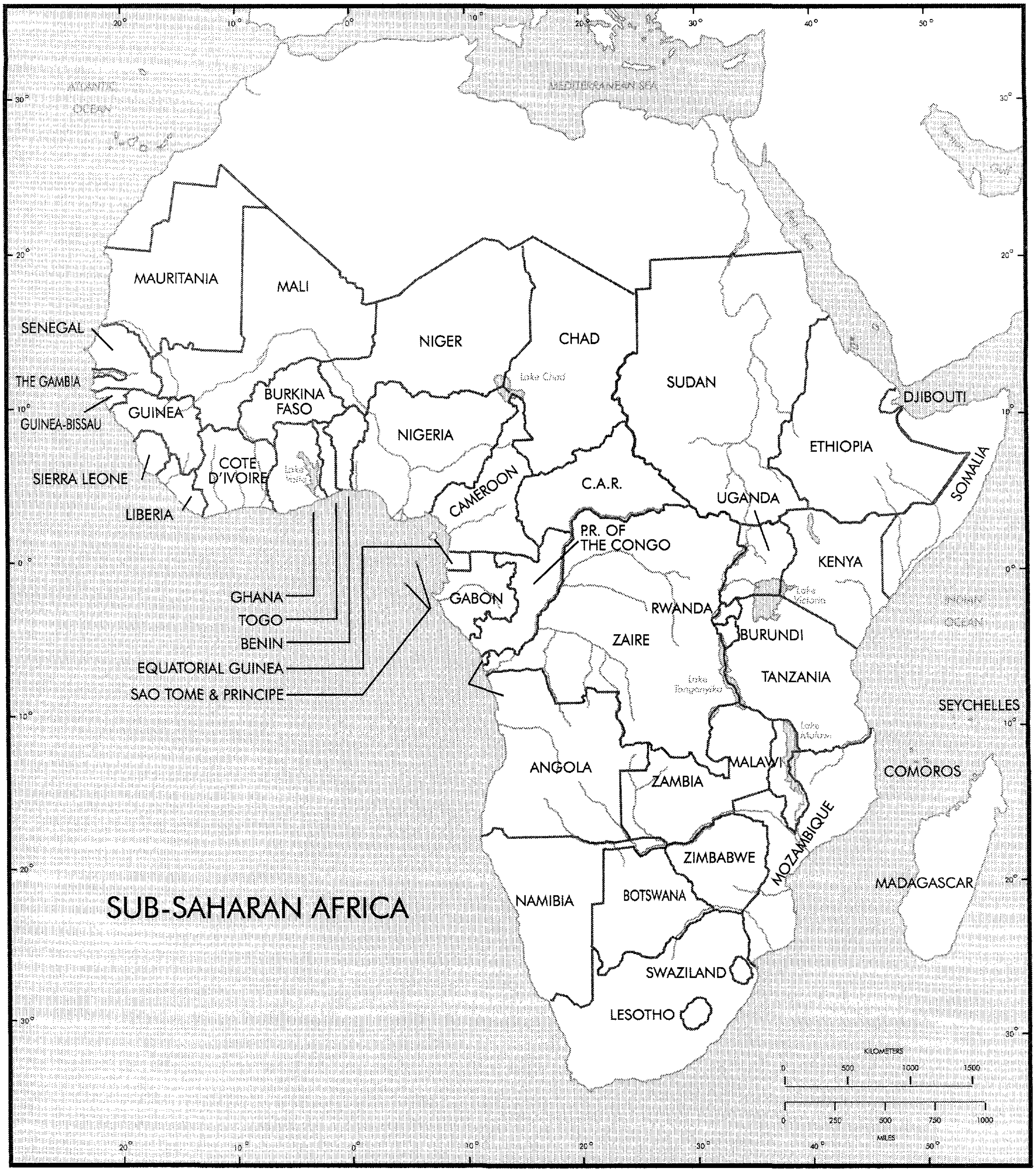

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