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PROJECT PAPER SUPPLEMENT

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ECONOMIC ANALYSIS OF THE LIVESTOCK SECTOR IN THE REPUBLIC OF MALI

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ECONOMIC ANALYSIS OF SELECTED ISSUES IN MALI'S LIVESTOCK SECTOR

Executive Summary

The following summary report condenses the principal findings, conclusions, and recommendations of a six-week mission by the author in January-February, 1988, to evaluate selective issues concerning the development of the livestock sector. Ten separate volumes are attached to this summary report, each dealing with a particular issue. Readers are encouraged to consult the more detailed volumes for in-depth treatment of the topics.

I. CATTLE HERDING TYPES IN MALI

Two main types of cattle raising systems are normally identified in Mali, namely the transhumant system that predominates in the northern pastoral area, and the sedentary system that predominates in the less arid southern zone. Ninety-five percent of cattle herds in the Kayes and Koulikoro regions could be classified as either sedentary or transhumant. A small but significant segment of the cattle population is in specialized production systems. Three of these systems merit special attention: oxen used in animal traction, males in embouche paysanne programs, and cows in specialized dairy herds.

Both transhumant and sedentary cattle depend almost exclusively on natural pasture for their nutrition. The nutritional quality of natural grasses varies greatly by season, but also by species and region. Cattle gain weight during the rainy season and early dry season; however, as the dry season advances, nutrient quality diminishes, while energy needs increase as distance from grass to water increases. Animals lose weight accordingly. This pattern of weight gain and loss is common to both transhumant and sedentary herds. Production and reproduction performance in these two systems are comparable. In many areas of Mali, the two systems coexist. Little can be done to raise the quality of natural pastures in Mali. Production performance of cattle can be improved through well-targeted programs to reduce mortality, especially among the young, and through better range and water distribution in pastoral zones aimed at reducing walking distances in the dry season.

Use of ox traction has expanded greatly in Mali in the last two decades, especially in areas of good rainfall with better agricultural potential. This expansion is closely linked to the increase in cash crop production, notably cotton and groundnuts; it is virtually non-existent for the exclusive production of cereal grains. Large and prosperous households are more likely

to benefit from incentives and credits for the acquisition of oxen and accessories such as costs and plows. Ox plowing leads to the expansion of cultivated areas under cash crops, but does not necessarily increase the intensity of cultivations in terms of yield per hectare.

Ox traction programs do not have a significant impact on beef supplies. Heavier live weights of culled oxen are compensated by fewer numbers reaching culling age. Demand for young male calves for animal traction offers a small but significant outlet for young stock, but does not add to overall demand, since the same animals are later slaughtered for meat. Pulling oxcarts for transport is probably as important a use of oxen as plowing and land cultivation. Donkeys and horses provide the bulk of animal power for transport throughout most of Mali. Further expansion of ox traction will be determined by the prospects for the main cash crops -- cotton and groundnuts -- as well as the expansion of the road network in rural areas. The latter helps by enhancing the marketing opportunity of farmers for grains and other cash crops.

The availability of cottonseed and cottonseed cake has generated a new type of livestock enterprise in those areas with access to the sources of these cotton by-products. Fattening cattle using cottonseed as the main feed supplement grew rapidly in the last decade, but its future growth is uncertain. The small-scale fattening program -- embouche paysanne -- carried out by Establissement de Credit et d'Investissement dans le secteur Betail-Viande (ECIBEV) has been cancelled. The program provided farmers with feed, technical assistance, and credit to purchase animals. Although some farmers have continued on their own, the great majority of ECIBEV beneficiaries have abandoned "embouche bovine."

Milk production on the periphery of Bamako basically comes from traditional sedentary cattle herds grazing on natural pasture, supplemented with only a small amount of cottonseed in the more progressive herds. Even in the most advanced dairy herds, cows spend the day grazing in the bush. Although intensive cattle production systems are highly visible herds that use natural pastures constitute nearly the entire cattle sector.

II. ECONOMIC ANALYSIS OF CATTLE HEALTH

Reductions in cattle mortality in Mali's Regions 1 and 2, the two regions of interest to the Livestock Sector Project, will have significant pay-offs. A one percent reduction in overall mortality among cattle in the project area over a 20-year period will bring $6.5 million in benefits to cattle owners, in net present value terms.

This is especially true for reductions in mortality at those ages when cattle are most vulnerable (before weaning). A reduction in calf mortality from 30 to 29 percent, sustained over 20 years, would yield an estimated net discounted benefit of about $12 million for cattle owners in the project area.

The largest contribution to benefits from reduced mortality comes from the value of cows in the herd, particularly the values of milk production and of male and female offspring. In addition, mortality has a large impact on herd growth over time, and the larger herd generates additional benefits.

Other animal health interventions effective in reducing mortality would have similarly attractive returns; however, depending on the specific type of intervention, investments in cattle health might or might not realize these high returns.

The easy solutions with high pay-offs have been implemented already. Vaccinations have effectively reduced the major infectious diseases (Rinderpest, CBPP, black leg, anthrax, and pasteurellosis) to tolerable economic levels, even though they are still endemic in the region.

Additional investments extending vaccination coverage to the cattle herd in Regions 1 and 2 might not be needed. The current level of coverage is sufficient to keep mortality from the endemic diseases to a few hundred head per year. Additional coverage might require investments not fully covered by real benefits from further mortality reductions. The same resources might be better applied toward other animal health interventions.

To the extent that the USAID Livestock Sector Project has concentrated its animal health resources in strengthening vaccination campaigns against major epidemic diseases, it deserves credit for their success. However, given the very low mortality from those diseases in the period before the project, it is difficult to demonstrate that the project has reduced mortality below the pre-project levels.

The economic analysis in the original project paper for the Livestock Sector Project vastly underestimated the benefits to be derived from reductions in mortality. On the other hand, it overestimated the actual number of livestock to be saved by the project. The project anticipated reduced overall mortality of 5 percent or the equivalent of 10,000 head of cattle per year, although the total actual toll from the main epidemic diseases in six years from 1980 to 1986 was only 2,735 head.

One of the principal outputs from this section is a microcomputer program to evaluate the impact of alternative animal health and economic interventions on the cattle subsector. The program could be used in the future to evaluate the impact of specific health measures and to update the current analysis as better information becomes available.

III. HEALTH INTERVENTIONS IN SMALL RUMINANTS

It has been recognized that sheep and goats deserve more attention in livestock development projects. In many projects, attention and funding are concentrated, sometimes exclusively, on cattle. Many observers have commented on this problem, but little progress has been made in improving the veterinary health coverage for small ruminants.

There is a widely shared notion that sheep and goats suffer high mortality, partly as a result of insufficient sanitary coverage; however, official statistics on outbreaks of all major contagious diseases among small ruminants indicate that their mortality incidence is surprisingly low. For example, there were no outbreaks of "peste de petits ruminants" in 1984, three in 1985, and six in 1986. No specific number of affected and dead animals is provided. With such low disease incidence, it is hard to justify additional investments in controlling this disease in the project area. Similarly, the loss of 138 sheep and goats in Regions 1 and 2 from pasteurellosis in 1986, equivalent to $7,000, does not justify additional project investments on the control of this disease.

The apparent good health of small ruminants and their resistance to major infectious diseases is remarkable, given the very thin vaccination coverage at present, and the limited livestock service resources devoted to sheep and goats. The diseases mentioned above mainly affect adult animals; however, the highest mortality takes place among newborn lambs and kids in the first few months of life. It is possible that current official statistics not only underestimate the actual occurrence of the "major" diseases among small ruminants, but that they completely ignore the principal causes of mortality in sheep and goats. Several empirical studies in Mali and other West African

Saharan countries clearly confirm the general observation that mortality in sheep and goats is especially high in the first year of life. Most of this mortality takes place before weaning.

Apparently little can be done about reducing the mortality rate. The system of veterinary health delivery is geared primarily toward the prevention of major endemic diseases in adult cattle; however, calf mortality remains the Achilles heel of cattle health. As with small ruminants, the importance of reducing calf mortality has been stressed by many observers for decades. The effects so far have been nil. There is no one-shot solution to the problem. No single injection can immunize a calf, lamb, or kid against malnutrition, diarrhea, and pneumonia for its first year. The Livestock Service network of vaccination ports is designed to service the animal vaccination campaigns, not to check on newborns in the field. Posts do not stock antibiotics on any significant scale, and herders cannot obtain them through private agents, since the distribution of veterinary medicines is practically a state monopoly. The lack of success in reducing calf mortality so far portends a similar failure in reducing mortality in sheep and goats.

For many economic, social, and environmental reasons, the productivity of small ruminants should be developed and promoted. The reasons have been stated often by many observers. Slaughter of small ruminants takes place mainly in the countryside, and higher sheep and goat productivities will lead directly to improved rural nutrition. Small stock is far more accessible to poor herders and farmers. Rural families and many urban families depend on the sale of small ruminants for quick cash in small amounts. Sheep and goat raising is not limited to pastoral groups. Farmers also have small stock grazing around their villages. Goats are browsers, as opposed to grazers, and thus complement cattle raising without competing for the same grass cover. Women might provide better health care for small ruminants, because small stock remain fairly close to the household. Sheep and goats are hardier in times of drought, and herd recovery is very rapid afterwards, replenishing depleted stocks of meat for both urban and rural consumers.

IV. PRIVATIZATION OF ANIMAL HEALTH SERVICES

Until 1986, it was illegal for a veterinarian to engage in private practice, even after retiring from government service. Recently, one of the major institutional changes introduced by the Government of Mali has been the legalization of private veterinary practice. The effects of this policy change are only now beginning to be felt, but they have the potential for providing a major impetus to increased productivity in the livestock sector. Two legal documents have been issued concerning the veterinary profession: a law signed on July 26, 1986 authorized its private exercise; and a decree of October 2, 1986 dealt with the organization and regulation of private veterinary practice. However, specific standards and regulations have not been made to deal with various issues such as the acceptable pricing margins on veterinary drugs. Different agencies within the government are responsible for the separate pieces of legislation. When any of the legislation will see the light of day is far from certain.

At present, the most obvious stumbling block preventing any real exercise of private animal health services is the inability of private veterinarians to procure medicines. The GOM Veterinary Pharmacy remains the legal monopoly for importing and distributing veterinary medicines and supplies, other than vaccines. The Central Veterinary Laboratory (CVL) is the sole entity producing, importing, and distributing vaccines. Only the CVL has a current policy for making the products accessible to private veterinarians.

Another obstacle blocking veterinarians' access to necessary supplies is the lack of GOM policy guidance on the prices the Veterinary Pharmacy will

charge private veterinarians, and the conditions under which sales will be made and on what marketing margins will be allowed. At the moment, veterinary distributions are made only through state or parastatal organizations, which purchase the products and are allowed a 10 percent discount, and then resell the products to livestock owners at fixed prices dictated by Veterinary Pharmacy schedules. The authorized prices of sale to herders are set by an interministerial accord at the same level that the Pharmacy uses for public sales through its own retail outlets. Since the current 10 percent margin allowed on veterinary medicines clearly does not cover their distribution costs, private veterinarians cannot be expected to become involved in the distribution of products that generate private losses. Thus, the current GOM system of rigid product pricing and fixed marketing margins for vaccinations and veterinary products effectively precludes private veterinarians from access to those products for distribution to the public.

In terms of increasing the effectiveness of the public sector in promoting animal health, what is perhaps most important is the pursuit of cost-recovery mechanisms, whereby the beneficiaries of these services contribute to financing their costs. In other words, the current system is not self-supporting, because the GOM has not been willing to adopt full-cost pricing.

There is one and only one exception to private sector activity in animal health. The Sahelienne de Production et Sante Animal (SAPROSA) has been operating since 1983. Its founder obtained a special presidential dispensation to establish a private veterinary clinic, and a pharmacy that obtains veterinary products from the National Veterinary Pharmacy. Recently, SAPROSA received a special authorization to import veterinary products directly to supply the needs of CMDT. The firm was able to do this at prices far below those charged by the Veterinary Pharmacy. Nevertheless, CMDT cannot pass the savings on to the cattle owners, since it is obligated by the GOM to sell to the public at the official price. The Veterinary Pharmacy is charging a markup of 67 percent over the actual CIF Bamako import cost.

The rationale for maintaining the legal monopoly of the Veterinary Pharmacy on imports, distribution, and pricing needs to be reexamined. There are valid reasons for establishing strict regulations with respect to the quality and truth in labeling for veterinary products. These functions clearly fall within the realm of government's regulatory role over private, commercial, and professional activities. These functions do not sufficiently justify establishing a state monopoly and effectively precluding private activities in the field. A more balanced allocation of responsibilities between the public and private sectors could greatly increase the effectiveness of the current system.

For the privatization of veterinary practice to succeed, the total state control of the vaccination campaigns must be relaxed. Presently, the market for veterinary services is dominated by the need for vaccinations against the major endemic diseases. If the private sector is relegated only to the minuscule market for non-vaccine products, the level of commercial activity would not justify establishing a private practice in rural areas. This would require allowing private veterinarians to charge herders the full costs for treatments. The official prices for vaccines would have to be increased to a level compatible with full cost recovery.

In fact, herdowners already pay more than the official prices for vaccinating their cattle. Unofficial charges are made in the forms of gratuities, gifts, food, travel expense reimbursements, or straight cash payments. Moreover, only a small portion of official funds actually collected from herders make their way to the Livestock Service. The accounting system used to monitor vaccination revenues is practically non-existent, and to develop a cost-effective accounting system would require raising the price charged to herders.

Unfortunately, the introduction of cost recovery for livestock vaccinations will have to wait another four or five years. Starting in 1989, the Pan-African Campaign will offer free vaccines to herders. The government will be reimbursed for the cost of production of vaccines. Free vaccinations are completely counter to the efforts of the past few years, which emphasized cost-recovery.

The probability of the Pan-African Campaign's success in eradicating Rinderpest is highly doubtful. The three or four cents that it saves the herders will have little impact on herd coverage. The real difficulties in reaching full coverage are posed by the insurmountable logistics of accessing herds in remote areas throughout the country.

One partial but effective solution to the problem of access to remote herds has been the provision of motor bikes to agents at the posts to allow them to travel to villages in their jurisdictions. This seems to be one of the major accomplishments of the Livestock Sector Project, judging by the unanimously favorable views expressed by those agents and other veterinary officers. Individual agents are loaned funds to purchase the motor bikes for themselves. Repayments have been good, which makes this program one of the most cost-effective contributions of the A.I.D. project.

Motor bikes have introduced an element of dynamism and private initiative into the system. Now, agents can go to vaccinate in villages rather than wait for herds to be brought to the park. The informal payments by herd owners, however unofficial, serve the purpose of motivating agents to do their jobs, while saving the herder much effort. It serves little purpose to frown on such compensation to agents unless we can offer alternative legal means to achieve the same results.

A simple alternative could be to allow agents to charge herders for vaccines at a price high enough to encourage them to scramble far into the bush in search of customers. Agents, in turn, could be charged some cost per vaccine to discourage ordering an excessive number of doses that would be wasted. There would be no reimbursements.

Fears that agents might abuse their positions to exact excessive prices from herders might necessitate GOM control measures. There are ways to prevent such abuses. First, flood the market with extra doses of vaccines; price gouging is only possible when supplies are scarce. Second, sell vaccines to private veterinarians at the same price as the agents, to encourage area competition.

V. PROSPECTS FOR MALIAN CATTLE EXPORTS

Malian cattle producers face favorable demand prospects for their product over the next five years. Current prices are exceptionally low, mainly as a result of sizeable dimping of EEC beef in the coastal countries of West Africa, and the poor economic growth performance of the area in the last few years.

Continued rapid urban growth and a modest increase in consumer income are expected to lead to a vigorous increase in demand for beef, especially in the coastal countries of Ivory Coast, Ghana, and Guinea. The darkest cloud on the horizon is the disposal of EEC beef surpluses on the coastal market at give-away prices. It is essential that Mali and other Sahelian countries protest the harm done to their livestock sectors by such EEC donations. Reasonable controls on the volume of EEC exports to coastal countries should be sought.

Assuming a leveling of EEC exports at 10,000 tons per year, we expect a gradual improvement of Malian cattle prices over the next five years, reaching up to $3 per kilo carcass at the end of the period, a 50 percent increase over the $2 prevailing in Bamako.

A computerized market trading program was developed in order to forecast the export market prospects for Malian cattle, and the potential impact on that market of health interventions and policy changes in Mali. Six countries of the central corridor of West African livestock trade were included: Mali and Burkina Faso are the traditional exporting countries, while Ivory Coast, Ghana, and Liberia are net importers of beef cattle. Guinea has

the unusual characteristic of being a coastal country with a large cattle population.

Beef production in Mali has been estimated at 43.7 kilotons, corresponding to a herd of 4.05 million head of cattle, with an 8 percent offtake rate, and an average carcass weight of 135 kilograms. Similarly, Burkina Faso, with a herd of 2.7 million, produced 28.2 kilotons of beef. Hypothetical consumption functions were derived for each country on the basis of their urban population, per capita consumption levels, and an assumed price elasticity of demand of -0.6. Whenever possible, data reported in secondary sources were used, but in their absence, our own subjective estimates were entered. As better information becomes available for Mali and the other countries, more appropriate estimates should be introduced. Transport costs have been assumed to be proportional to the surface distance between the capitals of the six countries involved.

Given the above information, we derived the pattern of trade flows, i.e. the level of exports and imports, that will result from a competitive trading system. Mali consumes domestically about half of its total production, and exports the other half to Ivory Coast, plus a small amount to Liberia. Burkina Faso consumes about a third of its production and exports the rest to Ivory Coast mainly, but also to Ghana. Guinea turns out to be a net exporter of cattle to Liberia. These trade flows agree well with recorded observations in the past decade. The corresponding levels of prices also match price patterns obtained in the CRED study of Livestock and Meat Marketing in West Africa, around 1980.

The impact of investments in animal health in Mali upon its export and domestic cattle market were analyzed. The trading program allows us to estimate the benefits to Malian cattle producers and consumers from increasing beef production as they are distributed by an efficient competitive marketing system. Consumption levels in all six countries increase as a result of Mali's additional output. Consumers in Bamako, and also in Ouagadougou and Abidjan, are beneficiaries of the investments in Malian cattle health. Not only is consumption higher everywhere, but prices are lower everywhere. In

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Bamako itself, the price per kilogram of carcass drops by 8.3 percent when Malian production increases by 10 percent. Herders in Burkina Faso, on the other hand, will suffer a loss of income, since now their animals will be getting lower prices. Cattle owners in Mali will benefit slightly, in terms of revenue, from higher production despite the drop in prices. The main beneficiaries are beef consumers in Bamako and in other importing and exporting countries.

Imports of 20 kilotons of beef from the EEC to Ivory Coast in 1987 caused a devastating impact on prices received by producers in Mali and Burkina Faso. A 10-kiloton import from EEC leads to increases in consumption in all countries, even when the imports are limited to Ivory Coast. In such a case, Mali and Burkina Faso export less and consume more domestically. Prices drop dramatically in all capitals. The consumer's delight is the cattle owner's distress, since producers in Mali, Burkina Faso, and elsewhere receive less when they sell their animals. A 10-kiloton EEC export reduces prices in Bamako by roughly 18 percent. Similar impacts are felt in Burkina Faso and other countries.

An increase in Malian beef supply will go partly to the domestic market, and partly for exports to Ivory Coast and Liberia. The negative price impact from increments in total Malian cattle products is lessened by the export market, that is, prices decline less than if the additional production were confined to Mali's borders.

The price elasticity of demand for Malian beef for the combined export and domestic markets, is more elastic than for the Malian market alone. The elasticity value calculated was between -1.03 and -1.05, while the price elasticity for the Bamako market was taken to be only -0.6. The nearly unitary price elasticity of demand for Malian beef indicates that total revenue from cattle sales remains basically constant for higher or lower levels of Malian production. In the short run, if production increases by 10 percent, prices decrease by an almost equal percentage, and total revenue is roughly the same.

VI. DOMESTIC MEAT MARKET PROSPECTS

OMBEVI is officially charged to keep track of all livestock slaughter in Mali, but a great deal of domestic slaughter takes place without being registered officially. This is especially the case for small ruminants, which are regularly killed in villages and urban households without official notice. Slaughter of cattle is more likely to be registered in official statistics, since most cattle are killed in controlled abattoirs, particularly in the larger cities.

During 1986, a total of 159,000 cattle officially were slaughtered, compared with 314,000 sheep and goats. Assuming an average carcass weight of 120 kilos for cattle and 11 kilos for small ruminants, their relative contribution to red meat production would be 19,000 tons of beef and 3,500 tons of mutton and goat meat. Camels also make a small contribution to the official national meat supply.

Regional slaughter levels in 1986 were consistently lower than in 1985 for all species. Complete data for 1987 are not yet available, but figures for Bamako indicate that the decline might have continued in 1987. Beef supply in 1986 declined by about 20 percent relative to 1985 supplies, and total red meat availability declined by 18 percent over the same period. The reduced numbers of slaughtered livestock are obviously the after-effects of the 1983-84 drought, which not only forced the slaughter of many cows because of distress, but also reduced the number of calves reaching markets in subsequent years.

Forty-seven percent of all cattle slaughtered in 1986 was from Bamako alone. Another 45 percent was distributed about evenly between the cities of Segou (15 percent), Sikasso, Kayes, and Koulikoro (10 percent each). Mopti, Gao, and Tombuctu together account for only 8 percent of the official cattle

slaughter. Bamako also has a higher average carcass weight for cattle killed. Only cattle exported are consistently heavier than those killed in Bamako.

Since 1984, a consistent downward trend is observed in the number of animals slaughtered and in the quantity of beef produced in the Bamako area. Although there were a total of 10,800 tons of beef in the Bamako market in 1984, by 1986 that total had declined to 9,500 tons, and for 1987 this figure will be even lower.

There is a marked and consistent drop in beef output in the middle of the year between June and September, the hungry period between one croping season and another. Starting in October, output begins to increase. From December through May, high levels of slaughter are maintained, with another steep drop from June to September.

Economically, the pattern described above makes sense. When the rains start in June and grass grows again, cattle owners would be reluctant to sell when their animals are about to recoup weight losses incurred during the dry season and resume overall growth. They increase their sales and net revenues when their animals are fat in October, November, and December. Prices increase consistently during the dry season, which encourages herders to retain their animals even when they are losing weight. Moreover, selling at the end of the year allows herders to purchase staple cereals immediately after the harvest, when prices are lowest.

The seasonal pattern of slaughter does not correspond well with the hypothesis that herders sell animals mainly under duress, when their households are under great stress. Needs are greatest at the end of the dry seasons and before the next harvest, but this period is precisely when the level of sales for slaughter are lowest.

There is an officially controlled pricing system for beef in Bamako, which announces meat prices periodically. At the moment, the official prices are 700 FCFA per kilo of beef with bone and 1,000 FCFA for boneless meat. These are the official prices quoted in OMBEVI's statistics; however, there

are many meat outlets that charge higher prices for better quality meat. Expatriate households, for example, can pay 2,500 FCFA for a kilo of lean hamburger meat at a butcher shop.

Under the system of flexible price controls for certain categories of products, enterprises are given a reference price, which they can exceed only if they can submit evidence to the authorities that their costs justify the higher price. For beef, a butcher can sell his meat at prices commensurate with the actual purchase prices for live animals, plus allowances for processing, distribution, and reasonable returns on labor and capital. Some meat stalls will sell the less valued front quarters of old cows at the official price, while the rear quarters and meat from cows in better condition are sold to a more affluent clientele at higher prices.

On-the-hoof prices of cattle are not controlled. OMBEVI monitors livestock markets on a regular basis to record numbers of animals presented, actual sales, and average prices received for different categories of animals. The daily cattle market in Bamako is one of the markets regularly monitored by OMBEVI. On the basis of reported prices for live animals, and visual estimates of average carcass weights, OMBEVI arrives at average prices per kilo carcass for different types of animals. Unfortunately, the Bamako abattoir does not keep track of how many cows, bulls, and oxen are slaughtered, or of which breeds. (This is an important item and should be included in the management information system for the livestock sector.) The price of Fulani cows was selected as a representative price, and is a barometer of the beef market in Bamako.