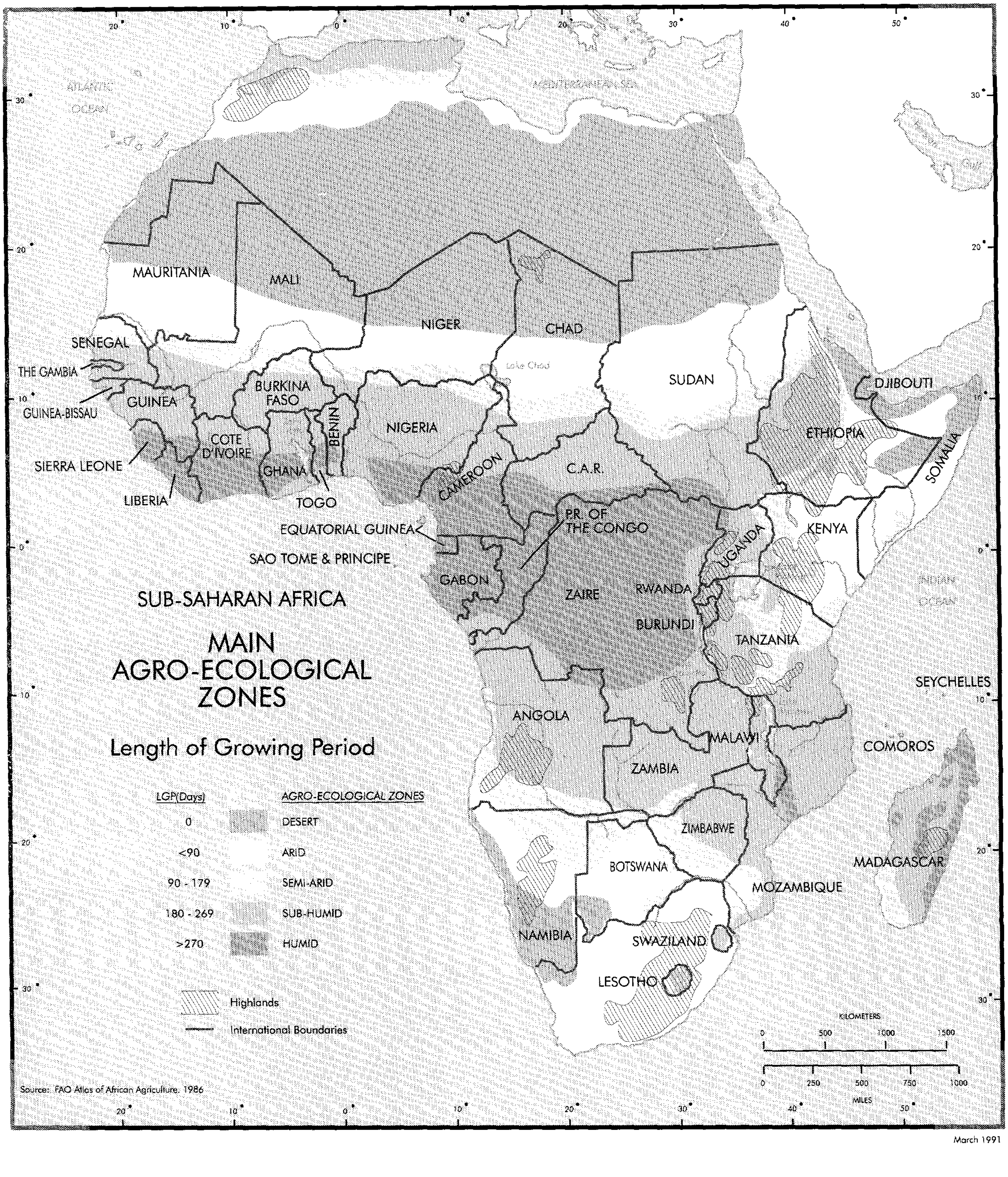

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