Between January 1984 and November 1987, beef prices in Bamako exhibited a sustained upward trend in contrast to the downward trend of beef supplies. Prices increased rapidly in the past four years, starting at just over 400 FCFA per kilo in January 1984, to just below 700 FCFA in November 1987. Prices are stable throughout the year, both in absolute terms and relative to the variations observed in beef availabilities; therefore, it is difficult to understand why the authorities worry so much about presumably excessive price variations from one month to another, when the recorded prices by

OMBEVI show no such variations. Nevertheless, a mild but consistent pattern of seasonal price movements is unmistakable, with a high point in August when supplies are lowest, and a low point in December when supplies are abundant. Clearly, the observed prices correlate strongly and inversely with the volume of beef in the market. This would indicate that the cattle market in Bamako is functioning normally in response to seasonal supply and demand conditions.

In view of the strong correlation between beef supply and live cattle prices, attempts were made to estimate a demand function for beef in Bamako. We estimated a price-consumption function. Demand for slaughtered cattle in the Bamako area reflects not only the city's demand, but also demand for cattle used for export, traction, fattening, and other economic variables.

Estimates of price elasticity of beef consumption in Bamako ranged from -0.51 to -0.90, depending on functional form, and whether adjustments for population growth and inflation are made. An intermediate value of -0.6 has been used in most of the analyses in this report. This value indicates that a 6 percent increase in beef supply will result in a 10 percent drop in price. Such a price decline is low relative to that expected for ordinary foods, but it reflects consumer behavior in Bamako. Beef is a luxury food in the diet; it is consumed mainly by the upper income strata. Unfortunately, there are no other values in the available documentation regarding the price elasticity of beef consumption for Bamako or a comparable city. The importance of this elasticity value becomes apparent when projecting potential price changes from alternative amounts of beef reaching the market.

VII. BEEF CONSUMPTION AND INCOME DISTRIBUTION

Ordinarily, beef consumption depends on the level of household income. Long-term beef demand projections require that we determine some quantitative relation between levels of income and levels of beef consumption. In Mali, as in other countries in West Africa, beef consumption is largely concentrated in urban centers. Bamako accounts for half of the official cattle slaughter in the country; therefore, we examined the relationship of incomes and beef consumption in the capital city. To do this we took advantage of the preliminary results of the Urban Household Food Expenditure Survey conducted in 1985/86 by the National Statistics Office, which are now being analyzed by a group from Tufts University. The Survey lasted one year and covered 576 households in Bamako and seven other regional capitals. In this report, we looked only at Bamako.

The poorest quartile of households spends 55 percent of its income on food, the wealthiest spends 47 percent, and the mean for all Bamako households is 51 percent. These percentages are surprisingly low, given the low per capita level of income. Moreover, there is very little difference between the highest and lowest income groups. In comparable countries, the poorest groups spend a much larger percentage of income on food than the wealthiest group.

In terms of expenditure, rice is the largest single item in the diet. The poorest group spends 26 percent of all food expenses on it, and the wealthiest group spends 20 percent. In addition, other cereals (millet, wheat, and sorghum) account for 14 percent of food expenses among the poor and 13 percent among the rich.

Meat consumption also accounts for a fairly large share of food expenditures in the Bamako diet, even among the poorest group, which spends 11 percent of all food costs on meat. The wealthiest group spends an average of 17 percent on meat and the average for all groups is 14 percent; therefore, meat consumption grows faster than income as income rises. Such consumer behavior is typical of luxury and high quality goods. There is a consistent upward trend: 11, 13, 14, and 17 percent of total food expenditures from the poorest to the richest quantities.

In absolute monetary terms, the poorest income group spends 323 FCFA per capita per month on meat, while the wealthiest group spends 1,627 FCFA. The corresponding values for quartiles 2 and 3 are 561 and 883 FCFA. Thus, the percent shares convey a deceptive image of evenness of meat consumption across income groups, while the absolute amounts show that actual expenditures on meat in the upper income quartile is on average five times the amount spent by the poorest quartile. Put another way, the wealthiest quartile of the Bamako population accounts for 48 percent of all meat expenditures in the city, while the poorest quartile of households accounts for 9 percent. The values for quartiles 2 and 3 are 16 and 26 percent.

This disproportionate share of meat consumption by the highest and lowest income groups is worth remembering when considering official pricing policies. Since three-quarters of all meat goes to the wealthier population, any measure to reduce the cost of meat will benefit mainly those wealthier segments. The rich benefit five times more than the poor, since they spend five times more on meat; therefore, it is hard to justify official price controls on meat on the grounds that they serve to protect the poor or encourage their consumption of meat.

The income elasticity of meat consumption measures the percentage that meat consumption will increase when household income increases by one percent. On the basis of the above household survey, we estimated the income elasticity at 1.27. This value indicates that meat consumption expenditures grow more than proportionally when income increases. A rise of 10 percent in household income will lead to a 12.7 percent increase in meat

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expenditures. As income grows, there is also a shift towards higher quality meat at higher prices, so that increases in actual meat quantity are less than increases in meat expenditures. A product with an income elasticity value higher than one is usually referred to as a luxury good, i.e., one for which consumers show a strong preference, and is purchased mainly by the wealthier strata of the population. This apparently is the case for meat consumption in Bamako.

VIII. DOMESTIC DAIRY MARKET PROSPECTS

In terms of contributions to the economy of the herding household, milk production is as important, if not more important, than the production of slaughter animals. In addition to providing a high quality food for the family, milk production allows herders to obtain grains and other goods through exchange with farmers in nearby villages.

Unlike live animals, the transport of milk from producers to consumers under typical African conditions poses enormous difficulties. After milking, the commodity is subject to rapid deterioration. The distance to towns and villages may be too far to allow daily trips to market. Surplus milk is often transformed into butter or local cheese for easier marketing. The bulk of milk production in Mali is consumed in rural areas, either by families that own cattle or by farmers who exchange grain or cash for milk. If not consumed fresh, the milk is either boiled for later use or made into soured milk.

There is a strong seasonality in the volume of milk marketed. Production and sales are highest during the rainy season becuase of the abundance of pasture and the concentration of calvings just before the rains. During the dry season, however, good pasture becomes scarce and most cows are at the end of their lactation curve. Then, the majority of production goes to satisfy the needs of the family.

Marketing of raw and soured milk has sometimes been banned, because these products are not pasteurized. Reasons of public health are often adduced, even though no one seems to get sick from consuming these nutritious products. Sometimes the ban is only a veiled effort to ensure the survival of modern dairy farms and processing plants when they are unable to

compete in price with products from the traditional dairy sector. We must be wary of efforts in that direction in Bamako.

Urban consumers are hampered in their access to fresh milk by the difficulties in establishing a transport and delivery system for locally produced milk. Rather, Bamako and many other large cities in Africa find it convenient and profitable to import powdered milk from overseas, add water, and sell it as reconstituted milk. Until recently, the supply of fluid milk in Bamako consisted almost entirely of reconstituted powdered milk processed by the city dairy plant (ULB, Union Laitiere de Bamako). Only 2 percent of the 8.2 million liters of fluid milk processed by ULB in 1984 was local fresh milk collected from farmers; the remainder was reconstituted powdered milk.

Most of the powdered milk used by the ULB is donated by the European Economic Community. The generosity of the EEC is the result of the Community's Common Agricultural Policy, which has generated vast surpluses of livestock products including beef and milk. Rather than pay for storage, the EEC finds it cheaper to give it away overseas.

Bamako's flow of powdered milk was suddenly reduced in 1986 as the EEC reduced its donations following the nuclear accident at Chernobyl. The production of reconstituted milk dropped from 8.2 million to 3.8 million liters in 1984. A major storage of fluid milk in Bamako was averted thanks to the rapid response by local producers. One of the main reasons for the success was the creation of COLAIBA, the dairy cooperative of Bamako. A major accomplishment of COLAIBA was to negotiate with the ULB a better price for fresh milk from its associated herds. The ULB is a parastatal. The leaders of the cooperative are influential individuals. The ULB agreed to purchase milk from the affiliated producers at 225 FCFA per liter, even though ULB sold the reconstituted milk at 110 FCFA wholesale. At the new price, the flow of milk to ULB increased dramatically. Membership in the cooperative also grew rapidly. The price offered by ULB to private milk producers was also increased to match the COLAIBA price, and a similar growth in milk deliveries from private producers followed. At the beginning of 1988, ULB was having difficulties accepting and paying for the volume of milk offered, and producers

were finding it necessary to sell part of their output in the open market as raw milk. The reasons for these difficulties at ULB are not known, but they could be linked to financial losses incurred because of the negative margin between the sale price and the producer price. By the end of February 1988, the agreement had collapsed, and COLAIBA producers have suspended deliveries of fresh milk to ULB.

Milk production levels of local cows are highly seasonal and dependent on feed availability. Herds under semi-intensive production systems, i.e., where feed supplements are given to cows, have higher production levels than herds grazing in natural pastures, especially during the dry season. An ILCA study concludes that local cows respond to feed supplementation by producing more milk; however, given the prices of milk and feed inputs at the time (1986), some farmers might not find it commercially worthwhile to purchase feeds for milking cows, even at the new 225 FCFA/liter price. By contrast, herders grazing cows in natural pastures could cover their costs even at the former low price (Kone and Von Massow, 1986).

Apparently, the increase in milk output response of local cows to feed supplementation is insufficient to justify its costs. This is too important a point to accept without further inquiry. Unfortunately, there are no ongoing tests to determine the milk production response to better nutrition by the local cows. The attention of animal science researchers at the INRZFH has been mainly concentrated on the genetic improvement of the local herd through the introduction of exotic blood.

There are ongoing efforts by private and public concerns to improve the genetic make-up of local breeds. COLAIBA has imported about 300 head of Montbeliarde cattle from France, mainly bred heifers, but also young bulls. The European Development Fund pays for the air freight, which is the largest cost component in each shipment. Both the technical viability of and economic rationale for these imports are doubtful. Similar attempts in other parts of West Africa at introducing European breeds have consistently failed to perform as expected. Mortality has been over 60 percent among the imported animals,

but some cross-bred animals have been produced and are distributed among COLAIBA members.

The National Institute of Agricultural Research (INRZFH) is carrying out a program of dairy genetic improvement on an experimental herd in Sotuba ranch, using semen of the Red-Steppes cattle from Eastern Europe. The results have been disappointing. During 1986, for example, out of 353 semen doses used, only 15 calves were born. The reasons for such a dismal performance are unknown, but until this conception rate can be improved, the potential for using artificial insemination to raise the genetic dairy potential of native cows will remain unrealized.

The dairy market in Bamako is further complicated by the presence of another parastatal enterprise, the Societe Malienne d'Importation et d'Exportation (SOMIEX). This enterprise has been given a legal monopoly for the importation and distribution of processed milk, either in powdered or condensed form. The GOM authorizes SOMIEX to sell these products at fixed prices throughout Mali.

SOMIEX sells both condensed and powdered milk through its own distribution network. An ILCA study estimated fluid milk equivalents for the different components of imported dairy products in Mali. For 1982, SOMIEX imported the equivalent of 18,000 tons of fluid milk -- 60 percent of the national import equivalent of 30,000 tons. About 60 percent of SOMIEX imports are distributed in Bamako, which amounts to the equivalent of 11,000 tons of fluid milk. By contrast, ULB reconstituted the equivalent of 6,000 tons of fluid milk, barely half of the milk equivalent distributed by SOMIEX that year. Two-thirds of milk consumption in Bamako is in the form of powdered or condensed milk. (Note: By the end of February 1988, it was reported that SOMIEX would no longer have the exclusive monopoly on imported processed milk).

Given the significant changes that have occurred in the last few years, and those taking place now, it would be worthwhile for A.I.D. to sponsor an

in-depth study by ILCA to update the import, production, and marketing situation in the dairy sector.

The relationship between income and milk consumption was examined using preliminary data from the Urban Household Consumption Survey of 1985/86 by DNSI. The poorest quartile of Bamako's population spent 2 percent of all food expenditures on milk products, and the other quartiles spent 2, 3, and 4 percent, in ascending order of income. In terms of actual money expenditure on milk, the poorest group spent 59 FCFA per month per person, while the other groups spent 86, 189, and 383 FCFA. Income elasticity of milk consumption was estimated at 1.73. Clearly, milk in Bamako has the character of a luxury food, i.e., one that can be afforded by the more prosperous segment of the population. The richest quartile accounts for 53 percent of milk consumption in Bamako. The second richest consumers account for 26 percent. That leaves 21 percent of consumption to be shared by the poorest half of the population: the less poor quartile gets 12 percent, and the poorest gets only 8 percent.

It is hard to justify a pricing policy for milk on the bases of "protecting the poor consumers." Since the wealthier half of the population consumes four-fifths of the available milk, they are the principal beneficiaries of a lower milk price. The poorer segment of the population hardly benefits at all because at their income, they cannot afford to buy milk.

IX. HERDERS' WILLINGNESS TO PAY

In Mali, as in most West African countries, veterinary services performed by the Government Livestock Service are provided almost free of charge. The tradition of practically free veterinary services dates back to pre-independence days. Private veterinary practice was legally prohibited until a few months ago; therefore, there is no tradition of government charging for animal health care supplies and services.

The present system of charges for vaccinations generates insignificant amounts of revenue for the government. The fee charged for vaccinations is only 12.5 FCFA or 4.5 U.S. cents per dose. Revenue collected is not retained by the Livestock Service, so there is little incentive for it to improve in the cost recovery effort. Leaks in the collection system are a major impediment to institutionalized cost-recovery. Another obstacle in enforcing strict controls over receipts for vaccines is the government's failure to pay the salaries of field agents on time: their salaries are currently four months overdue.

The current inability of the Livestock Service to recover the meager revenues from vaccinations is a far more serious obstacle to cost-recovery than the herders' lack of willingness to pay.

Herdsmen already pay far more than the official charges for vaccinations. Herd owners gladly prefer to pay unofficial incentives to veterinary agents to come to vaccinate their herds in their villages, rather than walk the entire herd all the way to the vaccination park and back.

Present levels of charges for vaccines are minuscule in relation to herders' revenue from livestock. A cattle owner with 100 head of cattle only needs to vaccinate about half of the herd in a given year. The total fee for Rinderpest vaccination only amounts to $2.25 per year. This is one-tenth of one percent of the expected revenue of $2,000 from the sale of eight head of cattle alone (assuming an 8 percent off-take rate).

Official charges for vaccinations cover only a fraction of the true cost to the government. Production costs at the Central Veterinary Laboratory are roughly 20 FCFA per dose of Rinderpest vaccine. Herders pay only 12.5 FCFA. Additional costs absorbed by the government are the transport, storage, delivery, and injection of the vaccines. All these costs would have to be covered if vaccinations were financially self-supporting. When these additional costs are taken into account, the delivery price to herdowners would rise to 100 FCFA per dose; therefore, cattle owners currently contribute only about one-tenth of the real cost per dose.

All evidence seems to indicate that herd owners in Mali are willing and anxious to pay for medicines and animal health services for their animals, when these are available. Availability of these inputs on a timely basis is a far more serious constraint than price. The current lack of use of mineral licks, antibiotics, and antiparasite treatment, is a reflection of their difficult availability in rural areas, rather than high price. The main reason for the less-than-full coverage of the cattle herd in the Rinderpest vaccination is not as much reluctance of herders to pay the modest fee, as it is their view that annual vaccinations of all their animals is unnecessary, a view that most veterinary experts share.

There is ample room to increase the fees charged to cattle owners for vaccinations. At the moment, only a fraction of the actual costs of vaccines are charged to cattle owners, and this charge amounts to a very small share of receipts from livestock sales. Charging more to herdsmen will little benefit the Livestock Service financial situation, unless two problems are addressed. First, a better system is needed for tracking money received from herd owners, and for ensuring that it gets delivered eventually (the Livestock

Sector Project could greatly help in this). Second, funds collected should be shared, at least partially, with the Livestock Service, instead of going solely to the Central Treasury.

Over the next few years the Pan-African Campaign will reimburse the GOM for the cost of the Rinderpest and CBPP vaccines, so that cattleowners can get them for no charge. The Campaign is predicated on the belief that the modest fee now charged to herders discourages them from vaccinating their animals, and that if the fee is removed, herd coverage will increase dramatically. We doubt this analysis. Removal of the tiny fee does not lower other more significant cost elements; therefore, we anticipate that the Pan-African Campaign will have an insignificant effect on raising herd vaccination coverage.

One unfortunate consequence of the Pan-African Campaign is the complete abandonment of the current system of fee collection for health services. Throwing away the current system, however imperfect, constitutes a major setback toward the goal of better cost-recovery.

The main complaint heard about non-vaccine pharmaceutical items is their limited and sporadic availability. There is an unsatisfied demand for veterinary products, even when priced at the substantial mark-up by their sole legal importer, the Veterinary Pharmacy. Currently, the issue is not so much whether cattle owners are willing to pay for non-vaccine pharmaceuticals -- they are -- but rather, how to improve the chronic shortage and limited spectrum available, especially in the remote pastoral areas where most of the cattle are.

VOLUME II

ECONOMIC ANALYSIS OF CATTLE HEALTH INTERVENTIONS IN MALI

I. Summary

Of the major conclusions and findings from the economic analysis of cattle health interventions in Mali, the following merit highlighting:

- Reductions in cattle mortality in Mali's Regions I and II, the two regions of interest to the Livestock Sector Project, will have significant pay-offs. A one percent reduction in overall mortality among cattle in the project area over a 20-year period will bring $6,500,000 in benefits to cattle owners, in net present value terms.

- This is especially true for reductions in mortality at those ages when cattle are currently most vulnerable, i.e., calves before weaning. A reduction in calf mortality from 30 to 29 percent, sustained over 20 years, would yield an estimated net discounted benefit in the range of about $12,000,000 for cattle owners in the project area.

- The largest contribution to benefits from reduced mortality comes from the value of cows in the herd, particularly the value of milk production and male and female offspring. In addition, mortality has a large impact on herd growth over time and the larger herd generates additional benefits.

- Other animal health interventions effective in reducing mortality would have similarly attractive returns. Depending on the specific type of intervention, however, investments in cattle health might or might not realize these high returns.

- The easy solutions with high pay-offs have been implemented already. Vaccinations have effectively reduced the major infectious diseases (Rinderpest, CBPP, Black Leg, Anthrax, and Pasteurellosis) to tolerable economic levels, even though they are still endemic in the region.

- Additional investments to extending vaccination coverage to the cattle herd in Regions I and II, might not be needed. The current level of coverage is sufficient to keep mortality from the endemic diseases to a few hundred head per year. Additional coverage might require investments not fully covered by real benefits from further mortality reductions. The same resources might be better applied toward other alternative animal health interventions.

- To the extent that the USAID Livestock Sector Project has concentrated its animal health resources in strengthening vaccination campaigns against

major epidemic diseases, it deserves credit for their success. However, given the very low mortality from those diseases in the period before the project, it is difficult to demonstrate that the project has in fact reduced mortality below the pre-project levels.

- The economic analysis in the original project paper for the Livestock Sector Project vastly underestimated the benefits to be derived from reductions in mortality. On the other hand, it overestimated the actual number of livestock to be saved by the project. The project anticipated reduced overall mortality of 5 percent - or the equivalent of 10,000 cattle heads per year - while the total actual toll from the main epidemic diseases in the six years 1980-86 was only 2,735 head.

- One of the principal outputs from this section is a microcomputer program to evaluate the impact of alternative animal health and economic interventions on the cattle subsector. The program could be used in the future to evaluate the impact of specific health measures and to update the current analysis as better information becomes available.

II. Purpose

The purpose of this chapter is to carry out an economic evaluation of the impact of animal health interventions by the Livestock Sector Project on the cattle herd in the Kayes and Koulikoro regions of Mali. A similar analysis for small ruminants should be done separately, because time did not allow its completion as part of this report.

The Livestock Sector Project makes investments in many activities in addition to animal health delivery, including investments in a diagnostic/ research laboratory, training, research in forage crop production, and management information systems. The impact of these upon cattle herders is transmitted almost exclusively through the activities of the National Livestock Service. The National Livestock Service's primary role is in animal health, and almost exclusively in the provision of vaccinations for the principal contagious diseases in cattle. Thus, to the extent that other components enhance animal health service delivery, their impacts are embodied in the present analysis. Mobilettes and radio communications equipment to link veterinary posts will enhance the ability of the Livestock Service to respond quickly to outbreaks of contagious diseases, thus contributing to lowering mortality and morbidity.

Outputs from other project components could lead to benefits other than reductions in mortality; for example, research in forage production could result in improved nutrition, higher calving rates, and faster rates of growth. Separate economic analyses might then be warranted for these project components and their corresponding outputs.

It is too early for either the research/diagnostic laboratory or other research activities sponsored under the Livestock Sector project to have yielded tangible benefits. Similarly, the linkages between investments in

improving the financial and administrative management of the Livestock Service, and their potential impacts on either reducing cattle mortality or increasing fertility and weight gain are at present tenuous. These linkages need to be further clarified for an economic analysis to be possible.

III. Methodology

We need to have the means to link specific animal health interventions to the value of different outputs from the herd. It is necessary therefore to differentiate animal health impacts between male and female cattle since outputs derived are differentiated by sex. Male animals are raised primarily for slaughter. Females, on the other hand, in addition to their carcass value, contribute milk and calves. There are other benefits to be derived from cattle that are not considered here, such as manure production, and the role of cattle as a source of personal prestige, for social exchanges, as financial assets, and as an insurance policy.

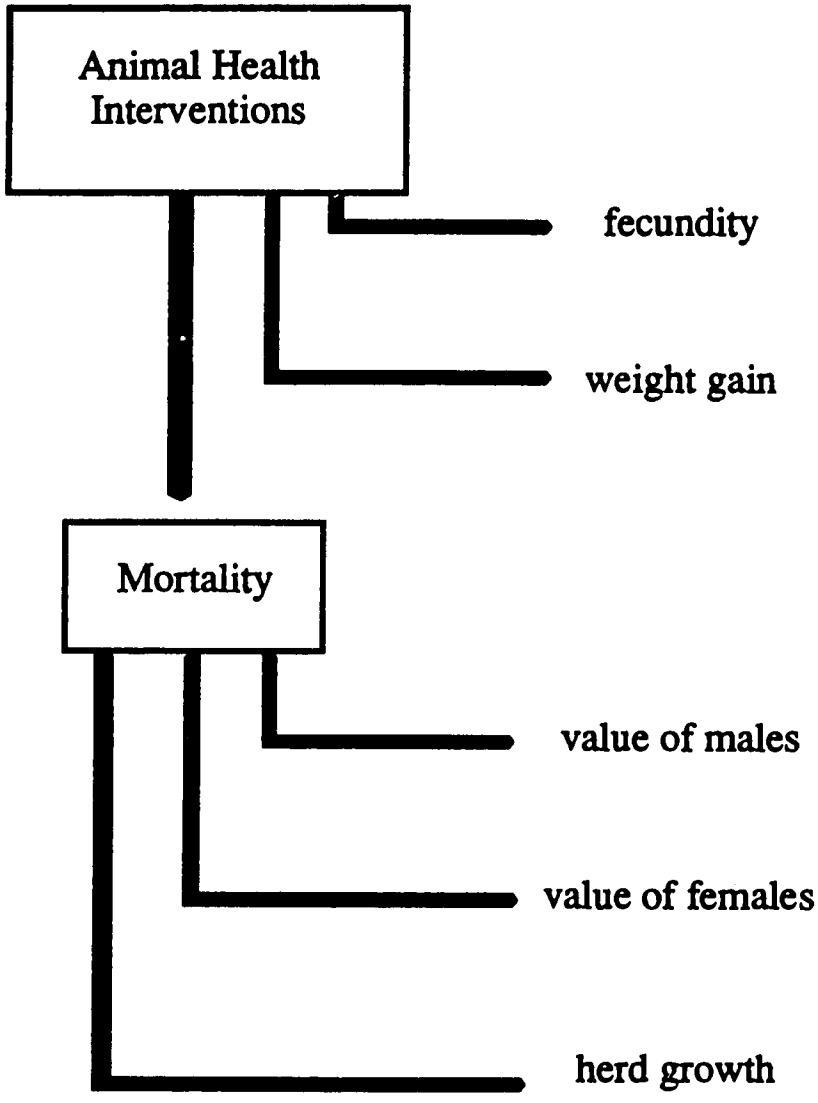
The approach taken here is rather simple: animal health interventions reduce herd mortality for both males and females. Reduced mortality leads to higher levels of economic outputs. We concentrate, therefore on establishing the linkages between male mortality and male outputs, and female mortality and female outputs (see Figure 1).