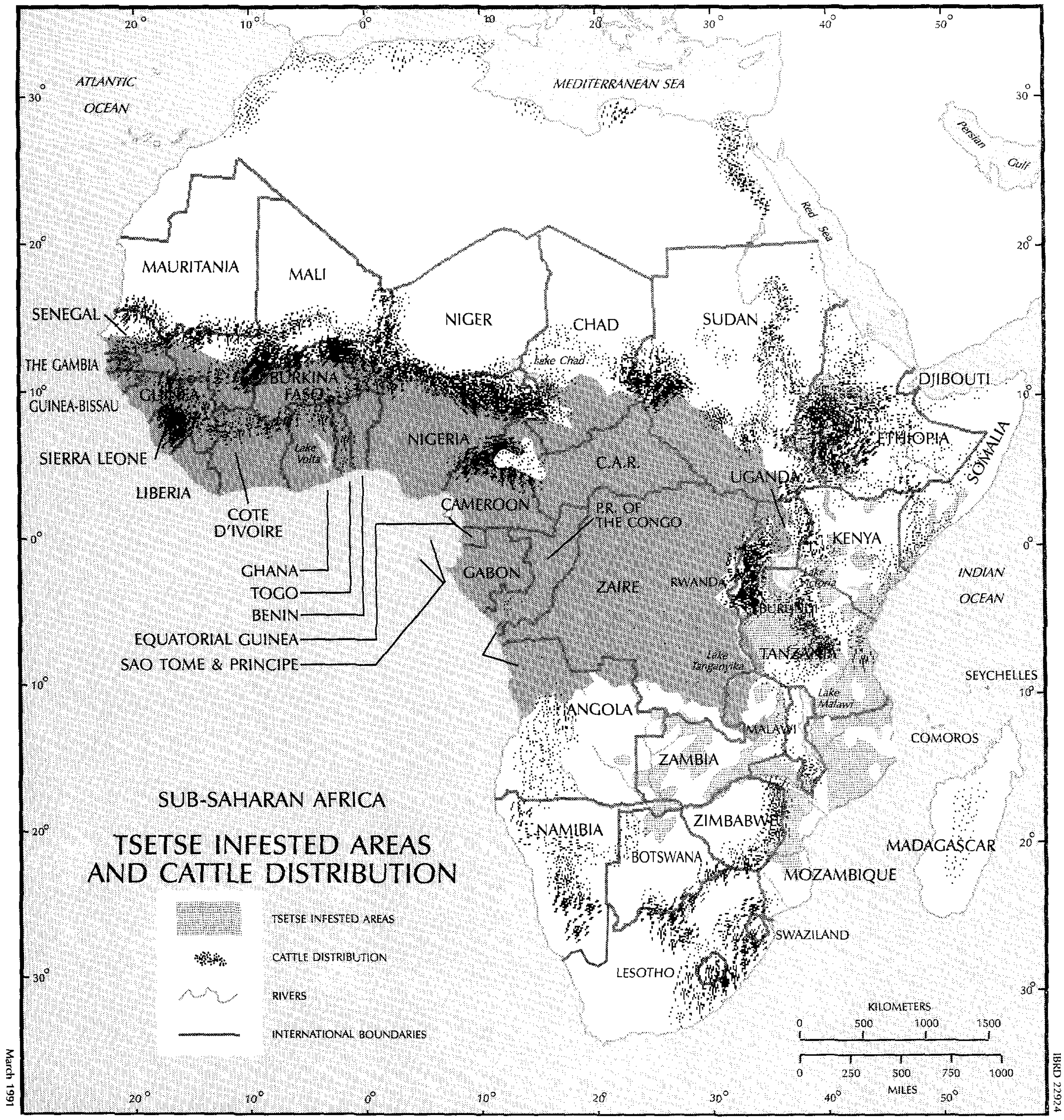
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