To be sure, there are other benefits to animal health interventions besides reduced mortality. Lower morbidity also leads to higher fertility and faster rates of weight gain, for example, both of which lead to tangible economic benefits. These benefits will not be taken into account in the subsequent analysis, because they are deemed at this stage to be relatively less important than reduced mortality. Further research may be warranted on incorporating these additional benefits into further analyses.

IV. Age-of-Sale Decision Modelling

Much of the subsequent analysis builds upon earlier work by the author in modelling age-of-sale decisions for cattle under extensive range conditions in Africa. More detailed explanations of the methodology are presented in "Cattle as Capital, Consumables, and Cash: Modelling Age-of-Sale Decisions in African Pastoral Production" by E. Ariza-Nino and K. Shapiro, in J. R. Simpson and P. Evangelou (eds.), Livestock Development in Subsaharan Africa. Constraints, Prospects, Policy (Westview Press, 1984). Earlier and more extensive coverage of the issue appears in a report entitled "Market Forces and Livestock Development in Africa," prepared by Kenneth Shapiro and Edgar Ariza-Nino for the World Bank's Agriculture and Rural Development Department in 1983.

Figure 1. Benefits from Annual Health Interventions



A. The Decision Rule

Each year a pastoralist has the option of selling any animal or keeping it until next year. If the animal is kept, the same decision will be faced next year. Thus, the long-run decision of when to sell an animal may be analyzed as a decision of whether or not to keep an animal one more period. The animal will be sold if the cost of keeping it one more year outweighs the benefits of keeping it for that year. In other words,

Keep animal if expected gains > expected costs

The gains will be realized in terms of weight gain, milk, offspring, security, liquidity, etc. The costs of keeping an animal one more year include (1) the costs of herding, feeding, and watering, (2) the cost of health maintenance, (3) the risk of mortality, and (4) the financial cost of income forgone by not selling the animal and investing the money in an alternative enterprise.

For young animals, the expected gains from one year to another exceed the expected costs. As the animal ages, however, the expected costs increase while benefits diminish. At some age, the decision is made to sell. We will analyze separately selling decisions for males and females. Subsequently, the implications of culling age decisions upon herd growth and off-take will be taken into account. That will allow us to evaluate the impact of mortality reductions on levels of output over time for the entire herd.

B. Mortality in Male Cattle

For a given male, we assume that its only benefit comes from gains in weight, i.e., we value output solely in terms of beef produced on the hoof. No consideration is given to reproductive potential since, given adequate numbers, any one male is redundant in insuring herd growth.

Figure 2 shows the factors in deciding when a male is to be sold for slaughter. For each year in the life of the animal, we need to know the live weight at that age (Wt), the mortality rate (m) for age, the expected cost (c), and the discount rate (d). We also need to know the price of beef per unit live weight (P).

Given these factors, the cattle owner will keep the steer an extra year if the expected value next year exceeds the current value plus the costs of keeping it one year. That is,

Keep if

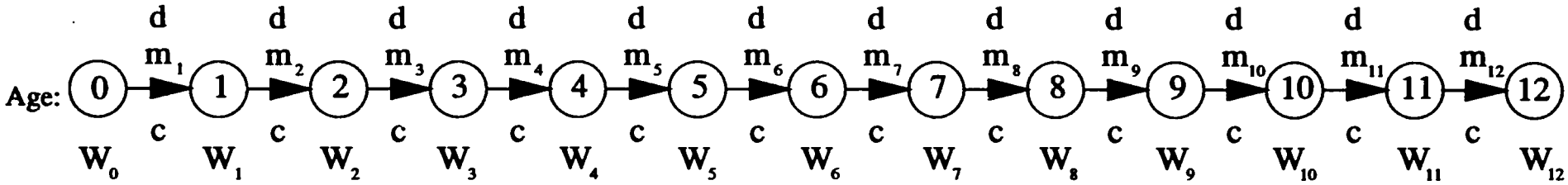
$$P*W(t)*(1-m(t))*(1-d) > P*W(t) + c$$

where W(t) is the live weight at age t and W(t+1) the live weight in the next year at age t+1. The factor (1-m(t)) represents the probability of survival to

Figure 2. Age-of-Sale Decision for Steer

Decision Rule: Keep if

$$P * W_{t+1} * (1-m_t) * (1-d) > P * W_t + c$$



W_0 : weight at birth
W_3 : weight at age 3 years
m_3: mortality rate for third year
d: discount factor, annual
P: price per kilo live weight
c: annual cash costs

next year, i.e., one minus the probability of mortality for age t. The factor (1-d) is the discount factor or one minus the discount or interest rate d.

An alternative formulation of the same decision rule is to sell the steer at the age which maximizes the Net Expected Present Value (at birth), i.e., the discounted stream of costs and benefits for each year of age, weighted appropriately by their respective survival probabilities. This is the formulation we will use henceforth, for ease of computation, but it is exactly equivalent to the above decision rule.

Mortality is one of the factors that enters in the age-of-sale decision. Notice that other things being equal a higher mortality rate, that is, a lower survival rate, will reduce the value of the left side of the decision rule. If mortality is high, males will be slaughtered earlier. Reductions in mortality will induce some pastoralists to sell steers at a later age.

C. The Growth Curve

We often do not know the live weight of an individual steer for each year of its age. Of course, each steer has its own growth pattern, and the owner has to make a selling decision for each individual animal. For the purposes of analyzing the impact of reduced mortality on the value of males, however, we are satisfied having a sequence of representative weights followed by an average Zebu or N'Dama steer in the regions of interest to the project.

A hypothetical growth curve represent the growth pattern of an average steer. The weight of such a steer follows a zig-zag pattern in keeping with the seasonal cycle of abundant grass in the rainy season and poor nourishment in the dry season (see Figure 3). A jagged growth function would complicate the analysis greatly; we simplify this by smoothing the curve to connect the high points achieved at the end of each rainy season. This smooth growth curve is depicted in Figures 4 and 5.

The sigmoid growth curve is generated using a mathematical equation whose parameters can be derived on the bases of the birth weight, the maximum adult weight, and the age at sexual maturity, where the inflection point of the curve is assumed to take place. For a Zebu steer in western Mali, we have assumed a birth weight of 20 kilograms, an adult weight of 500 kilograms, and sexual maturity attained at 3.5 years.

D. Live Weight Price

On the basis of the growth curve and a given live weight price per kilogram, it is possible to compute the value of a steer at any given age. A constant live weight price per kilogram has been assumed throughout the life of the animal (in fact throughout the life of the project). In November 1987, the average carcass price for cows slaughtered in the Bamako abattoir was close to 675 FCFA per kilogram. Assuming a dressing percentage of 50

Figure 3. Seasonal Variation in Body Weight of Steer

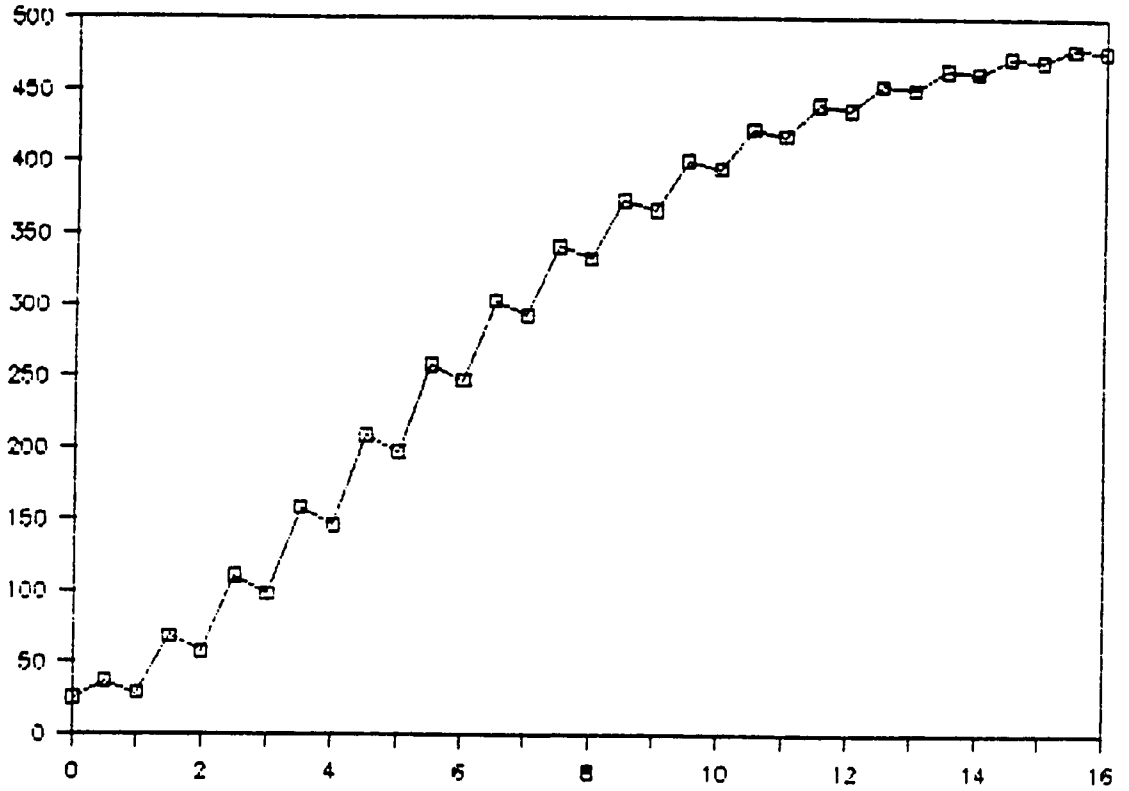


Figure 4. End-of-Rainy-Season Growth Curve of Steer

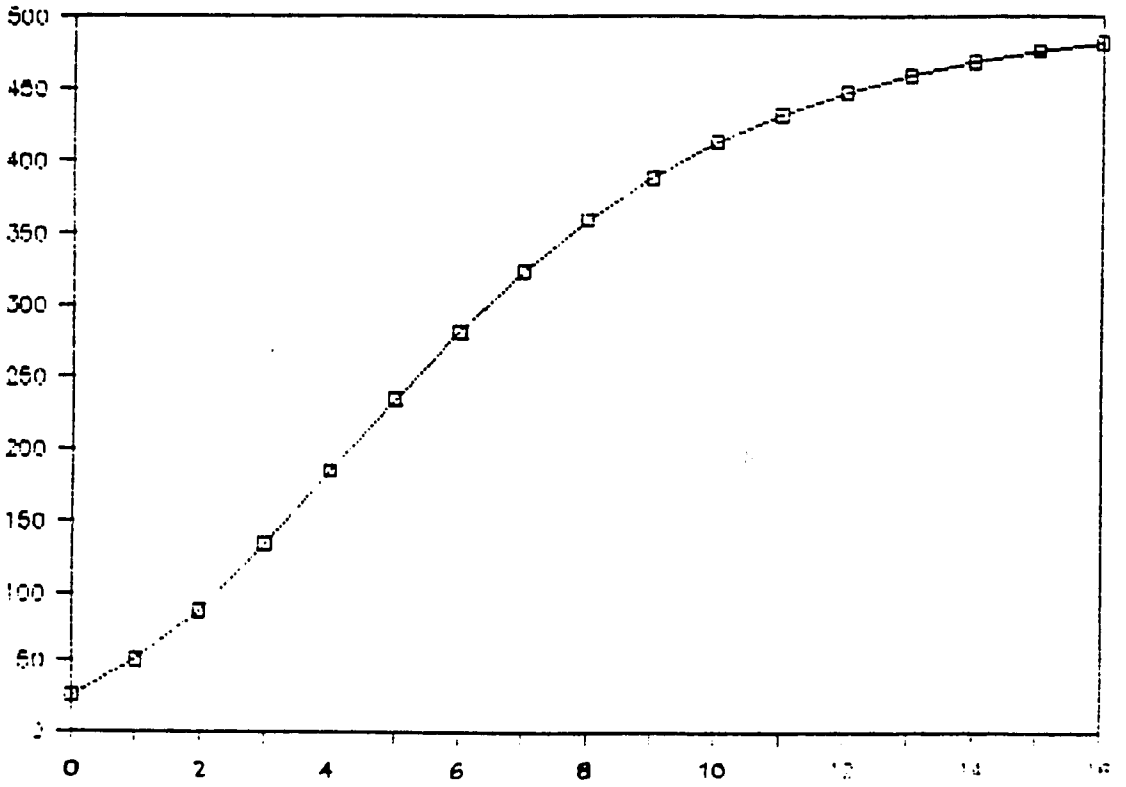
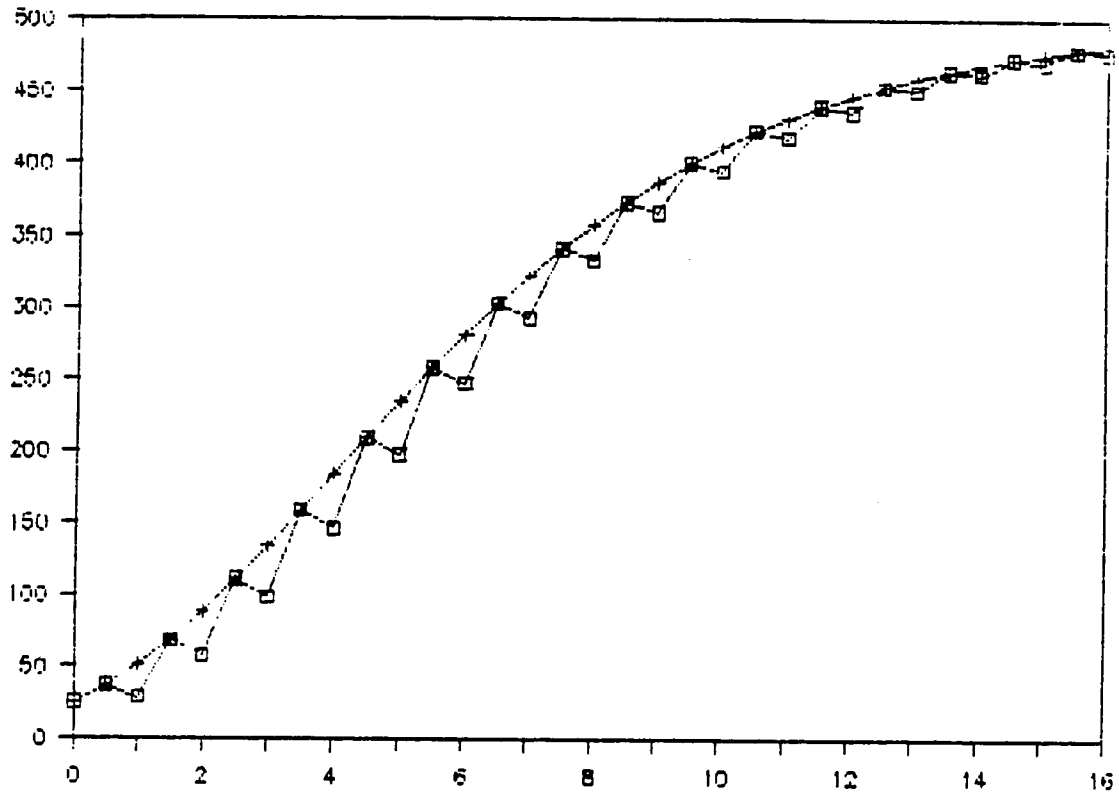


Figure 5. Growth Curve vs. Actual Body Weight



percent, this carcass price corresponds to a live weight price of 338 FCFA per kilo. Since this is the price in Bamako, there is a marketing cost component in the price. If we have a marketing margin of 15 percent between the market in Bamako and a representative rural market, e.g., Nara, where producers originally sell their cattle to traders, then the price to the producer is roughly 287 FCFA per kilogram liveweight. The latest exchange rate for the US dollar at USAID/Bamako on February 26, 1988 was 287 FCFA. Therefore, we will use a price of $1.00 per kilogram live weight in our modelling.

E. Survival and Expected Values

Price times the animal's weight gives its value at any age. Table 1 presents the hypothetical evolution of weight and value of a Peul Zebu steer in western Mali for every year from birth to 16 years in the first three columns on the left. Figure 6 graphs this evolution. At five years, for example, weight reaches 268 kilos, and, if the animal is sold at $1.00 per kilo, the seller gets $268.

However, the chance that a male calf will survive to that age is only 56 percent, which in Table 1 appears under the Life Expectancy column. This percentage is the cumulative percentage of multiplying the survival rates in all the years from birth.

The expected value of a male calf is, therefore, only $151, i.e., 56 percent of $268 if sold at age 5. If, on the other hand, it were sold at age 6, the expected value would be $173 (see column on Expected Values in Table 1 and the graph in Figure 6).

F. Discounting the Future

A discount rate of 12 percent is now introduced. This rate is chosen to reflect the time preference of cattle owners for cash now, as opposed to a year from now. Alternatively, it could be viewed as the return on capital, if invested in other uses. Over five years, a discount rate of 12 percent, results in a discount factor of .57, means that $100 five years from now is worth only $57 today. If so, the $151 that the owner expects to get for male calf in five years is only equivalent to $86 at birth (see Figure 7).

G. Accounting for Costs

Cash costs of cattle owners for their animals are minimal under the extensive range conditions in Regions I and II of Mali. There are some payments to veterinary agents for obligatory vaccinations, and perhaps for some medications and mineral salt blocks. A herder, if hired, might need to be paid in cash. For lack of a better cost estimate, we have put a hypothetical cost of $5.00 per year per animal but this does not include any

Table 1. Hypothetical Evolution of Weight and Value of a Peul Zebu Steer in Western Mali

Age	Weight	Value	Mortality Rate	Survival Rate	Life Expectanc	Expected Value	Discounting Factor	Discounting Value	Cost	Discount Cost	Present Discont Cost	Net P.V. of Steer
0	20.00	20.00	0.00	1.00	1.00	20.00	1.00	20.00	5	5.00	5.00	15.00
1	49.89	49.89	0.30	0.70	0.70	34.92	0.89	31.18	5	4.46	9.46	21.71
2	95.99	95.99	0.10	0.90	0.63	60.47	0.80	48.21	5	3.99	13.45	34.76
3	153.37	153.37	0.05	0.95	0.60	91.79	0.71	65.34	5	3.56	17.01	48.33
4	214.52	214.52	0.03	0.97	0.58	124.54	0.64	79.15	5	3.18	20.19	58.96
5	272.79	272.79	0.03	0.97	0.56	153.61	0.57	87.16	5	2.84	23.02	64.14
6	324.00	324.00	0.03	0.97	0.55	176.98	0.51	89.66	5	2.53	25.56	64.11
7	366.48	366.48	0.05	0.95	0.52	190.17	0.45	86.03	5	2.26	27.82	58.21
8	400.28	400.28	0.07	0.93	0.48	193.17	0.40	78.02	5	2.02	29.84	48.18
9	426.38	426.38	0.09	0.91	0.44	187.25	0.36	67.52	5	1.80	31.64	35.88
10	446.10	446.10	0.11	0.89	0.39	174.36	0.32	56.14	5	1.61	33.25	22.89
11	460.79	460.79	0.13	0.87	0.34	156.69	0.29	45.04	5	1.44	34.69	10.36
12	471.60	471.60	0.15	0.85	0.29	136.31	0.26	34.99	5	1.28	35.97	-0.98
13	479.50	479.50	0.17	0.83	0.24	115.03	0.23	26.36	5	1.15	37.12	-10.76
14	485.23	485.23	0.19	0.81	0.19	94.29	0.20	19.29	5	1.02	38.14	-18.85
15	489.38	489.38	0.21	0.79	0.15	75.13	0.18	13.73	5	0.91	39.05	-25.33
16	492.37	492.37	0.23	0.77	0.12	58.20	0.16	9.49	5	0.82	39.87	-30.38

-42'

Figure 6. Expected Value of Steer

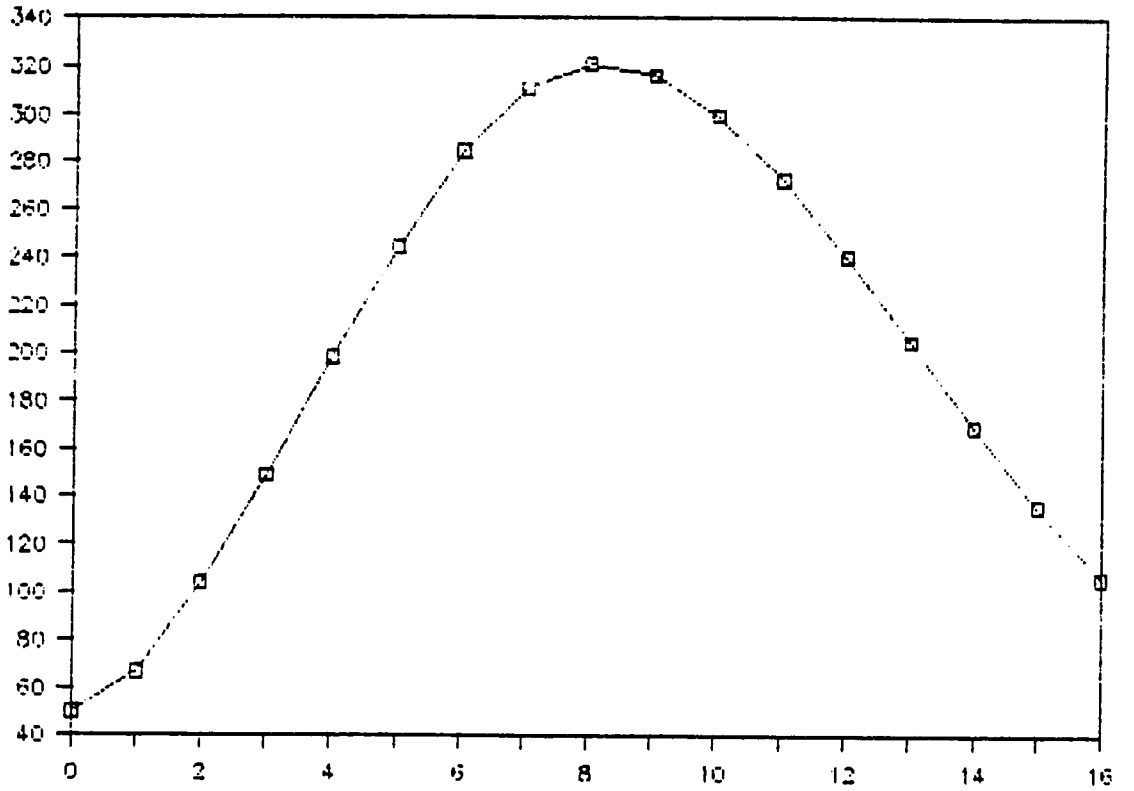
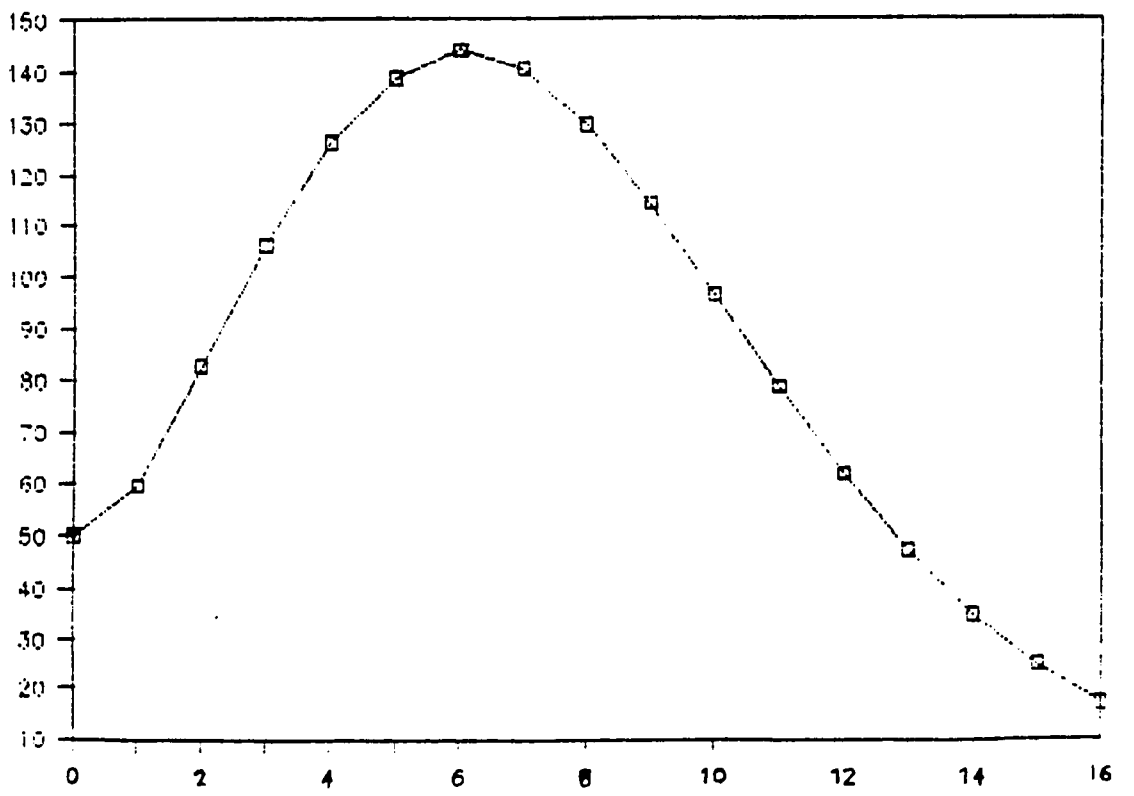


Figure 7. Expected Present Value of Steer



implicit values for grass or water consumed since these are considered to be public goods in Mali available at no charge.

The same discounting principle applies to costs, since they will be taking place in future years, so the present value of each year's cost diminishes in importance. However, since costs are cumulative, the overall present value of all costs keeps mounting over the years. Over five years, the total present value of all cash costs reaches $23.02 (see Figure 8).

H. Net Present Value of Steer

After subtracting the present value of costs from the expected present value of the steer, the net expected present value for the steer sold at age five has declined to $62.51. If the steer were sold at 6 years of age, the net present value would be $62.08. These figures appear in the last column of Table 1. The evolution of the expected value, the discounted costs, and the net present value are shown over the life of an animal in Figure 8.

I. Culling Age and Maximum Net Present Value

It is easy to see in Figure 8 and Table 1 that the maximum net present value is obtained at age five, at $62.51. Beyond that age, the net present value declines because of higher mortality, higher costs, and additional discounting, even though the steer continues growing.

J. Prices Count for Little

One of the more interesting features of the above analysis is that the age of sale for males is fairly insensitive to the price of beef. Under pastoral conditions, the value of c, representing cash disbursements for taxes, vaccines, fees, etc., is fairly small. A similar result is found for cows. This conclusion raises questions about the notion of altering off-take rates through better prices. If anything, a higher price will tend to delay the age of sale for a steer, i.e., it will reduce the off-take rate, if expressed as a percentage.

K. Female Fecundity and Mortality

The same sort of exercise is needed for a heifer calf. The objective is to determine optimal culling age and maximum net expected present value of that calf at birth, taking account of the whole stream of benefits that the female calf will generate over its lifetime. Figure 9 presents a graphic representation of the computational process, similar to the one followed for males.

In addition to mortality, cash costs, and discount rates, however, in the case of females we have to introduce the fertility rate starting in the fourth

Figure 8

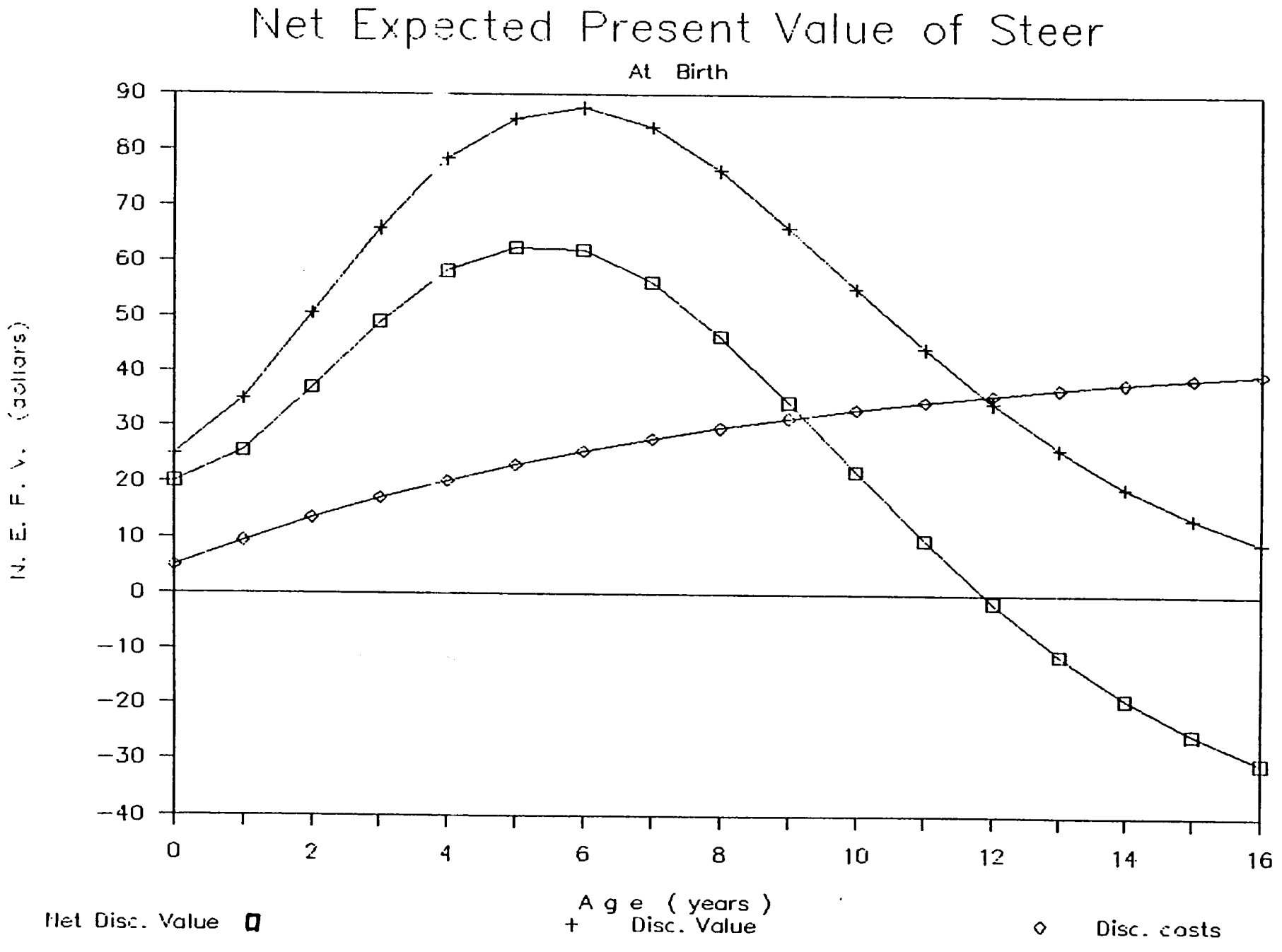
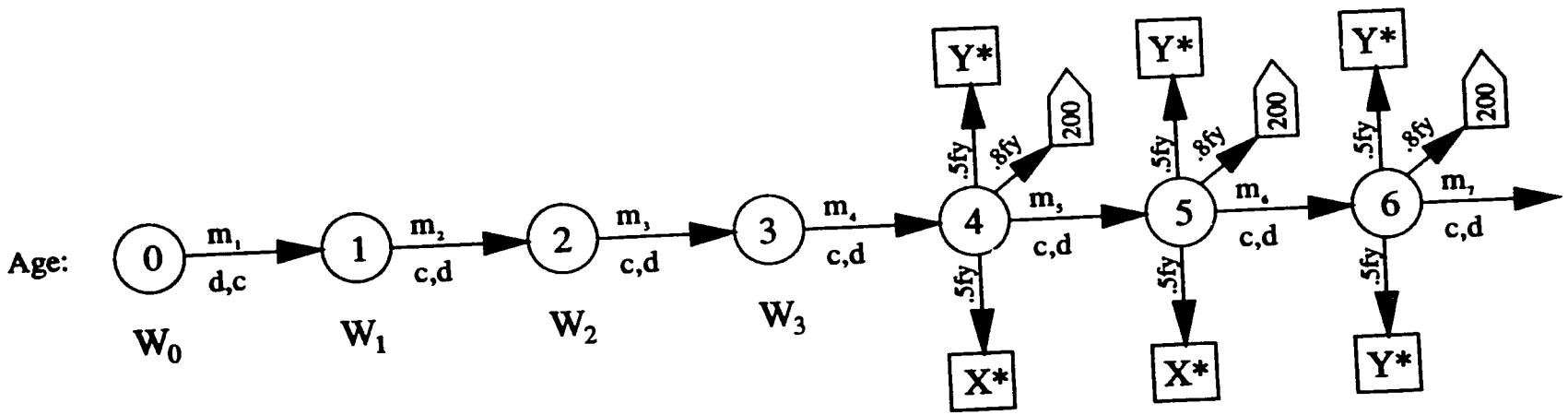

Net Expected Present Value of Steer
At Birth
N. E. P. V. (dollars)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
0
2
4
6
8
10
12
14
16
A g e (years)
Net Disc. Value
+ Disc. Value
◇ Disc. costs

Figure 9. Determining Culling Age for Cows



W_0 : weight at birth
W_1 : weight at 1 year of age
m_1 : mortality rate first year
d: discount rate, annual
c: cash cost per year
f_4: fertility (calving rate) at age 4
Y*: net expected present value of male calf at birth
X*: net expected present value of female calf at birth
200 : lactation, liters

year. Strictly speaking, we are introducing the calving rate, i.e., the probability of a female of that age having a calf that year. There are three additional arrows emerging from age four, the upward arrow indicating the probability of a male calf being born (.5 the calving rate for year four). The downward arrow is the probability for a female calf, and the diagonal arrow is the probability of having a full lactation (.8 of calving rate). For each subsequent year, the same set of arrows is repeated.

L. Beef Value of Cow

Exactly the same procedure used for a steer is applied to estimate the beef value of a cow at any given age in its lifetime. We have kept even the same price per kilo live weight on the general assumption that the beef market makes little differentiation for beef quality. Introducing separate prices for males and females poses no conceptual problems, however. Figure 10 shows the evolution of the expected present value of a cow. It follows the same pattern as for a steer, but the values are lower to account for the smaller body size.

M. Net Present Value of Milk Production

An average lactation of 200 liters is anticipated each time a cow has a calf, which corresponds to a 200-day milking period at an average of 1 liter per day. However, when calves die before weaning, lactation may be shorter. Malian cows, unlike American and European dairy cows, need their calves to suckle to produce milk letdown and release milk. Only if a substitute calf can be procured will the cow continue producing milk for a full lactation.

A price has to be assigned to milk to convert it into value terms. Since most milk production takes place in rural areas, and even in rangelands far away from villages, it is difficult to specify a market price. The price of milk in Bamako is hardly a proper measure since it is such a different situation. Producers are reported to sell fresh milk in the open market anywhere from 160 to 300 FCFA per liter. We have arbitrarily adopted a price of 100 FCFA per liter as typical for a village situation.

Figure 11 shows how the total value of milk production increases as the cow gets older. Note that the line does not decrease even at advanced age. Every year there is additional milk and the value of the lactation diminishes in present value terms. It remains positive, however, and therefore adds to the previous cumulative value of total milk production.

N. Value of Male Offspring

We have already determined the present value of a male calf at birth on the basis of its beef value. Whenever a cow has a male calf, the discounted value of that calf should be credited to the cow. Taking due account for the

Figure 10. Meat Value of Cow

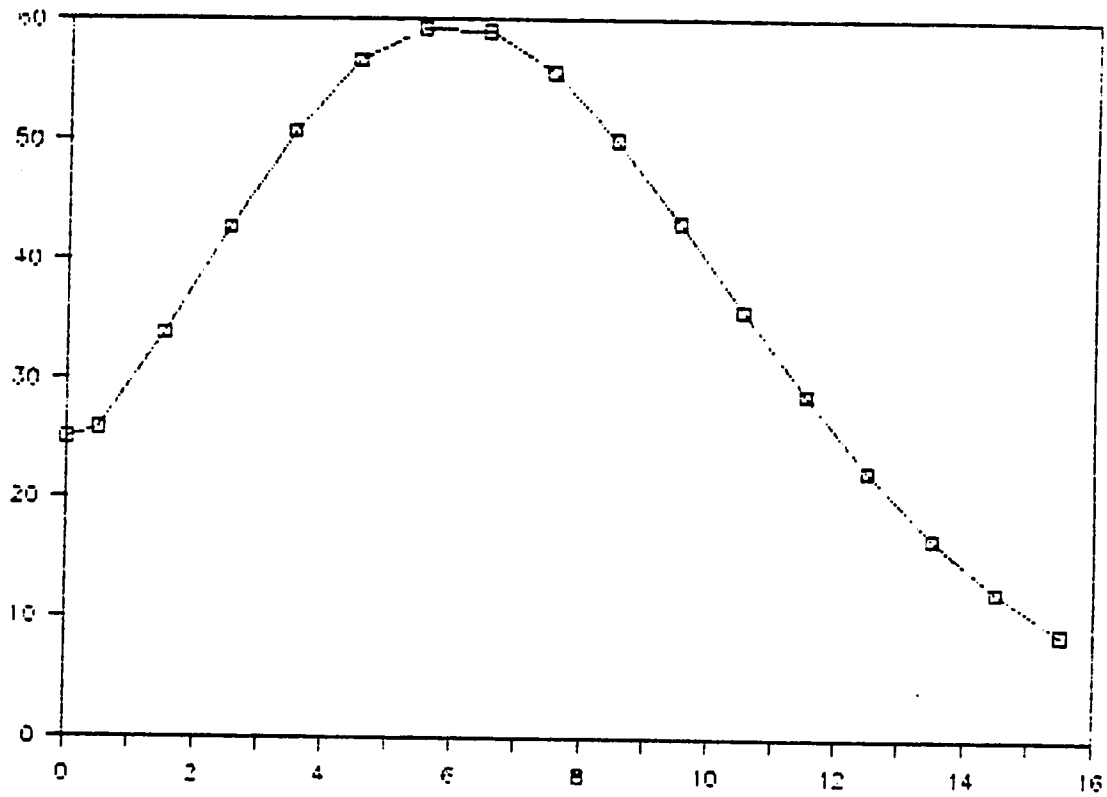
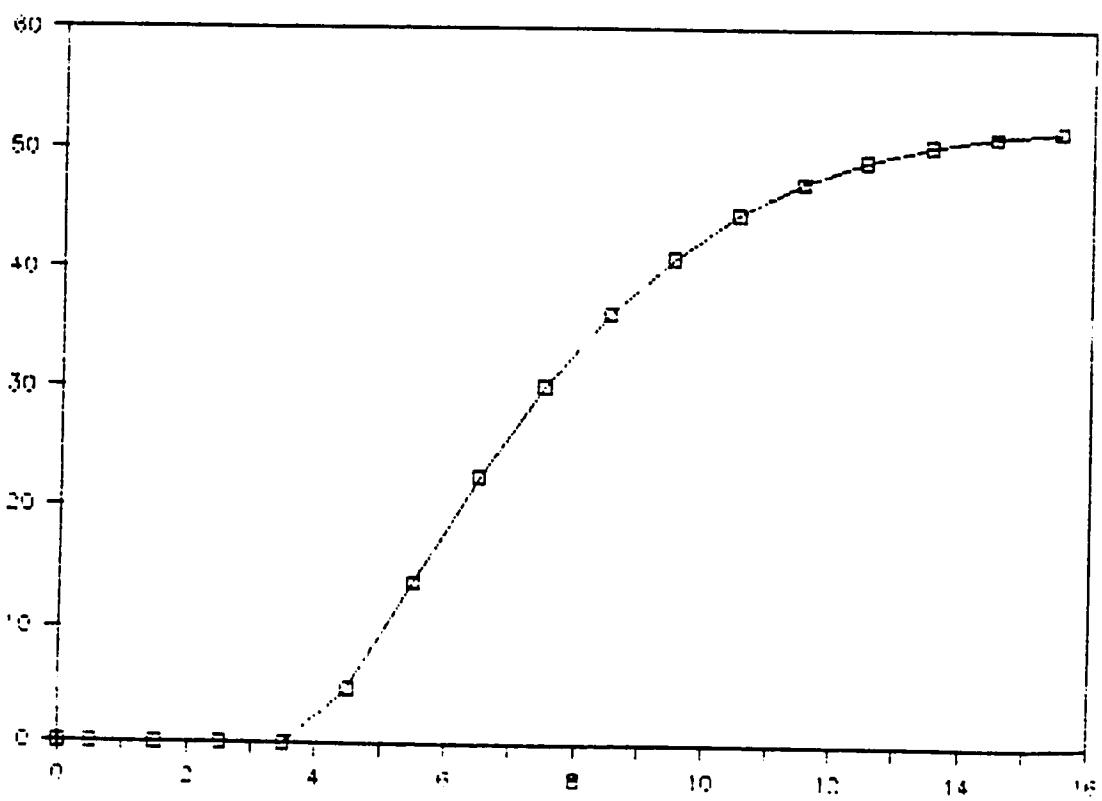


Figure 11. Value of Milk from Cow



calving rates and discounting back to the birth of the cow, it is possible to add up the value of all male calves that a cow might have over its lifetime.

Figure 12 shows how the cumulative value of male progeny increases as the cow gets older, but the increase late in life is very small; and as the probability of the cow dying increases, its calving rate diminishes with age.

O. Value of Female Offspring

The same addition should be done to determine the present value of the female progeny. Unfortunately, we do not yet know the value of a female calf at birth. Without that, we cannot determine the value of a cow at birth, and so on. A little reflection, however, will reveal that the present value of a female calf at birth must be the same as the value of its mother when she was born. With the help of a bit of algebra, we can solve the problem simultaneously and determine the value of a female calf at birth.

Figure 13 shows how the value of female offspring increases over the age of the cow. The shape of the curve is identical to the value for the male progeny, but the scale is doubled. he value of females increase much faster than the value of males. Females are much more valuable than males, about three times as much depending on the particular set of mortality, fertility, lactation, and discounting factors.

P. Expected Present Value of Cow at Birth

We can now aggregate all the value components for the different products a cow will generate. Figure 14 makes it easy to visualize the evolution of these components over the life of the cow. First, notice how small the meat value of the cow itself is in relation to the value of the other products.

Milk production by itself is far more important to the owner than the money he gets for the cow when it is culled. In fact, the value of milk production exceeds even the value of all the male calves produced.

The largest component in the value of a cow is the accumulated value of all its female offspring. The value of all females is about three times the value of all males over the life of the cow. Females are valuable because they produce females.

Q. Culling Age

A cattle owner acting purely on commercial incentives will keep a cow as long as the expected gains from keeping it one more year exceed the cost of keeping it. An equivalent rule would be that the cow would be culled at an age when its discounted net present value is maximized.

Figure 12. Value of Male Progeny

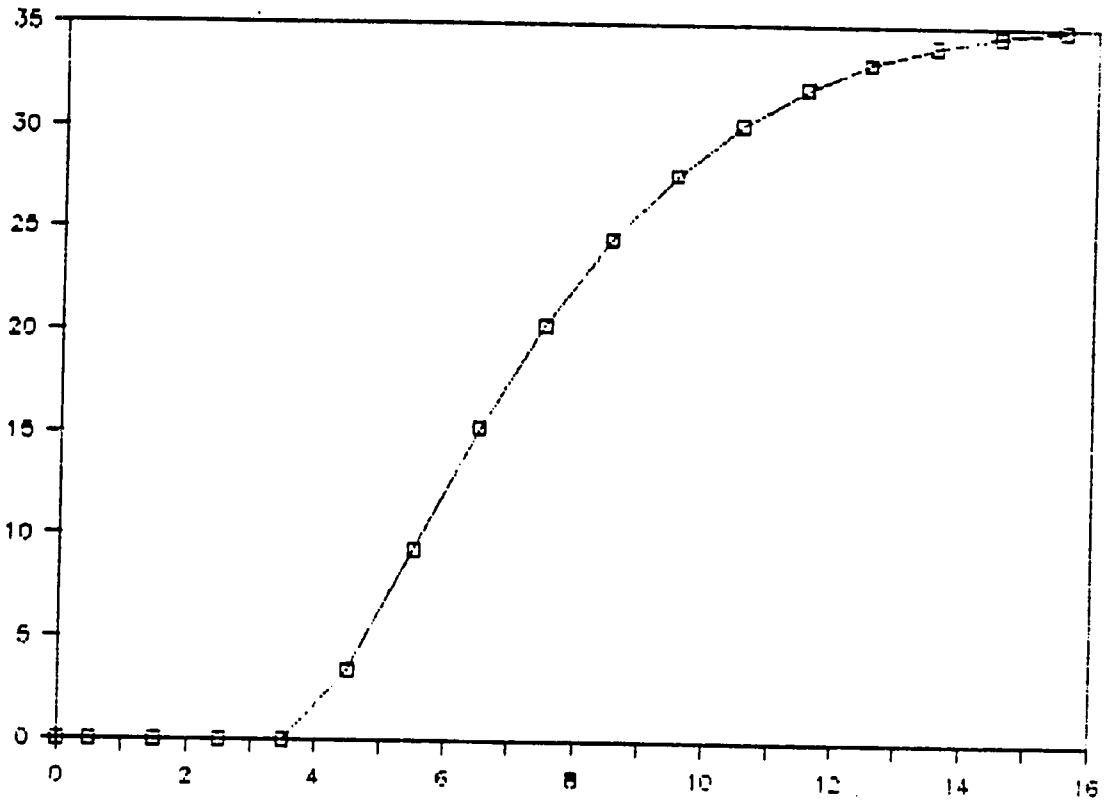


Figure 13. Value of Female Progeny

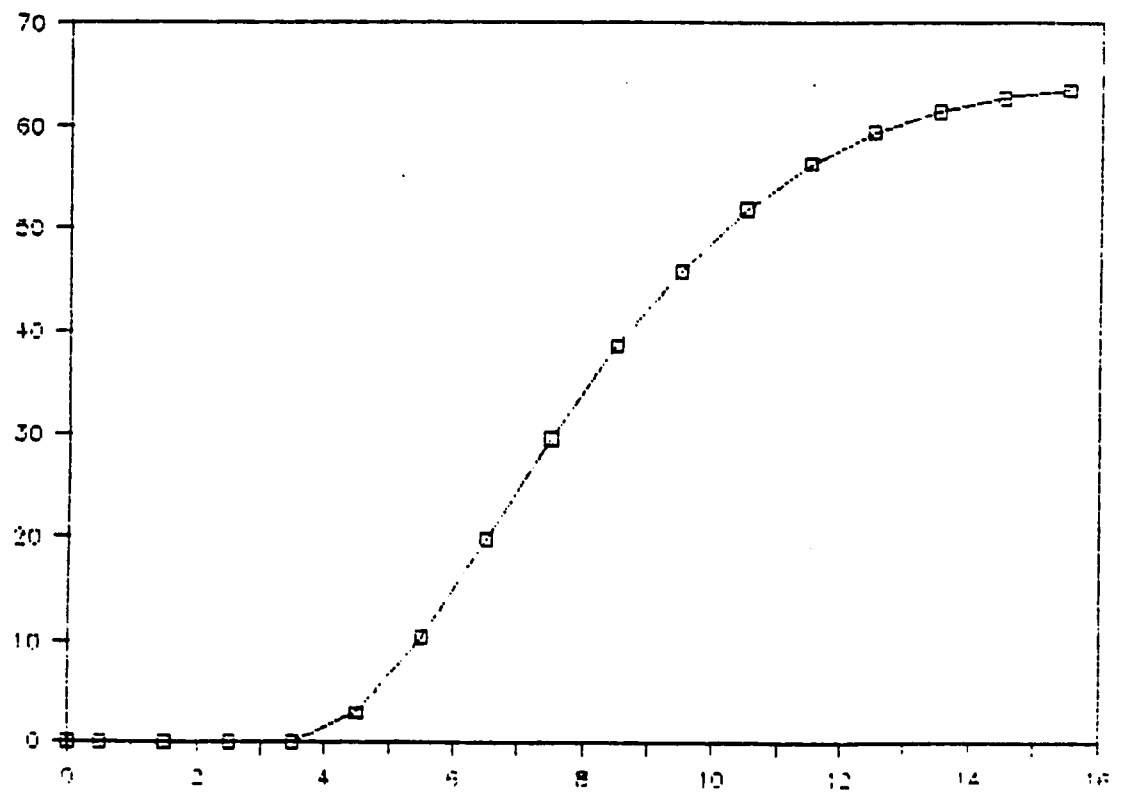
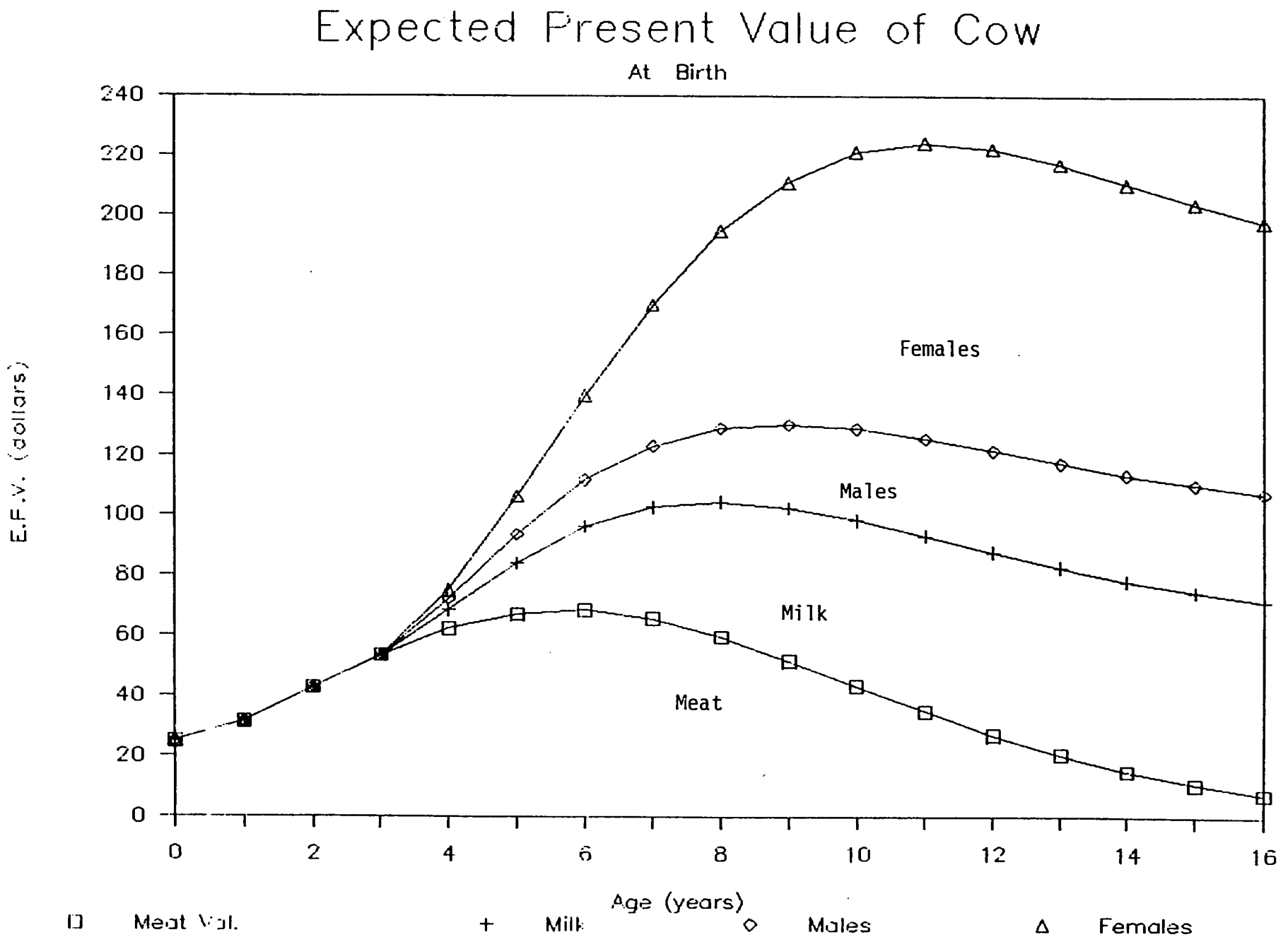


Figure 14


Expected Present Value of Cow
At Birth
E.F.V. (dollars)
240
220
200
180
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
Age (years)
Females
Males
Milk
Meat
Meat Val.
Milk
Males
Females

Annual costs incurred in keeping a cow have been assumed to be the same as for a male, i.e., $5 per year. They accumulate progressively over the life of the cow. To determine the net present value, we need to deduct these cumulative costs from the expected present value of the cow. When this is done, the maximum net present value is obtained when the cow is between 10 and 12 years of age, depending on the specific mortality and fertility rates.

V. Automating the Valuation Process

All of the above computations are straightforward but time-consuming and often confusing. Errors are likely to occur and are compounded as the process advances. A microcomputer has been programmed to perform all of the calculations quickly and without computational error. Lotus 1-2-3 has been used to perform these tasks in an interactive fashion. This should encourage the user to try alternative values for different parameters and to observe the logical consequences instantaneously. The program is named **MAVERIC**, an acronym for Mali Veterinary and Range Economics.

A diskette containing the program can be obtained from the USAID/Bamako agricultural economist. Table 2 shows the information that appears in the first page of the program on the computer screen.

A. Initial Information Needed for MAVERIC

In order to use MAVERIC for a particular population of cattle, it is necessary to collect the data discussed above. Each breed of cattle will have its own set of parameters, which are affected to varying degrees by weather region, and management environment. To recapitulate, we need information on

* Mortality rates, by year of age, for males and females
* Calving rates, by year of age
* Birth weights for males and females
* Maximum adult weights for males and females
* Age at sexual maturity
* Price per kilogram live weight
* Milk production per lactation, in liters
* Price per liter of milk
* Annual cash costs per head
* Discount rate

Table 2

Age	Mortality Rates Males	Females	Fertily Rate		MALES	FEMALES		
					25.00	25.00	:	Birth Weight
					500.00	400.00	:	Adult weight
0	0.00	0.00	0.00		3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00		1.00	1.00	:	Price per kg
2	0.10	0.10	0.00			200.00	:	Lactation (lts)
3	0.05	0.05	0.00			0.35	:	Milk Price
4	0.03	0.03	0.30		0.12	0.12	:	interest rate
5	0.03	0.03	0.60		1.00	1.00	:	Mortality Change
6	0.03	0.03	0.70			1.00	:	Fertility change
7	0.05	0.05	0.70		5.00	5.00	:	Cost per year
8	0.07	0.07	0.70		5	11	:	Culling age
9	0.09	0.09	0.65		63	190	:	Net E.P.V.
10	0.11	0.11	0.65			210	:	20-Yr P.V ($000)
11	0.13	0.13	0.60			Offtake	Herd Grow	Total
12	0.15	0.15	0.55			Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year	0	8		1000
14	0.19	0.19	0.45	Year	10	8	1	1085
15	0.21	0.21	0.40	Year	20	8	1	1176
16	0.23	0.23	0.35	Year	30	8	1	1276

B. Mortality Rates

This is the main factor of interest for purposes of this report. Animal health interventions will have effects on mortality rates. Ancillary effects might affect fertility rates and the growth curve, but for this exercise we will concentrate only on effects on mortality.

Separate mortality rates are provided for males and females. Previously, we determined that the value of females was several times the value of males, which could imply that a cattle owner would favor female calves over males in things like veterinary care and amount of milk calves consume. Some preliminary results of recent surveys of herds in various regions of Mali seem to confirm that mortality for heifer calves in the first year is significantly lower than for bull calves (see, for example, "**Situation de l'Elevage Bovin dans la Zone de Kolondieba,**" Direction National de l"Elevage, Bamako, January 1988). Processing of a similar survey for the Kayes region is in progress at the moment. When available, the parameters obtained could be introduced into MAVERIC for a closer approximation to the situation in the Project Regions I and II.

For the moment, the mortality figures used reflect the level of mortality rates found in existing technical documentation for Malian cattle. The 1986 OECD Club Du Sahel, "**Rapport sur l'Analyse de la Situation de l'Elevage Malien,**" reports the productivity parameters shown in Appendix 1. Mortality in the first year is reported ranging from 20 to 44 percent by various authors.

Alternatively, the FAO report "**Mali. Mission de Revue du Secteur Elevage. Evaluation de la Productivite des Troupeaux,**" (Rome, April 1986), reports for the same year mortality rates of 10 to 20 percent for Zebu Peul in the Delta region. In view of the divergence of technical opinions on these rates, we have adopted the rate of 30 percent. Similarly, for other ages, we specify rates within the range reported in the literature.

One advantage of MAVERIC is that its accessibility and ease of use make it possible for animal scientists to enter their own set of mortality rates for specific herd conditions.

C. Fertility

There seems to be no close agreement on fertility rates for cows of different ages. Environmental and range conditions exert a large influence on observed calving rates. The OECD/Club Du Sahel report cites calving rates ranging from 50 to 80 percent but most other reports give average rates of about 65 percent. Age-specific fertility rates are not often found, but the DNA survey in progress is computing these rates for various breeds and regions. We have provisionally specified in MAVERIC fertility rates of 65 and

70 percent for most cows, but lower for the first calf heifers, and declining rapidly beyond age 10.

D. Growth Curve

The parameters used here are birth weight, adult weight, and age at sexual maturity. Most cows have their first calf in their fourth year. Sexual maturity is specified then at about 3.5 years. Adult weight is a maximum weight achievable by a male or female in good condition; most animals never reach such adult weight. Males are ordinarily slaughtered at earlier ages and females are under nutritional stresses of gestation and lactation which prevents optimal weight gains during their reproductive years. Calf birth weights were specified at 25 kilograms.

E. Lactation

Already described above, milk production is 200 liters per lactation and is priced at $.35 per liter.

F. Prices and Costs

They have been discussed earlier: $1.00 per kilogram live weight for both males and females and $5.00 in cash costs per head per year.

G. Discount Rate

Twelve percent.

VI. Simulation of Animal Health with MAVERIC

MAVERIC provides two ways of modifying mortality rates to explore the consequences of reduced or increased mortality among the herd. First, each individual mortality rate for a particular age and either for males or females can be changed at any point. Second, it is possible to change **all** mortality rates simultaneously in the same proportion.

A. Insensitivity in the Males

Changing overall mortality by a few percentage points leaves culling age for males unchanged but may change it for females. When reduced by 2 percent, i.e., when mortality is 98 percent of the base values, the culling ages for both males and females remains at 5 and 11 years, respectively. The NEPV do change: for males from $63 to $64 and for females from $190 to $199.

Tables 3 through 11 provide the results of changing mortality rates from 10 percent below to 10 percent above the base values. Table 12 summarizes the results. Note how insensitive male culling age and total value are to the range of mortality values. Only when mortality is reduced by 10 percent does culling age for males increase from 5 to 6 years. Net Expected Present Values for male calves decrease as mortality increases, from $68 to $57 when mortality goes from 10 percent below to 10 percent above base value.

B. Culling and Sensitivities in Females

The NEPV of females is far more sensitive to changes in overall mortality. This can be seen in Table 12. The culling age for females changes from 10 years when mortality is 10 percent above to 12 years when mortality is 10 percent below baseline values. NEPVs for females change dramatically with mortality, from $152 to $243, or by 60 percent when mortality goes from 10 percent above to 10 percent below base values (as opposed to 19 percent for males).

C. Herd Dynamics

Changes in mortality affect more than the values of individual males and females. Herd structure and growth in numbers change with mortality. Even while maintaining exactly the same fertility values for females, herd growth changes because as mortality drops, more females survive to reproductive age, and increase the growth potential of the herd.

Another source of growth is the increase in culling age for females as a result of reduced mortality. At lower mortality, it pays to keep each cow longer in the herd, which increases the number of newborn calves in subsequent years. The last column of Table 12 shows the theoretical rates of growth for the herd when mortality is varied. It is remarkable that such small changes in mortality as those postulated here have such impacts on herd growth: from a 2 percent decline with a mortality rate at 10 percent above to a 3 percent increase with mortality at 10 percent below base-line values. It is true, therefore, that animal health programs can have very strong impacts on the growth of the cattle herd.

D. Herd Structure

The rates of growth reported above are computed for a theoretical herd structure derived entirely on the bases of the initial data for mortality, fertility, and culling ages for males and females. This herd structure corresponds to the structure that would eventually prevail in a herd in which these parameters were constant for many years.

Table 3

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	0.90	0.90	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	6	12	:	Culling age
9	0.09	0.09	0.65	68	243	:	Net E.P.V.
10	0.11	0.11	0.65		282	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	7		1000
14	0.19	0.19	0.45	Year 10	7	3	1326
15	0.21	0.21	0.40	Year 20	7	3	1761
16	0.23	0.23	0.35	Year 30	7	3	2337

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	0.92	0.92	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	12	:	Culling age
9	0.09	0.09	0.65	67	230	:	Net E.P.V.
10	0.11	0.11	0.65		279	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	7		1000
14	0.19	0.19	0.45	Year 10	7	3	1302
15	0.21	0.21	0.40	Year 20	7	3	1695
16	0.23	0.23	0.35	Year 30	7	3	2208

Table 4

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	0.94	0.94	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	11	:	Culling age
9	0.09	0.09	0.65	66	219	:	Net E.P.V.
10	0.11	0.11	0.65		244	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	8		1000
14	0.19	0.19	0.45	Year 10	8	1	1149
15	0.21	0.21	0.40	Year 20	8	1	1319
16	0.23	0.23	0.35	Year 30	8	1	1516

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	0.96	0.96	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	11	:	Culling age
9	0.09	0.09	0.65	65	209	:	Net E.P.V.
10	0.11	0.11	0.65		232	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	8		1000
14	0.19	0.19	0.45	Year 10	8	1	1127
15	0.21	0.21	0.40	Year 20	8	1	1270
16	0.23	0.23	0.35	Year 30	8	1	1432

Table 5

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	0.95	0.95	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	11	:	Culling age
9	0.09	0.09	0.65	65	214	:	Net E.P.V.
10	0.11	0.11	0.65		238	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	8		1000
14	0.19	0.19	0.45	Year 10	8	1	1138
15	0.21	0.21	0.40	Year 20	8	1	1294
16	0.23	0.23	0.35	Year 30	8	1	1473

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	0.97	0.97	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	11	:	Culling age
9	0.09	0.09	0.65	64	204	:	Net E.P.V.
10	0.11	0.11	0.65		226	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	8		1000
14	0.19	0.19	0.45	Year 10	8	1	1116
15	0.21	0.21	0.40	Year 20	8	1	1246
16	0.23	0.23	0.35	Year 30	8	1	1391

Table 6

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	0.98	0.98	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	11	:	Culling age
9	0.09	0.09	0.65	64	199	:	Net E.P.V.
10	0.11	0.11	0.65		221	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	8		1000
14	0.19	0.19	0.45	Year 10	8	1	1106
15	0.21	0.21	0.40	Year 20	8	1	1223
16	0.23	0.23	0.35	Year 30	8	1	1352

Table 7

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	0.99	0.99	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	11	:	Culling age
9	0.09	0.09	0.65	63	194	:	Net E.P.V.
10	0.11	0.11	0.65		215	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	8		1000
14	0.19	0.19	0.45	Year 10	8	1	1095
15	0.21	0.21	0.40	Year 20	8	1	1199
16	0.23	0.23	0.35	Year 30	8	1	1314

Table 8

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	1.01	1.01	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	11	:	Culling age
9	0.09	0.09	0.65	62	185	:	Net E.P.V.
10	0.11	0.11	0.65		205	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	8		1000
14	0.19	0.19	0.45	Year 10	8	1	1074
15	0.21	0.21	0.40	Year 20	8	1	1154
16	0.23	0.23	0.35	Year 30	8	1	1240

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	1.02	1.02	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	11	:	Culling age
9	0.09	0.09	0.65	61	181	:	Net E.P.V.
10	0.11	0.11	0.65		200	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	8		1000
14	0.19	0.19	0.45	Year 10	8	1	1064
15	0.21	0.21	0.40	Year 20	8	1	1132
16	0.23	0.23	0.35	Year 30	8	1	1204

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Table 9

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	1.03	1.03	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	11	:	Culling age
9	0.09	0.09	0.65	61	177	:	Net E.P.V.
10	0.11	0.11	0.65		195	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	8		1000
14	0.19	0.19	0.45	Year 10	8	1	1054
15	0.21	0.21	0.40	Year 20	8	1	1110
16	0.23	0.23	0.35	Year 30	8	1	1170

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	1.04	1.04	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	10	:	Culling age
9	0.09	0.09	0.65	60	172	:	Net E.P.V.
10	0.11	0.11	0.65		169	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	9		1000
14	0.19	0.19	0.45	Year 10	9	-1	888
15	0.21	0.21	0.40	Year 20	9	-1	788
16	0.23	0.23	0.35	Year 30	9	-1	700

Table 10

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	1.05	1.05	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	10	:	Culling age
9	0.09	0.09	0.65	60	169	:	Net E.P.V.
10	0.11	0.11	0.65		165	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	9		1000
14	0.19	0.19	0.45	Year 10	9	-1	879
15	0.21	0.21	0.40	Year 20	9	-1	773
16	0.23	0.23	0.35	Year 30	9	-1	680

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	1.06	1.06	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	10	:	Culling age
9	0.09	0.09	0.65	59	165	:	Net E.P.V.
10	0.11	0.11	0.65		161	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	9		1000
14	0.19	0.19	0.45	Year 10	9	-1	870
15	0.21	0.21	0.40	Year 20	9	-1	758
16	0.23	0.23	0.35	Year 30	9	-1	660

Table 11

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	1.08	1.08	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	10	:	Culling age
9	0.09	0.09	0.65	58	158	:	Net E.P.V.
10	0.11	0.11	0.65		154	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	9		1000
14	0.19	0.19	0.45	Year 10	9	-2	853
15	0.21	0.21	0.40	Year 20	9	-2	729
16	0.23	0.23	0.35	Year 30	9	-2	622

Age	Mortality Males	Rates Females	Fertily Rate	MALES	FEMALES		
				25.00	25.00	:	Birth Weight
				500.00	400.00	:	Adult weight
0	0.00	0.00	0.00	3.50	3.50	:	Sexual maturity
1	0.30	0.30	0.00	1.00	1.00	:	Price per kg
2	0.10	0.10	0.00		200.00	:	Lactation (lts)
3	0.05	0.05	0.00		0.35	:	Milk Price
4	0.03	0.03	0.30	0.12	0.12	:	interest rate
5	0.03	0.03	0.60	1.10	1.10	:	Mortality Change
6	0.03	0.03	0.70		1.00	:	Fertility change
7	0.05	0.05	0.70	5.00	5.00	:	Cost per year
8	0.07	0.07	0.70	5	10	:	Culling age
9	0.09	0.09	0.65	57	152	:	Net E.P.V.
10	0.11	0.11	0.65		148	:	20-Yr P.V ($000)
11	0.13	0.13	0.60		Offtake	Herd Grow	Total
12	0.15	0.15	0.55		Percent	(pct/year	Stock
13	0.17	0.17	0.50	Year 0	9		1000
14	0.19	0.19	0.45	Year 10	9	-2	837
15	0.21	0.21	0.40	Year 20	9	-2	701
16	0.23	0.23	0.35	Year 30	9	-2	587

Table 12. Simulation of Impacts of Reducing and Increasing Herd Mortality

Mortality change (percent of base)	Culling age		Net expected present value at birth		Net present value of herd (20 years)	Commercial offtake rate (percent)	Herd rate of growth (percent)
	Males	Females	Males	Females			
90	6	12	68	243	282	7	3
92	5	12	67	230	279	7	3
94	5	11	66	219	244	8	1
95	5	11	65	214	238	8	1
96	5	11	65	209	232	8	1
97	5	11	64	204	226	8	1
98	5	11	64	199	221	8	1
99	5	11	63	194	215	8	1
100	5	11	63	190	210	8	1
101	5	11	62	185	205	8	1
102	5	11	61	181	200	8	1
103	5	11	61	177	195	8	1
104	5	11	60	172	169	9	-1
105	5	10	60	169	165	9	-1
106	5	10	59	165	161	9	-1
108	5	10	58	158	154	9	-2
110	5	10	57	152	148	9	-2

E. Offtake Rates

Offtake rates change with mortality, but the results seem at first sight counter-intuitive. At higher mortality, higher offtakes occur; whereas at lower mortality, lower offtakes occur. When mortality is 10 percent below base, offtake is only 7 percent (but herd growth is 3 percent). At a mortality rate 10 percent over base, offtake is 9 percent (but herd growth is -2 percent).

Offtake is defined as the number of animals (males and females) culled per year divided by the total number of animals in the herd. At lower mortality rates, the herd grows faster and females are kept longer in the herd. Proportionately fewer cows are culled and the size of the herd is larger.

The offtake rate is, therefore, an ambiguous parameter with which to measure improvements in herd productivity from animal health programs. Success in reducing mortality would appear to be reflected in lower offtake rates. This is an entirely logical consequence and should not be attributed to irrational economic behavior by cattle owners.

Offtake values obtained with the base-line data are lower than most values reported in the existing literature. Rates of 12 to 15 percent are often reported. The above-mentioned FAO report, cites an offtake rate as high as 20 percent for Fulani cattle in the Delta. Such a high rate could of course happen in a particular year, but it would not be sustainable over time given reported rates of fertility and mortality.

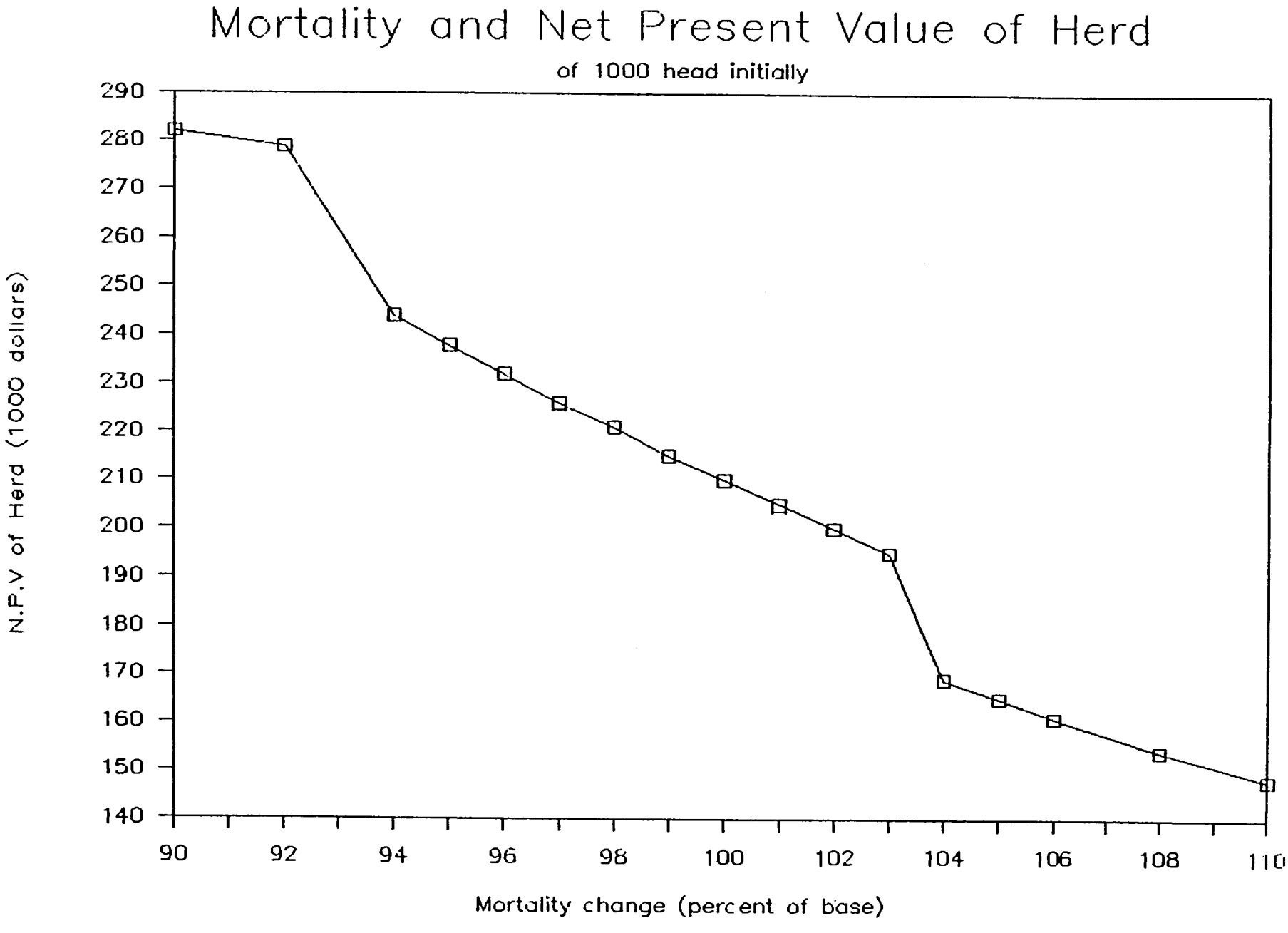
The discrepancy between the offtake rate derived above and those cited elsewhere could imply that either the base-line mortality rates are too high, or the fertility rates used too low. Alternatively, if mortality and fertility rates are correct, it could mean that estimates of offtake rates are too high. Notice that the offtake rate is not an independent variable, but it is fully determined by the mortality, fertility, and culling ages adopted for the model.

F. Present Value of Herd

We have all the elements needed to derive the present value of a representative herd and compare the derived values for different mortality rates. The herd structure can be derived implicitly from initial parameters. Using the fertility rates, we can derive the size of the calf crop for each year in the future. We know the present values for calves, both males and females.

It is then a simple matter to calculate the present value for all calf-crops for a period of 20 years. For the baseline case, the present value of a herd of 1000 head is $210,000 (see Table 12 and Figure 15). In the latter table, we report the herd Present Values for alternative mortality rates. The

Figure 15


Mortality and Net Present Value of Herd
of 1000 head initially
N.P.V of Herd (1000 dollars)
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
90
92
94
96
98
100
102
104
106
108
110
Mortality change (percent of base)

present value almost doubles, going from $148,000 to $282,000 when the mortality rate drops from 10 percent above to 10 percent below base-line.

Near the base-line mortality rate, a one percent change in the mortality rate is worth $5,000 for a herd of 1,000 head.

VII. Project Benefits from Animal Health

The Livestock Sector Project concentrates its direct animal health activities in Regions I and II of Mali. These two regions contain about one-fourth of the national cattle herd, or about 1.3 million head, distributed roughly equally in Kayes and Koulikoro regions (see Table 13). Project activities are directed at reducing overall mortality in the herd.

A one percent permanent reduction in the overall mortality rate in the project areas would generate the equivalent of $6,500,000 in additional revenues to cattle owners. Achieving the 5 percent reduction in overall mortality would result in $32,500,000 in added revenues to owners.

A. Project's Impact on Mortality

MAVERIC allows us to compute the economic benefits for a particular set of mortality reductions. It does not tell us what reductions can be attributed to project activities (see in Figure 16). The $6,500,000 cited above is for a hypothetical reduction of 1 percent drop in the overall mortality rate. It does not assert that the Livestock Sector Project has reduced mortality by that much. The actual impact of the project on mortality rates remains to be established.

There are two main lines of activities pursued by the Livestock Sector Project with direct impacts on cattle health. These are labelled Health Delivery and Health Research. Another major project activity, the Management Development Support Team, is aimed at strengthening the administrative, financial and management system of the National Livestock Service. This activity, if successful, would help to increase the effectiveness of the DNE and, in doing so, will enhance animal health delivery.

B. Animal Health Delivery

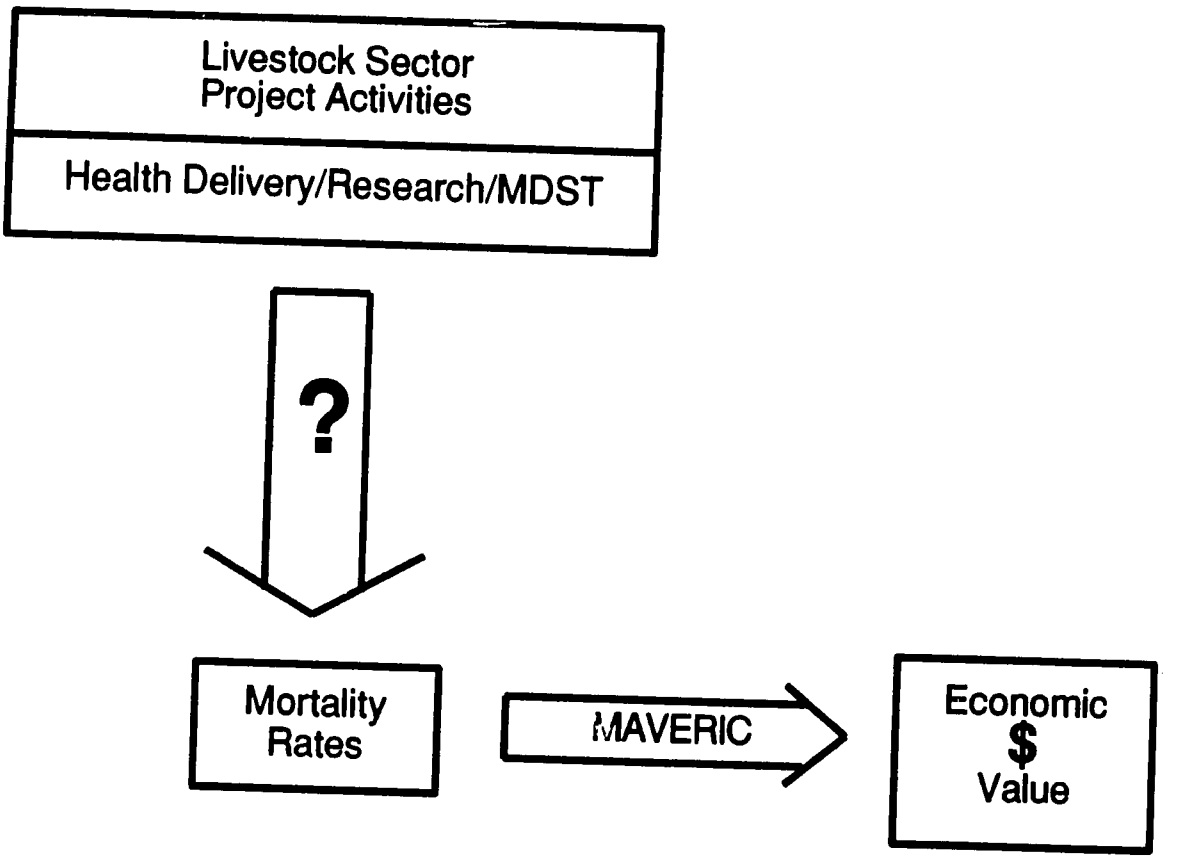
The bulk of resources in this activity are the financial allocations made to support the budget of the Livestock Service and ensure a proper herd vaccination coverage against the major epidemic diseases:

* Rinderpest (Peste Bovine)
* Contagious Bovine Pleuro-Pneumonia (Peripneumonie)
* Black leg (Charbon Symptomatique)

Table 13. Livestock Inventories in Mali, by Species, by Region (thousand heads)

Regions/species	Cattle	Sheep & goats	Horses	Donkeys	Pigs	Camels	Poultry
Kayes	662	1,049.000	12.000	17.000	–	2.800	–
Koulikoro	649	1,600.000	14.000	31.000	2.000	13.000	–
Sikasso	1,170	506.000	1.200	33.000	–	–	–
Segou	581	1,273.000	22.000	39.000	52.000	100	–
Mopti	1,031	3,029.000	16.000	142.000	–	2.600	–
Tombuctu	249	1,195.000	1.100	90.000	–	80.000	–
Gao	117	1,650.000	600	31.000	–	46.000	–
Bamako distr.	26	38.000	–	–	–	–	–
Total	4,475	10,340.000	67.000	383.000	54.000	144.500	22.000

Figure 16. Linkages Between Livestock Project Interventions and Livestock Economic Value



* Anthrax (Charbon Bacteridien)
* Pasteurellosis

In addition, the project supports the vaccination delivery and storage system by providing freezers and refrigerators for veterinary posts, vehicles and motor bikes, and short-wave radios to facilitate communications with headquarters.

C. Health Research

The project supports various animal health research efforts. Outputs from these activities are coming in, and field implementation of their results has not yet been significant. The principal item under this category is the financing of a disease diagnosis and research laboratory housed in the Central Veterinary Laboratory in the outskirts of Bamako.

Two other activities sponsored are designed to strengthen the vaccination production efforts of the CVL. They consist of a quality control laboratory for vaccines and a serum surveillance program to monitor the effectiveness of vaccines in generating immunity.

Research on diseases is concentrated on treatments against trypanosomiasis and diagnosis and treatment of pasteurellosis affecting both calves and small ruminants. Other diseases of interest are brucellosis and tuberculosis in cattles, as well as respiratory viral complex in both small ruminants and calves. Tick-borne diseases such as anaplasmosis and babesiosis, and internal parasites such as liverfluke, are receiving some attention.

D. Effectiveness of Rinderpest Vaccination Campaign

Rinderpest represents by far the greatest thrust of the animal health delivery system in Mali. In 1986, there were 1,400,000 vaccinations against Rinderpest, representing 37 percent of all vaccinations made. In 1985, 1,700,000 Rinderpest vaccinations accounted for 44 percent of all vaccines. For a cattle herd population of 4,500,000 million head, this represents a coverage of 31 percent of the herd in 1986.

Animal health authorities often state the need to increase the coverage to the entire herd. In fact, the new animal health policy being designed by the Government requires obligatory annual immunizations for all animals. There is some controversy regarding the desirability of such a policy. On the one hand, if the vaccine is effective, immunized animals should acquire lifetime protection. To be on the safe side, many veterinarians recommend three consecutive years of vaccinations. Only a fraction of the total herd needs to be vaccinated every year, but what percentage exactly is difficult to say.

One way to answer the question is to look at the current levels of mortality caused by Rinderpest and judge if the additional costs required to increase coverage are like to be compensated by reductions in the value of the

numbers of animals dying. Table 14 presents the official mortality statistics collected by the Livestock Service for Rinderpest in the Kayes and Koulikoro regions.

In the six years reported from 1980 to 1986, a total of 930 head of cattle in Kayes and 230 head in Koulikoro died from Rinderpest. Almost all these losses occurred in the two drought years of 1983 and 1984, when the pattern of cattle movements were severely disrupted. For the two most recent years, 1985 and 1986, only 12 animals died in both regions.

E. Conclusion

Clearly, the current level of coverage for Rinderpest is adequate to protect the cattle herd from serious economic losses. Too few head will saved by additional efforts to extend coverage to justify any expansion. No additional investments to expand Rinderpest vaccination campaign in the project zone are recommended.

F. Mortality from CBPP

The second largest disease prevention effort is directed at Contagious Bovine Pleuro-Pneumonia. In 1985 and 1986, vaccinations for CBPP reached 1,200,000 and 1,000,000 doses, respectively, corresponding to 32 and 28 percent of all vaccinations nationwide. Together, CBPP and Rinderpest vaccinations accounted for 76 percent of all vaccines used in 1985, and 65 percent in 1986.

Table 15 presents the official Livestock statistics for mortality from CBPP. The picture that emerges is one of almost complete success in conquering this disease. In the entire 1980-86 period, a total of 44 head of cattle died in the Kayes and Koulikoro regions from CBPP. By any standards, this is a remarkable achievement.

As in the case of Rinderpest, and perhaps more so, the current level of herd coverage against CBPP appears more than adequate. Accordingly, it would seem to be unnecessary to incur any additional investments in increasing the general coverage beyond the current levels. Emphasis should be on containment in case of localized outbreaks.

G. Mortality from Black Leg

Black leg is a more serious and consistent threat to cattle health than CBPP. In both Kayes and Koulikoro, there are several reported outbreaks every year. In 1984, 47 head died from Black leg in Koulikoro, with 74 in 1985 and 66 in 1986. In Kayes, 66 head died in 1984, with 16 in 1985 and one in 1986 (see Table 16). These are more serious mortality figures than those for CBPP, but are they sufficient to warrant a larger level of coverage?

Table 14.

Cattle Mortality from Rinderpest in the Kayes Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	-0-	112	743
1981			
1982	-0-	151	801
1983	-0-	85	732
1984	532	405	565
1985	398	343	525
1986	-0-	226	662

Cattle Mortality from Rinderpest in the Koulikoro Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	-0-	368	758
1981			
1982	8	309	838
1983	146	264	724
1984	85	458	606
1985	9	289	628
1986	3	330	649

Source: Annual Reports from the National Livestock Service

Table 15.

Cattle Mortality from C.B.P.P. in the Kayes Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	-0-	199	743
1981			
1982	10	179	801
1983	-0-	95	732
1984	-0-	56	565
1985	-0-	138	525
1986	-0-	126	662

Source: Annual Reports from the National Livestock Service

Cattle Mortality from C.B.P.P. in the Koulikoro Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	1	480	758
1981			
1982	-0-	314	838
1983	-0-	221	724
1984	-0-	258	606
1985	-0-	211	628
1986	33	279	649

Source: Annual Reports from the National Livestock Service

Table 16.

Cattle Mortality from Black Leg in the Kayes Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	35	59	743
1981			
1982	10	76	801
1983	19	65	732
1984	66	54	565
1985	16	49	525
1986	-0-	44	662

Source: Annual Reports from the National Livestock Service

Cattle Mortality from Black Leg in the Koulikoro Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	105	152	758
1981			
1982	-0-	125	[illegible]
1983	13	116	721
1984	47	60	[illegible]
1985	[illegible]	[illegible]	[illegible]
1986	[illegible]	[illegible]	[illegible]

Source: [illegible] National Livestock Service

16

Currently only 7 percent of the herd is immunized against Black leg in Kayes, and 14 percent in Koulikoro. This is a very modest coverage but it was apparently sufficient to keep mortality within a modest range. The largest number of deaths occurred in 1984, a drought year, when 113 animals died in both regions. Valued at $200 a head, a total loss of $23,000 was incurred in that year of maximum outbreak. In an average year, the cost would be about half as much.

Despite the loss of 269 head of cattle in the three years between 1984 and 1986, it does not seem necessary to spend significant amounts of additional resources in increasing herd coverage against Black leg.

H. Deaths from Anthrax

Nearly the same situation pertains with Anthrax as with Black-leg. The Livestock Service maintains a policy of selective vaccinations, concentrating in specific areas where there is a history of the disease. Deaths reported vary a great deal from year to year. In the past three years, there were hardly any deaths in Kayes. In Koulikoro they ranged from 9 in 1984, to 60 in 1985, and 13 in 1986 (see Table 17).

The current policy of selective protection seems to afford an adequate level of containment. However, the Livestock Service needs to maintain strict vigilance in monitoring new outbreaks, and be prepared to act promptly when the need arises.

I. Pasteurellosis Mortality

In Koulikoro region far more animals have died of pasteurellosis than any other disease. Over the 1980-86, period 674 deaths have been reported -- over 100 per year on average -- although half the deaths occurred in 1980 (323 dead). In 1986, only 17 deaths were reported. The disease is not as serious in Kayes, where only 72 animals died in the 1980-86 period (see Table 18). The rate of coverage is three times as high in Koulikoro as it is in Kayes, 18 percent in the former compared to 6 percent in the latter.

Does the saving of 750 head over six years warrant the investment necessary to increase the rate of herd coverage? It is doubtful that a general increase in herd immunizations is necessary, but well-targeted, localized interventions in the districts which report multiple outbreaks could be justified.

J. Conclusion on Epidemic Diseases

Insofar as epidemic diseases are concerned, the Livestock Service has succeeded in protecting the cattle herd against major losses. The most serious

Table 17.

Cattle Mortality from Anthrax in the Kayes Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	-0-	1.1	743
1981			
1982	116	4.4	801
1983	-0-	5.5	732
1984	-0-	1.8	565
1985	4	2.2	525
1986	-0-	2.1	662

Source: Annual Reports from the National Livestock Service

Cattle Mortality from Anthrax in the Koulikoro Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	42	45	758
1981			
1982	43	38	838
1983	27	7	724
1984	9	4	606
1985	60	7	628
1986	13	18	649

Source: Annual Reports from the National Livestock Service

Table 18.

Cattle Mortality from Pateurellosis in the Kayes Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	14	42	743
1981			
1982	1	85	801
1983	-0-	67	732
1984	45	32	565
1985	11	40	525
1986	1	41	662

Source: Annual Reports from the National Livestock Service

Cattle Mortality from Pasteurellosis in the Koulikoro Region.

1980 - 1986

Year	Dead	Immunizations (1000's)	Cattle Stock (1000's)
1980	323	163	758
1981			
1982	87	284	838
1983	150	105	724
1984	18	100	606
1985	79	89	628
1986	17	118	649

Source: Annual Reports from the National Livestock Service

outbreaks of Rinderpest occurred during the drought years, when the condition of animals was poor and the inflow of foreign herds was at a maximum.

The Livestock Sector Project has supported the Livestock Service in its vaccination campaigns and should receive partial credit for the successes in fighting contagious diseases.

On the other hand, mortality from the major epidemic diseases was already low at the beginning of the decade. The project has helped to sustain the gains achieved, but no further advances can be detected.

How many cattle has the project saved? We cannot say but probably few so far. There are no pre-project baseline data on cattle herds in the project area, so there is no way to determine what progress has been made, if any. It should be the responsibility of the Monitoring and Evaluation component of the project to gather information regularly to quantify and evaluate changes as they occur during the project.

The Mid-Term Evaluation team made no attempt at estimating what benefits have been derived from the project. It said that "With the available data, there is no basis for a meaningful cost/benefit calculation for the DNE [component]" and "a quantified economic analysis was prepared [in the PP] and apparently accepted by USAID. It suggested a benefit/cost ratio of 1.26 for health services. The meaning of this analysis is not clear to us and a study is warranted. This should be done in the context of a comprehensive livestock sector study, rather than as part of an evaluation such as this."

In the entire 6 years reported between 1980 and 1986, the total number of dead cattle from Rinderpest, CBPP, Black leg, Anthrax, and Pasteurellosis has been 2735 head - or an average of 456 per year. For the years preceding the Project for which we have data (1980, 1982, and 1983), the total dead from the two major diseases, Rinderpest and CBPP, was exactly 165 head.

It is difficult, therefore, to see how the project paper team could have based its economic analysis on the expectation of saving 10,000 head of cattle per year, when, in the previous three years, there had been a total reported mortality of 165 head from the two diseases projected to absorb most of the project resources.

K. Recommendations

1. The premise on which the project was based - that there is high mortality among cattle in the project zone - should be critically re-examined. The herd study (Enquete des Troupeaux) that the Livestock Service is executing at present seems well suited to answering this question.

2. If cattle mortality is found to be high, animals must be dying from causes other than the five endemic diseases which have preoccupied the project to date. We need to find out what these other causes of death are, if they truly are serious, and how they are to be combatted.

3. The project should identify more precisely which diseases must be addressed and how this is to be done. It must also define as clearly as possible the target population, for project interventions, i.e., calves less than 6 months of age, draft oxen, lactating females.

4. There should be a reexamination of the current project activities to ensure that there are clear linkages between project inputs and the expected outputs.

5. Adequate methods of monitoring and evaluating project activities must be established to allow assessments of the impact of project activities on cattle mortality.

Appendix 1. Productivity Parameters for Zebu Cattle in the Sahel

Parameters	I	II	III
Reproduction			
- Age at first calving	3-5 years	4.2 years	3.3 years
- Calving rate	50-65%	54%	80%
Mortality			
0-1 years	20-40%	30-40%	31%
1-2 years	5-10%	6%	5%
2-3 years	2-5%	4%	3%
3+ years	2-5%	8%	3%
Milk Production			
- Milk extracted	100-200 kg	219 kg	586 kg
- Mild consumed by calf		±445 kg	±589 kg
Live body Weight-Females			
Birth weight	20-25 kg	16 kg	20 kg
3 months		40 kg	48 kg
6 months		53 kg	77 kg
1 year		78 kg	122 kg
2 years		121 kg	202 kg
3 years		163 kg	-
Adult weight		215 kg	317 kg

I: Average of various publications.
II: From Wagenaar, Diallo and Sayers (ILCA) for Zebu Peul, (1978-82)
III: Niono Sahel Station herd.

Source: OECD, Club du Sahel, "Rapport sur l'Analyse de la Situation de l'Elevage Malien" 1986.

Appendix 2. Productivity Parameters for Various Cattle Herds in Mali, (1984-85)

Breed	Area	Calving	Herd Growth	Offtake	Live-weight/ Live-stock Unit
		%	%	%	kg
Peul	Delta	56.6	-3.3	14.2	107
Various	Gourma	45.0	-7.6	13.8	86
Peul	Delta	30.0	-26.9	20.0	66
Maures	Niono	71.7	3.0	14.7	157
Peul	Niono	71.2	3.5	14.1	145
Cross	Niono	74.4	3.7	14.3	162
Tuareg	Tilemsi	40.0	-22.2	19.4	84
Tuareg	Douentza	40.0	-25.0	19.5	84
Peul	Gossi	58.6	0.4	11.5	85
Toronke	Kayes	49.0	-20.4	15.0	87
N'Dama	Mali Sud	54.0	-1.4	14.3	92
N'Dama	Mail Sud	54.0	-1.4	16.7	82
N'Dama	Madina Diassa	60.0	-15.4	18.2	101
N'Dama	Madina Diassa	67.5	-0.1	15.7	108
Mere	Sikasso	45.0	-16.4	14.4	83
Maures	Tumbuctu	72.0	5.0	15.7	114

Source: FAO Mali, Mission de Revue du Secteur Elevage. Rome, April 1986.

Appendix 3. Basic Productivity Parameters for a Zebu Peul Herd in Delta Region of Mali, under Good Conditions (1985)

Age Sexual Maturity	28 months
Age First Calving	40 months
Fertility rate	85 percent
Calving Interval	18 months
Number of locations	5
Productive life	7.5 years
Calving rate	56.6 percent
Culling rate - old cows	13.3 percent
Culling rate - sterile cows	5.0 percent
Culling age - cows	11 years
Mortality rate: 0-3 months	20 percent
3-12 months	10 percent
12-24 months	8 percent
24+ months	3 percent
Female Replacement rate	21.3 percent
Milk Production per lactating cow	600 kg
Weight - culled old cow	290 kg
- culled sterile cow	310 kg
- culled male	320 kg
- birth	20 kg
- 1 year	45-100 kg
- 2 years	140-180 kg
- 3 years	210-240 kg
- 4 years	280 kg
- First calving female	310 kg
- male, 5 years	300 kg
- male, 6 years	310 kg
- male, 7 years	320 kg

Source: FAO "Mali, Mission de Revue du Secteur Elevage" April 1986.

VOLUME III

POSSIBLE ECONOMIC RETURNS TO HEALTH INTERVENTIONS IN SMALL RUMINANTS

I. Scope of Work

Based on the experiences of the A.I.D. Livestock project, other Mali activities, and other activities in the Sahel, an assessment of the economic costs and benefits of animal health interventions for small ruminants is needed. This paper will assess not only overall economic benefits to society, but also financial and growth linkages with the rest of the economy.

II. Importance of Small Ruminants

It has long been recognized that sheep and goats deserve more attention in livestock development projects. In many projects, attention and funding are concentrated, sometimes exclusively, on cattle. Many observers have commented on this problem but little progress has been made in improving the veterinary health coverage for small ruminants.

In numbers alone, sheep and goats are twice as numerous as cattle. The **1986 Annual Livestock Service Report** puts the population of sheep and goats at 10,300,000 head, compared to 4,500,000 head of cattle. In the two regions of interest for the Livestock Sector Project, the Livestock Service reports 2,650,000 head of small ruminants (1,050,000 in Kayes, and 1,600,000 in Koulikoro), compared to 1,310,000 head of cattle (660,000 in Kayes and 650,000 in Koulikoro). (See **Appendix I** for livestock numbers by region.)

Another source of information on numbers of sheep and goats is the census carried out by the administrative authorities annually for tax purposes. Not surprisingly, the numbers reported by the census differ significantly from those of the Livestock Service. For Kayes, for example, only 130,000 head are reported, and for Koulikoro 364,000 head. (**See Appendix I**). We will ignore the administrative figures and use the Livestock Service's numbers in this paper.

III. Main Diseases

A. Peste des Petits Ruminants

The Livestock Service reports that two types of vaccinations are used on sheep and goats against "Peste ovine-caprine" and "Pasteurelloses ovine." In 1986, 115,000 head were vaccinated against Peste des Petits Ruminants but none were vaccinated during 1985. This is a rate of coverage of 1.1 percent of the flock in 1986 and 0 percent in 1985.

Nevertheless, mortality from Peste des Petits Ruminants is almost non-existent. No outbreaks occurred in 1984; there were three in 1985; and five in 1986. No specific numbers of affected and dead animals were provided. The rate of mortality of affected animals is estimated at 50-60 percent (DNE Rapport Annuel, 1986, p. 35). DNE concludes that vaccinations against this disease should be intensified. With such a low disease incidence when the coverage is so thin, however, it is hard to see the rationale for additional coverage.

Official figures on outbreaks of this disease for the country indicate that its incidence is very low. No additional investments in controlling this disease seem justified for the project area.

B. Pasteurelloses

A far more important disease in economic terms is Pasteurelloses. Appendix I shows the reported outbreaks of Pasteurelloses among small ruminants by region. A total of 486 sheep and goats are reported to have died in 1986 in all of Mali. In Kayes, 15 small ruminants died. In Koulikoro, 123 deaths were reported. For the entire project area, total mortality from the disease amounts to 138 head.

More deaths would undoubtedly have occurred had it not been for the vaccination campaigns: 59,000 vaccinations were administered in Kayes, and 42,000 in Koulikoro, a total of 101,000 in the project area. That is a coverage rate of 3.9 percent of the total of the 2,600,000 small ruminants. In all of Mali, 283,000 vaccinations against small ruminant pasteurelloses were given in 1986. This is a decline from 1985 when there were 491,000 vaccinations. The national coverage rate for pasteurelloses in 1986 was 4.7 percent.

The economic cost of these losses to society can be calculated. Prices reported in Koulikoro region for sheep ranged between 9,000 and 21,000 FCFA live weight and for goats from 6,000 to 19,000 FCFA per head live weight. We will use an average figure of 15,000 FCFA per head in our calculations. At that price, the country incurred a total loss of 7,300,000 FCFA, or $26,000 at the exchange rate prevailing at the end of February 1988. The total loss in the two project regions, Kayes and Koulikoro, amounted to $7,213.

The loss of 138 sheep and goats in Regions I and II from Pasteurelloses does not justify additional project investments on the control of this disease.

C. Clavelee or Variole (Sheep Pox)

In 1984 and 1985, three outbreaks of pox were reported among goats in Segou, Mopti, and Gao regions. In February 1988, the chief of the Banamba veterinary district reported widespread incidence of the disease in that area. Fifty thousand doses of imported vaccine from Senegal were being used to

immunize sheep and goats in the area. No figures on actual deaths are available.

At least in the Banamba area, this disease is taking a toll of small ruminants. Absence of official figures on the disease incidence makes it difficult to recommend specific control programs. Until there is some evidence that the economic threat justifies the costs, no further actions are recommended.

D. Conflicting Claims

The apparent good health of small ruminants and their resistance to major infectious diseases is remarkable given the very thin vaccination coverage at present and the limited Livestock Service resources devoted to sheep and goats. For example, 3,400,000 doses of vaccines were used on a cattle herd of 4,500,000 head, compared to 400,000 doses on a herd of 10,300,000 sheep and goats.

E. Diseases of Young Animals

The diseases mentioned above affect mainly adult animals. However, the highest mortality takes place in the first few weeks and months of life among newborn lambs and kids. We appear to have a situation then of high newborn mortality and low incidence of the major infectious diseases in adults. Suppose, for example, that 30 percent of kids die of pneumonias or diarrheas in their first months; official statistics would not report these deaths as "major" diseases. It is possible, therefore, that official statistics at present not only underestimate the actual occurrence of the "major" diseases among small ruminants but that they completely ignore what are the principal causes of mortality in sheep and goats.

F. How Serious is Mortality?

Most of the available literature on small ruminants report high rates of mortality. Excerpts from several of these reports concerning mortality in sheep and goats are annexed to this section.

OMBEVI in 1985 carried out a study for the Livestock Sector Project on **"Les Facteurs de Production et Socio-Economiques des Petits Ruminants au Mali,"** (attached as Appendix II) under the direction of Dr. Almouzar M. Maiga (Document No.125, October 1985). The study reports on a series of field surveys made throughout the country on small ruminants. Table 56 of the Appendix shows reported mortality statistics for sheep and Table 52 for goats. For Kayes, mortality among sheep in the first year was 38.4 percent; for animals between 1 and 2 years, it was 10 percent; and, for animals more than 2 years, it is 4.4 percent. The corresponding mortality figures for sheep in Koulikoro were 45.7, 9.2, and 7.5 percent, respectively.

Similar statistics are reported by the study for mortality of goats. In Kayes, kids in the first year of life died at a 36.8 percent rate; and in Koulikoro at 35.2 percent. For animals between 1 and 2 years, mortality was 9.6 percent in Kayes and 12.3 in Koulikoro. For adult goats, the mortality was 4.7 percent in Kayes and 3.5 percent in Koulikoro.

These mortality rates are roughly corroborated by other reports for Mali and Sahelian West Africa. A SEDES study for a small ruminants project in the lakes area, uses the following parameters in their projections: for sheep, mortality in the first year, 20 percent, and for adults 10 percent; for goats, the same percentages (see Appendix III). It is not clear where these particular percentages came from, but SEDES is a highly reputable organization. On the other hand, these are projected parameters for their development efforts and surely the actual mortalities among Malian flock/herds would be higher than those anticipated for the project.

The FAO review mission on the Mali livestock sector published the report **"Evaluation de la Productivite des Troupeaux"** (Annex 4 of the Mission's Report, FAO, Rome April 1986). For a herd of Peul sheep raised under average conditions in the Niono area, the Mission reported actual levels of mortality of

Birth to weaning (4-5-6 months) ..... 30 percent
Weaning to 12 months ..... 10 percent
12 to 18 months ..... 8 percent
More than 18 months ..... 5 percent

Much lower mortality rates are reported for a herd of sheep, also Peul, in the Mali Sud region, under "good conditions." Actual mortality levels reported are

Birth to weaning (4-5-6 months)..... 14 percent
Weaning to 12 months ..... 10 percent
12 to 18 months ..... 9 percent
More than 18 months ..... 8 percent

Other important herd parameters for sheep can be seen in the attached tables at the end of this section.

The FAO team obviously has a computerized herd production model that allowed them to project flock/herd growth and total meat production from sheep and goats. The Livestock Sector Project should try to obtain access to this flock/herd production simulation model in order to explore the potential gains from animal health interventions. The FAO Mission report has a number of simulations of flocks/herds under improved conditions, i.e. with more favorable production parameters generated by a package of interventions. These do not separate mortality improvements by themselves.

The FAO Mission also reports on two herds of goats, one in Niono and another one in Tombuctu. They report actual mortality rates observed on the Peul breed Niono herd under average conditions as

Birth to weaning (3-4-6 months)..... 40 percent
Weaning to 12 months ..... 10 percent
12 to 18 months ..... 10 percent
More than 18 months ..... 10 percent

The Institut d'Elevage et de Medecine Veterinaire des Pays Tropicaux, (IEMVT) in a 1980 publication reports information on small ruminants in West Africa (**Les Petits Ruminants d'Afrique Centrale et d'Afrique de L'Ouest**, IEMVT, Maison Alfort, France, 1980). Selected data from this report, included as Appendix V, present mortality rates for sheep herds in different parts of West Africa, differentiated by sex and age.

Mortality rates for two Sahelian sheep herds, one Peul in Burkina Faso and another Peul Oudah are reported as

	Peul Burkina-Fasso		Peul Oudah	
Age	Males	Females	Males	Females
0 - 1 yrs	53.5	30.8	24.2	23.4
1 - 2 yrs	13.3	9.6	7.0	7.8
2 - 3 yrs	10.7	3.8	6.7	2.0
3 - 4 yrs	16.7	5.3	7.0	2.0
4 - 5 yrs	-	4.3	7.0	2.0
5 - 6 yrs	-	-	7.0	2.0
6 - + yrs	-	-	7.0	2.0

The same IEMVT publication cites mortality rates collected by Dumas and co-workers for goat herds. For two goat herds in Burkina Faso the mortality rates reported are

	Peul		Mossi	
AGE	Males	Females	Males	Females
0 - 1 yrs	41.6	32.6	35.2	24.3
1 - 2 yrs	25.0	16.4	16.3	15.5
2 - 3 yrs	16.2	13.2	13.8	13.4
3 - 4 yrs	13.4	10.1	10.5	9.8
4 - 5 yrs	10.5	7.0	-	7.4
5 - 6 yrs	-	4.3	-	6.1
6 - + yrs	-	-	-	-

Clearly these figures confirm the general observation that mortality in goats is especially high in the first year of life, and most of it takes place before weaning.

IV. What can we do?

Apparently very little.

The system of veterinary health delivery established by the Livestock Sector is geared primarily towards the prevention of major endemic diseases in adult cattle. Calf mortality, however, remains the Achilles heel of animal health in cattle. The importance of designing interventions to reduce calf mortality have been stressed by many observers for decades. The effects so far on program directions are nil.

There are reasons for this serious failure. First, there is no one-shot solution to the calf mortality problem. No single injection can immunize a calf against malnutrition, diarrhea, and pneumonia for its first year. Second, mortality of nursing young stock is closely related to nutritional and environmental conditions. Calves are born at the very end of the dry season when the cow is emaciated and there is no fresh grass available. When the rains come, the calf is weak and easily succumbs to pneumonia and diarrhea. Treatments for these problems depend on having antibiotics available on time and in locations easily accessible to herders during calving season.

The Livestock Service network of vaccination posts is designed to service the annual vaccination campaigns, not to check on newborn calves in the field. Posts do not stock or distribute antibiotics on any significant scale. Moreover, herders do not have the equipment to use injectibles even if they were available.

As with calf mortality, there is a parallel situation with interventions designed for small ruminants. The lack of success in reducing calf mortality portends a similar failure in reducing mortality in sheep and goats. Once sick, the young animals are not easily carried to a veterinary post for treatment, and even if they were to be transported, the post agent at present has very little to offer the patient. Since the distribution of veterinary medicines is strictly controlled by the Livestock Service and the Veterinary Pharmacy, it is not possible for herders to obtain these products through private agents.

Finally, the small size and therefore low value of small ruminants, especially the young, make it harder to justify the cost of veterinary treatments. Veterinary services are demanded more for high value animals such as horses and oxen. There is a high implicit cost in seeking veterinary care for a sick animal, regardless of the species. A visit by a veterinarian cost the same whether it is for a horse or for a goat. Livestock owners are therefore more likely to call the vet for the former than for the latter.

V. Desirability without Means

This pessimistic assessment of what the Livestock Sector Project can do to reduce small ruminant mortality at present should not be construed as throwing in the towel on this issue. For many economic, social, and environmental reasons, the productivity of small ruminants should be developed

and must be promoted. The reasons have been amply stated by many observers. We recapitulate the principal ones as

A. Source of rural meat

Since beef is consumed mainly in urban areas, people in rural areas consume mainly sheep and goats. The bulk of the slaughter of small ruminants takes place in the countryside, and higher sheep and goat productivities will lead directly to improved rural nutrition.

B. Importance to the poor

Smaller investments are required to acquire small stock and this makes them more accessible to poor herders and farmers.

C. Source of Cash

Cattle provide large lump sums of cash when sold, but for everyday expenditures, rural and many urban families depend on the sale of small ruminants for quick cash in small amounts.

D. Farmers as well as Herders

Sheep and goat raising is not limited to pastoral groups. Farmers have their own herds of small ruminants grazing in areas surrounding their villages. Of course, small ruminants are also important for the pastoralists engaged in cattle raising.

E. Environmental advantages

Goats especially are highly selective in their eating habits and have strong preference for green vegetation from shrubs. They are browsers, as opposed to grazers. In this sense, they complement cattle raising, without competing with them for the same grass cover.

F. Importance to Women

Small stock remain fairly close to the household and a great deal of the responsibility for their care rests on the children and women. Their proximity to the household suggests that women might be better placed to provide elementary health care for small ruminants.

G. Drought Resistance

Small ruminants are hardier under nutritional stress in times of drought. Proportionally, fewer of them die than cattle, even though they are less mobile.

H. Fast Recovery

After a drought is past, the recovery in herds of small ruminants is very rapid and helps to replenish depleted stock of meat for both urban and rural consumers.

VOLUME V

PROSPECTS FOR MALIAN CATTLE EXPORTS

I. DILALI

A. Introduction

In order to be able to forecast the potential outcomes from either health interventions or policy changes in the Malian cattle sector, a computerized trading simulation model has been developed. It has been designated **DILALI**, the Hausa name for cattle traders. A listing of the BASIC program statements is attached. A detailed explanation of the assumptions built into the program, the computational procedure, and the initial conditions is given below.

B. Countries

Six countries were selected to be included in the simulated West African market: Guinea, Mali, Burkina Faso, Liberia, Ivory Coast, and Ghana. These countries form part of what is sometimes referred to as the Central Corridor of West African livestock trade. Mali and Burkina Faso are clearly net exporters for cattle in most years. Equally obvious is the status of Ivory Coast, Ghana, and Liberia as net importers of beef or cattle. Guinea has an ambiguous status since it is a coastal country with a large urban population, and also has a sizeable domestic herd of mainly N'Dama cattle, based in its northern mountains. Guinea therefore is treated both as a potential importer and exporter of cattle.

II. Simulations with DILALI: Base Situation

Before we can take advantage of the capability to simulate alternative conditions affecting the cattle market, it is necessary to establish how well **DILALI** can replicate the market situation in a period for which information is available. We will take this situation to be the years before the 1983-84 drought.

A. Beef Production

The accompanying Table provides an easy guide to the base situation. Production in Mali has been calculated at 43.7 kilotons, corresponding to a herd of 4.05 million head of cattle, with an 8 percent offtake rate, and an average carcass weight of 135 kilograms. Similarly, for Ivory Coast, a herd of 0.67 million, also with 8 percent offtake but slightly lower carcass weight (125 kg) produces 6.7 kilotons of carcass beef. Burkina Faso, with a herd of 2.71 million, produces 28.2 kilotons, and so on.

Table 1a. Livestock Population in West Africa, 1979
(thousand head)

Country	Cattle	Sheep	Goats	Camels
Ivory Coast	666	723	566	-
Ghana	823	1,130	874	-
Liberia	30	548	952	-
Guinea	1,956	1,021	1,021	-
Burkina Faso	2,708	1,854	2,783	7
Mali	4,048	8,653		145

Source: Animal Health Services in Sub-Saharan Africa, by Cornelis de Haan and Nicos J. Nissen. World Bank Technical Paper No.44, 1985.

Table 1b. Estimated Beef Production in West Africa, 1979

Country	Cattle (million)	Offtake	Carcass (avg kg)	Beef Prodn. (kilotons)
Ivory Coast	.67	.08	125	6.7
Ghana	.82	.08	125	8.2
Liberia	.03	.08	110	0.26
Guinea	1.96	.08	120	18.8
Burkina Faso	2.71	.08	130	28.2
Mali	4.05	.08	135	43.7
		Total		.105.9

95

B. Consumption Functions

For each market, a consumer demand function was constructed, relating per capita consumption to the local price of meat. For Mali, we have used the consumption function evaluated earlier. For other countries we have no similar demand functions available. Instead we have derived hypothetical demand functions on the basis of their per capita consumption levels and an assumed price elasticity. In the absence of other elasticity estimates, we have used the final estimate we chose for Bamako beef consumption, namely -0.6. Estimates of population, urban population in particular since beef consumption is heavily concentrated in cities and towns, were obtained from World Bank publications. Per capita consumption estimates were obtained from the University of Michigan's CRED studies on livestock and meat marketing in West Africa.

C. Transport Costs

Cattle are usually transported from the Sahel to coastal urban centers by trekking. Truck transport may be used in the coastal countries during the final stage of the trip, when dense vegetation, lack of grass along the way, and local regulations make trekking difficult or illegal. Transport costs have, therefore been assumed to be proportional to the surface distances between the capitals of the six countries involved: Conakry, Bamako, Ouagadougou, Monrovia, Abidjan, and Accra. The mileages from the Michelin map for West and North Africa were taken, and costs between any two pairs of capitals were assessed at $1.00 per kilogram of beef per 1000 kilometers. As better information becomes available, it could be inserted in the appropriate places of the program.

For the time being, the transport costs used were as follows: Bamako-Abidjan, $1.20; Bamako-Monrovia, $1.26; Bamako-Conakry, $0.97; Bamako-Accra, $1.60, Ouaga-Monrovia, $1.70, Ouaga-Abidjan, $1.16; Ouaga-Accra, $1.01, Conakry-Monrovia, $0.75, and Conakry-Abidjan, $1.89.

III. Results: Base Situation

Given the above information, the task of **DILALI** is to find the pattern of trade flows, the levels of exports and imports, that will result from a competitive trading system linking these countries. It does that by finding the levels of prices in each market, and whenever there is a price difference that exceeds transport costs, it ships some supplies from the low-price market to the high-price market. It keeps doing that until all profitable opportunities are exhausted. At that point the program reports the equilibrium levels of consumption and prices, and the flows from exporting to importing countries.

Table 2. Estimated Beef Consumption in West Africa
(circa 1980)

Country	Urban Population (million)	Beef Consumption Per Capita (Avg kg/year)	Beef Consumption Total Consumpt (kilotons)
Ivory Coast	4.6	9	41.4
Ghana	4.8	3	14.4
Liberia	0.82	6	4.9
Guinea	1.59	8	12.7
Burkina Faso	0.73	15	11.0
Mali	1.39	16	22.2
		Total	106.6

Source: World Bank, Development Report, 1986
CRED, Livestock and Meat Marketing in West Africa. 1980.

Table 3. Road Distances Between West African Capitals (kilometers)

From \ To	Abidjan	Accra	Monrovia	Conakry
Ougadougou	1,164	1,002	1,702	1,703
Bamako	1,195	1,605	1,257	971
Conakry	1,889	2,689	753	0

Source: Carte Michelin 153 (West Africa).

Transfer Costs between West African Capitals (dollars per kilogram)

From \ To	Abidjan	Accra	Monrovia	Conakry
Ougadougou	1.16	1.01	1.70	1.70
Bamako	1.20	1.60	1.26	.97
Conakry	1.89	2.69	.75	.00

Source: Carte Michelin 153 (West Africa).

A. Consumption and Exports

Mali ends up consuming only 21.96 kilotons of beef domestically, and exporting the rest to Ivory Coast (21.22 kt) and Liberia (.52 kt). Burkina Faso exports 11.58 kt to Ivory Coast and 5.94 kt to Ghana, leaving only 10.69 kt for its own urban population. Guinea turns out to be a net exporter of cattle to Liberia, on the order of 4.75 kt.

B. Consumption and Imports

Ivory Coast receives most of its beef from Mali and Burkina Faso, which combined with its own production provides a total supply of 39.50 kt for its consumers. Ghana supplements its own production with imports from Burkina Faso, for a total 14.14 kt of consumption. Liberia gets almost all its beef from outside, mainly from Guinea (4.75 kt) but also a small amount from Mali, which all add up to a total consumption of 5.53 kt.

C. Prices and Transfer Costs

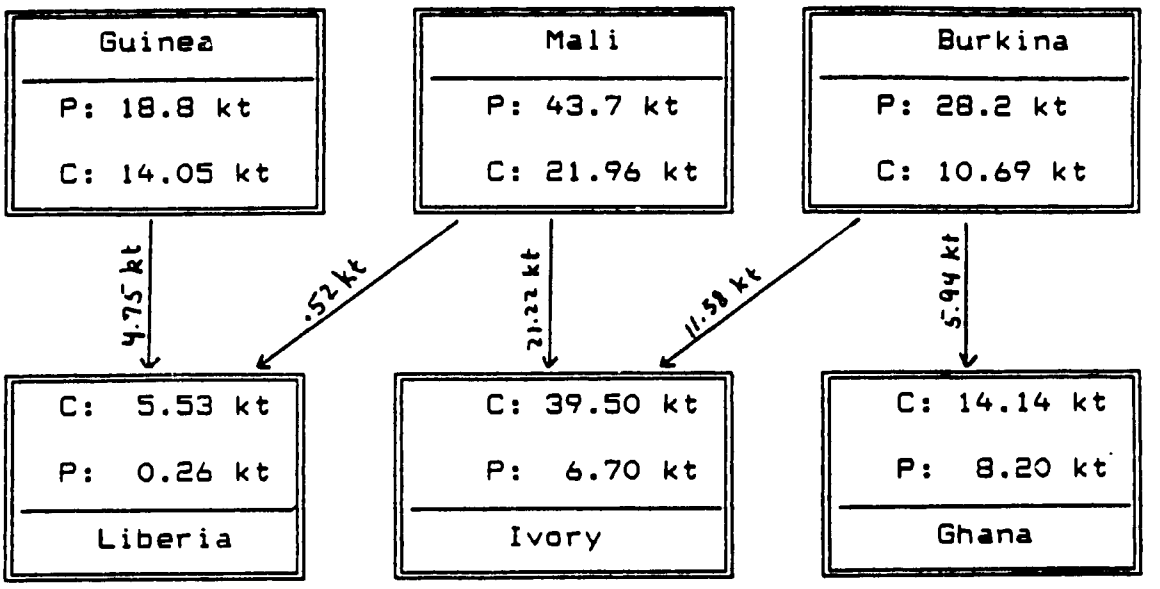
The accompanying diagram (Figure 1) provides the carcass prices that are expected to result from a competitive marketing system. The price in Ivory Coast, for example, is expected to be $3.24 per kg carcass, while in Mali it is only $2.04. The arrow between the two boxes indicates the price difference between the two markets, $1.20. Now, the price differential is exactly equal to the transport cost initially stated. This is a characteristic of a well-functioning market, when the gain from the price between any two markets just covers the transfer costs. Notice also that the price in Ouagadougou is $2.08/kg carcass, which is $1.16 less than the price in Abidjan, and $1.01 less than the price in Accra. Again, these price differentials exactly match the transport costs stated above.

IV. Simulating Malian Increase in Production

Suppose that Mali manages to increase its beef output by 10 percent as a result of, say, wise investments in animal health measures. How would the benefits of such an increase be distributed by an efficient marketing system? The results are given in Figure 2. Except for the higher production of Mali, 48.1 kt, the production figures for all other countries remain identical to the previous diagram.

However, after DILALI finishes its work, the consumption levels in all six countries have been increased. Consumers in Bamako, and also in Ouagadougou, Abidjan, Conakry, and the other capitals are beneficiaries of the investments in Malian cattle health. Not only is consumption higher everywhere, but prices are lower everywhere. In Bamako itself, the price per kilogram of carcass drops from $2.04 to $1.87, an 8.3 percent decline. Consumers in Ouagadougou also benefit from lower prices, since prices there

Figure 1. PRODUCTION, CONSUMPTION AND TRADE FLOWS: BASE SITUATION



PRICE RELATIONSHIPS IN IMPORTING AND EXPORTING COUNTRIES

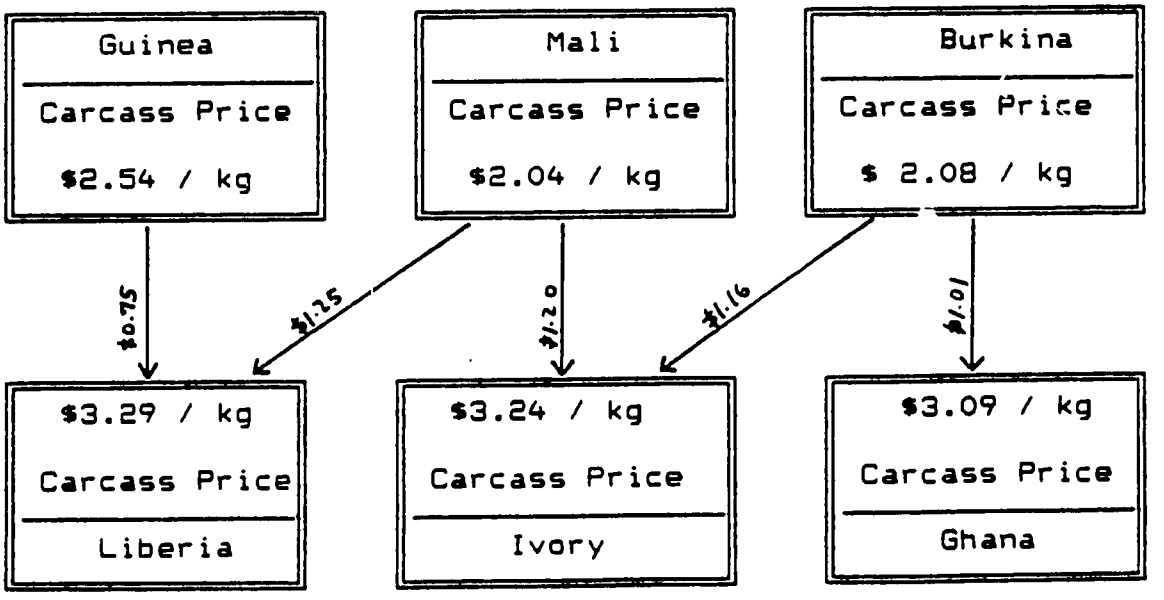
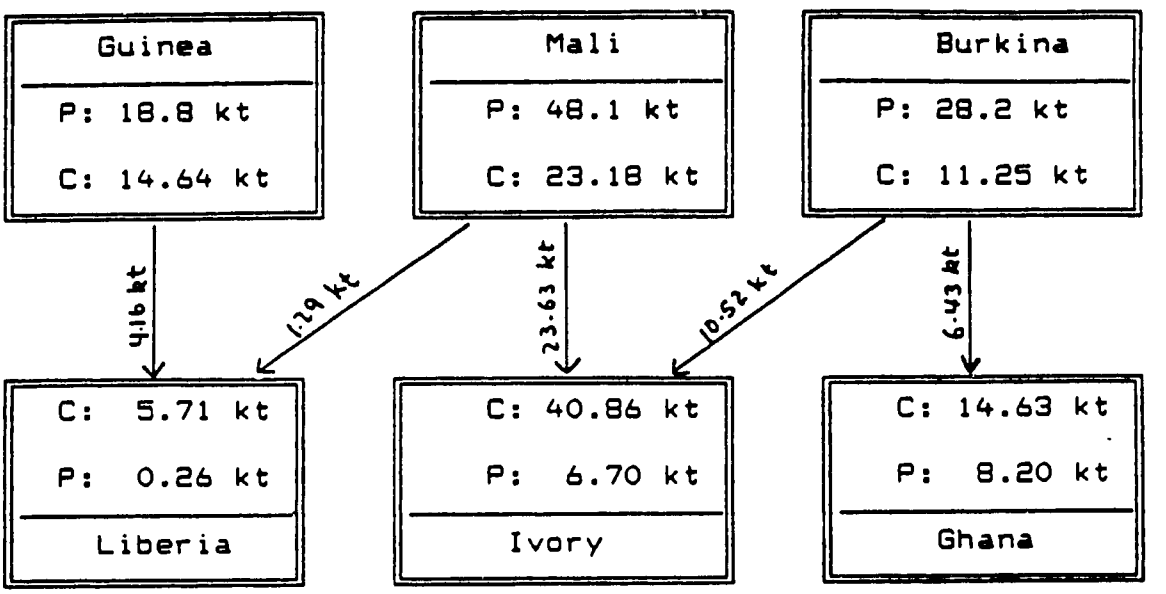


Figure 2. PRODUCTION, CONSUMPTION AND TRADE FLOWS:

CASE: MALIAN PRODUCTION INCREASES BY 10 PERCENT



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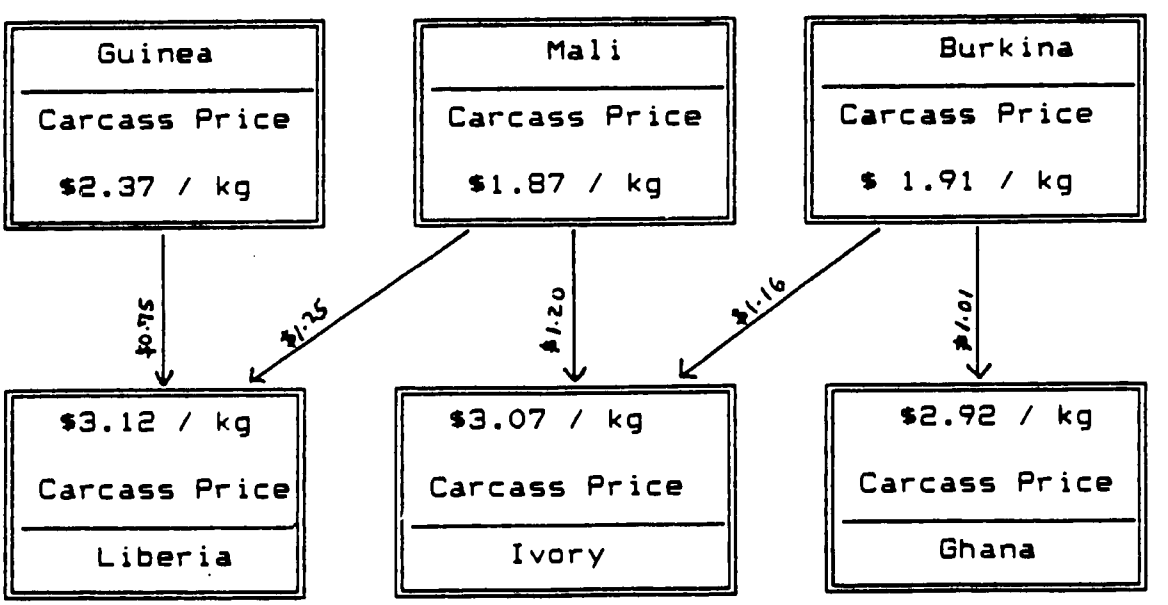


drop from $2.08 to $1.91 as a result of the increase in Malian production. Herders in Burkina Faso, on the other hand, will suffer a loss of income since now their animals will be getting lower prices.

Herders in Mali benefit from the higher production but suffer a loss in prices, but they still come out ahead. Before, 10 steer of 150 kgs carcass weight would have sold for $3,060, at $2.04 per kilogram, but now a herder can sell 11 steers at $1.87 for a total of $3,085. Not much of a gain (less than one percent), but at least not a loss.

Ivorian consumers also have to thank the Malian animal health system for lower prices for beef, since they get also a saving of 14 cents per kilogram (the same saving as in Bamako, but proportionately less since the price is higher in Abidjan).

V. Simulating Frozen Imports

Suppose now that the European Economic Community decides to donate 10 kt of beef to Ivory Coast, partly out of an altruistic desire to help Ivory Coast, but also looking for an outlet for the mountains of excess beef that its agricultural policies generate every year.

We can ask DILALI to help us determine the outcome of such generosity to the consumers and producers of West Africa. The next diagram (Figure 3) provides the DILALI forecasts. Notice that the only change in the initial conditions has been the increase in the Ivorian "production" from 6.7 to 16.7 kt, the sum of its own production and the 10-kt EEC gift.

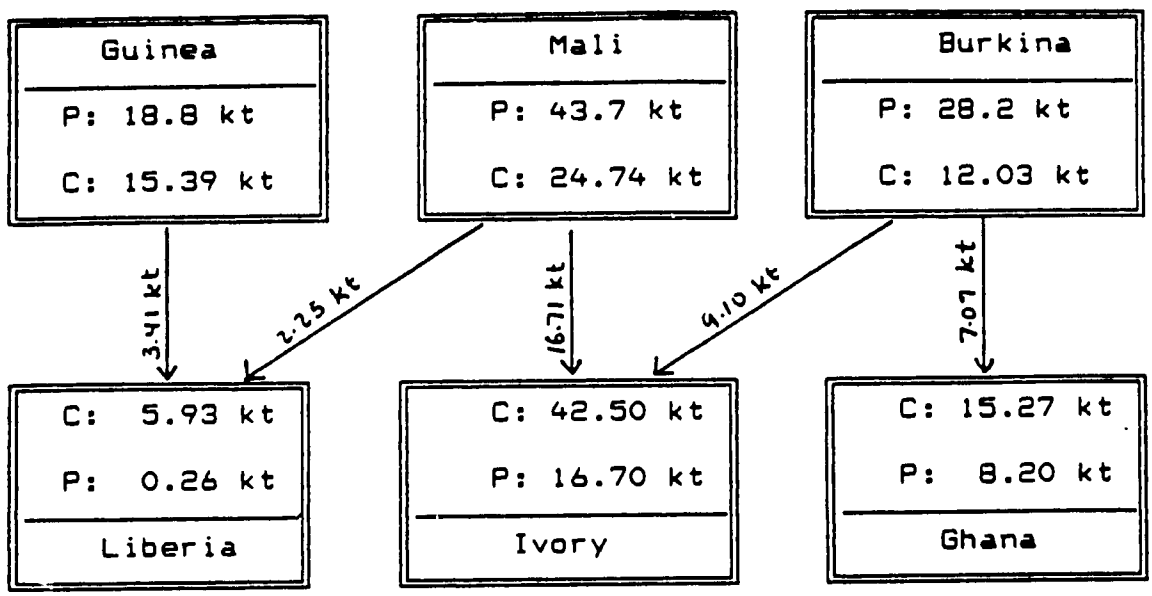
Not surprisingly, consumption in all six countries increases as a result of the gift to Ivory Coast. Even in Bamako, domestic consumption increases from 21.96 kt in the base year to 24.74 kt after the EEC gift. Of course, Malian exports to Ivory Coast decline too from 21.22 kt to only 16.71 kt. But that leaves room for an increase of exports to Liberia, which serves to drive the price in Monrovia down to $2.93 from $3.29 before the gift.

Burkina Faso also increases its own consumption, and reduces exports to Ivory Coast, but increases its exports to Ghana, to the delight of consumers in Accra who now can buy beef at $2.72 instead of $3.09.

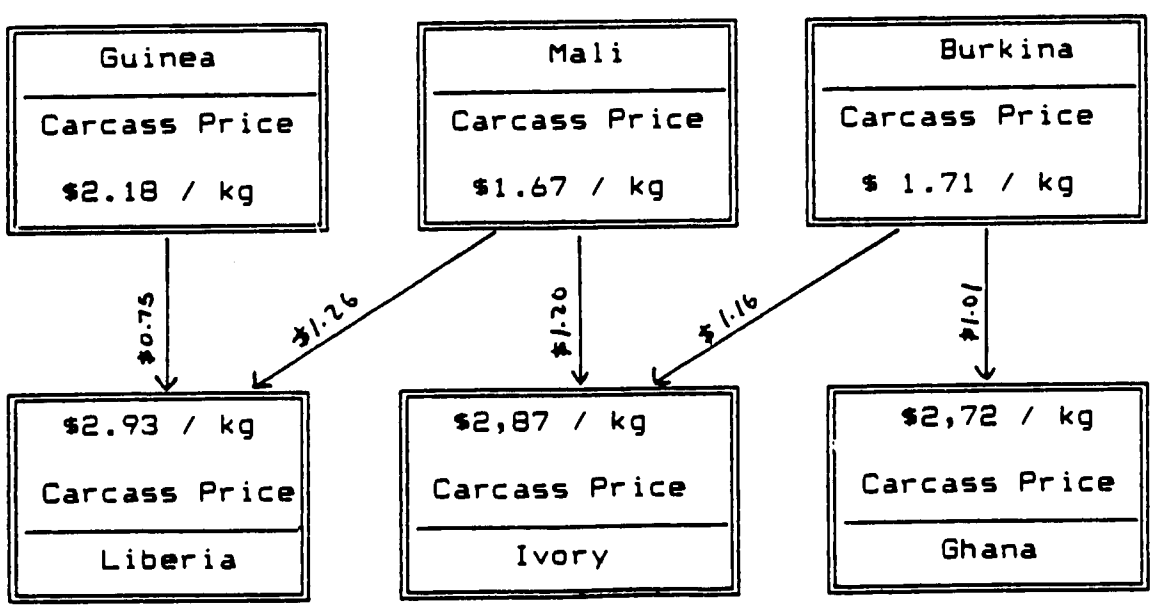
The consumer's delight is the cattle owners' distress, since now producers in Mali, Burkina Faso, Guinea, and also in Ivory Coast and Ghana will receive less when they sell their animals. What is the damage for Malian livestock owners? Before the EEC donation, Malian cattle sold at $2.04 in Bamako, but after the EEC donation the price dropped to $1.67 per kg carcass. This is a drop of 18 percent in revenue to producers. Similar impacts are felt by producers in Burkina Faso and other countries.

Figure 3. PRODUCTION, CONSUMPTION AND TRADE FLOWS:

CASE: 10 kt EUROPEAN BEEF DUMPED IN IVORY COAST



PRICE RELATIONSHIPS IN IMPORTING AND EXPORTING COUNTRIES



VI. Short-Run Demand for Malian Beef

We have estimated elsewhere the demand for beef in Bamako, and found it to be positively related to income and negatively related to price. In previous pages we have extrapolated this demand to apply to the rest of the urban population in Mali. However, demand for Malian beef is the joint result of the demand for beef in Mali, and the demand for Malian beef from the deficit coastal countries. A given increase in Malian beef supply will go partly to the domestic market, and partly for export to Ivory Coast and Liberia.

The negative price impact from increments in total Malian cattle production is lessened by the export market, i.e., prices would decline less than if the additional production were confined to the Malian borders. We can use DILALI to derive an approximation of the short-term demand for Malian beef when the export market is taken into consideration.

When beef production in Mali is specified at 15 percent below the 43.7 kt in the base situation, carcass price for beef in Bamako increases from $2.04 to $2.38. This increase assumes that everything else -- beef production in the other countries, urban population, and consumer income -- remains constant. Gradual increases in beef production in Mali permit us to foresee the impact on prices expected in the short run. At the other end of the range, were Malian beef production to increase by 20 percent to 52.44 kilotons, the resulting price in Bamako would be $1.72 per kilogram (see Figure 4).

For a range of production from 15 percent below to 20 above the 43.7 kt in the base situation, the corresponding carcass prices are given below:

Percent change	Beef Production	Bamako Price
-15 %	37.15 kt	$2.38 / kg
-10 %	39.33 kt	$2.25 / kg
- 5 %	41.52 kt	$2.13 / kg
0 %	43.70 kt	$2.04 / kg
+ 5 %	45.89 kt	$1.95 / kg
+10 %	48.07 kt	$1.84 / kg
+15 %	50.26 kt	$1.79 / kg
+20 %	52.44 kt	$1.72 / kg

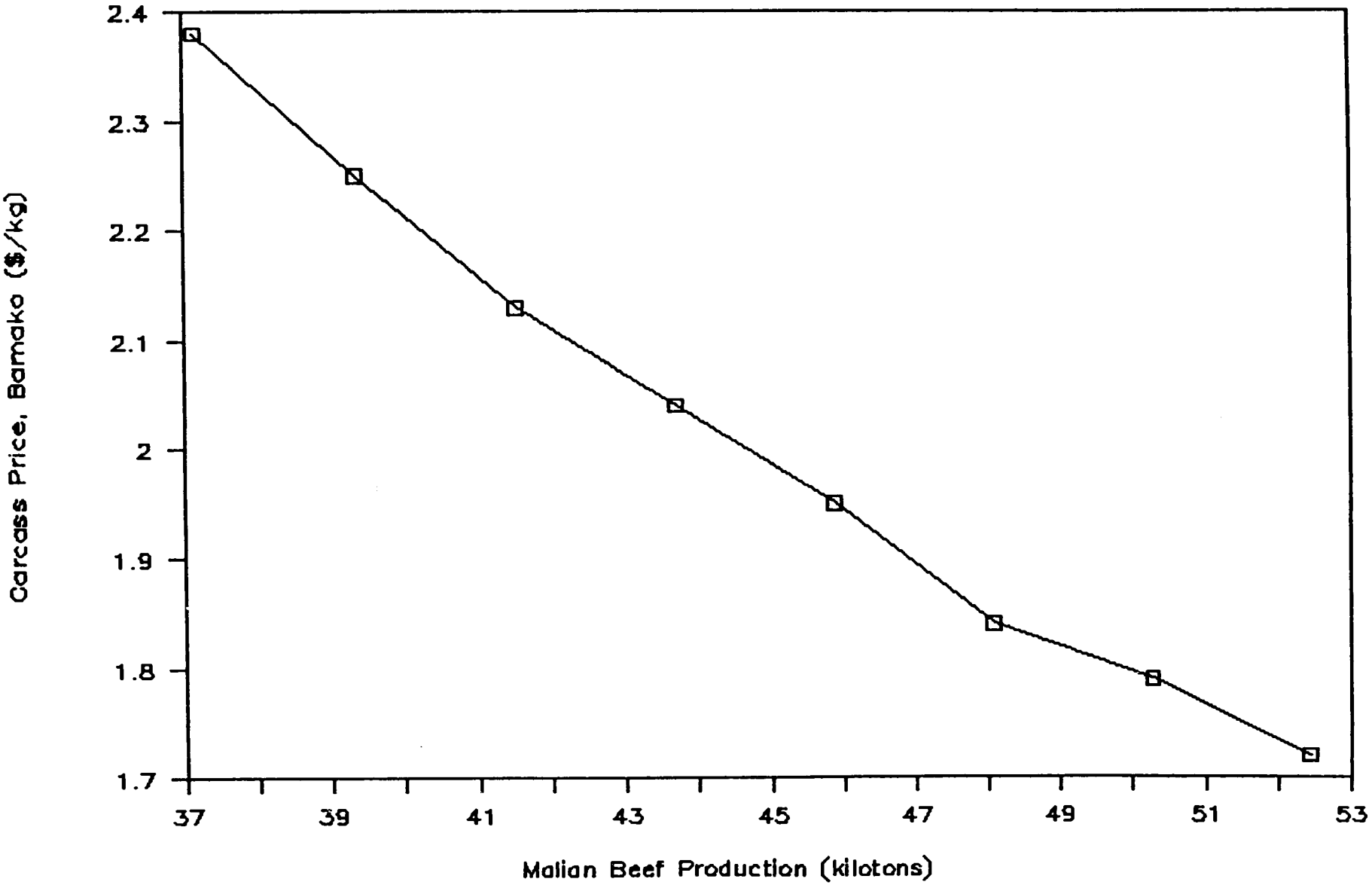
The price elasticity of demand for Malian beef for the combined export and domestic markets is more elastic than for the Malian market alone. For the price-quantity relation corresponding to the above values, the elasticity calculated was **-1.03 to -1.05** using a linear or logarithmic form, respectively. Recall that the price elasticity for the Bamako market was taken to be -0.6.

The nearly unitary price elasticity of demand for Malian beef implies that total revenue from cattle sales remains basically constant for higher or lower levels of production, within a limited range of current production. In the

Figure 4.

Short–Run Demand for Malian Beef

Carcass Price ($/kg) FOB Bamako



short run, if production increases by, say 10 percent, prices decrease by an equal percentage, and total revenue is roughly the same.

VII. Five-Year Demand Projection for Malian Cattle

Future demand for Malian cattle will have to take into account not only the growth in Mali's domestic market, but also developments in supply and demand in the other West African countries. The principal sources of growth in demand for beef over periods of several years come from changes in urban population and per capita consumer income. Supply, on the other hand, will also increase as cattle herds in surplus and deficit countries grow in size, and as alternative sources of beef appear in the market (European, South American, or other African countries).

Some basic economic indicators are presented in the adjoining table for the West African countries included in this analysis of the cattle and beef market. Average annual growth rates of urban population for the period 1973-84 have been extrapolated to arrive at estimates of urban populations five years from the base situation. For Ivory Coast for instance, the growth rate was 8.3 percent over that period, which five years hence translates into an increase in urban population of 49 percent over the base year. In terms of people, this fast growth means that the 4.6 million urban inhabitants will increase to 6.85 in just five years. For Mali, on the other hand, a slower urban growth of 4.5 percent annually translates into a 25 percent increase in urban population in five years.

For each country included in DILALI, its urban population has been revised to reflect the anticipated growth in urban population five years after the base situation, using the historical average growth rates in the accompanying table.

Consumers' per capita income is another major determinant of beef consumption in urban areas. In the short run, average income does not increase appreciably, but over a five-year period the increase can have important consequences. Moreover, it was determined earlier that in Mali, income elasticity of beef consumption is 1.27; hence an increase in income results in a more than proportional increase in beef consumption. More specifically, an increase of 10 percent in per capita income will redound in an increase per capita consumption of 12.7 percent by city dwellers. For lack of other information, the same income elasticity of beef consumption is assumed to prevail in the urban markets of other countries on West Africa.

Recent economic performance in West African countries has been disappointing in terms of growth of per capita income. During the first half of the 1980s growth has in fact been negative in four of the six countries included. Only Burkina Faso had a sustained increase in GDP per capita (2.4 percent per annum). The principal beef market, Ivory Coast, had a decline in per capita GDP of -1.7 percent during 1980-85. Mali's performance was also mediocre, with a net decline of -.5 percent over the same period (see Table 2).

Table 4. Basic Economic Indicators of West African Market Countries

Indicator	Mali	Burkina Faso	Guinea	Ghana	Liberia	Ivory Coast
Total Population (millions)						
1984	7.3	6.6	5.9	12.3	2.1	10.0
1990	9	7	7	15	3	13
2000	11	9	8	20	4	17
Average Annual Growth (percent)						
1973-1984	2.6	1.8	2.0	2.6	3.3	4.5
1980-2000	2.6	2.0	2.1	3.5	3.2	3.7
Urban Population						
Percent of Total, 1984	19	11	27	39	39	46
Avg Growth Rate (percent)						
1973-84	4.5	4.8	6.2	5.3	6.0	8.3
Percent in largest city	24	41	80	35	80 (a)	34
GNP per capita ($)						
1984	140	160	300	350	470	610
Growth Rate (1965-85)	1.4	1.3	0.8	-2.2	-1.4	0.9
Daily Per Capita Calorie Intake. 1983	1864	2014	1939	1516	2367	2576
GDP Growth Rate (percent)						
1965-1980	4.1	3.2	3.9	1.4	3.2	6.8
1980-1985	-0.5	2.4	0.9	-0.7	-1.9	-1.7

Notes: (a) Estimate

Source: World Bank, Development Report. 1986, 1987.

Looking to the future, we anticipate a more positive economic performance for the countries of West Africa in the next five years than for the first half of the decade. Many radical reforms in economic policy have been recently introduced in most of these countries, notably Ghana and Guinea. The result of these reforms is uncertain at the moment even among the experts. We postulate, however, for the purposes of forecasting beef demand in the region, a modest increase in per capita income in urban areas of 2 percent per year, or 10 percent in the five year period. Such an increase in income will generate a shift in demand of 12.7 percent, after taking into consideration the income elasticity of 1.27.

Finally, the market output in five years will also be affected by the long-term growth of the cattle herd in both Sahelian and coastal countries. There are wide discrepancies regarding rates of increase in cattle numbers. Many of the difficulties in interpreting stock numbers arise from migrations, both seasonal and semi-permanent following drought periods. Large variations in numbers are often the result of cattle movements rather than high mortality and fertility rates.

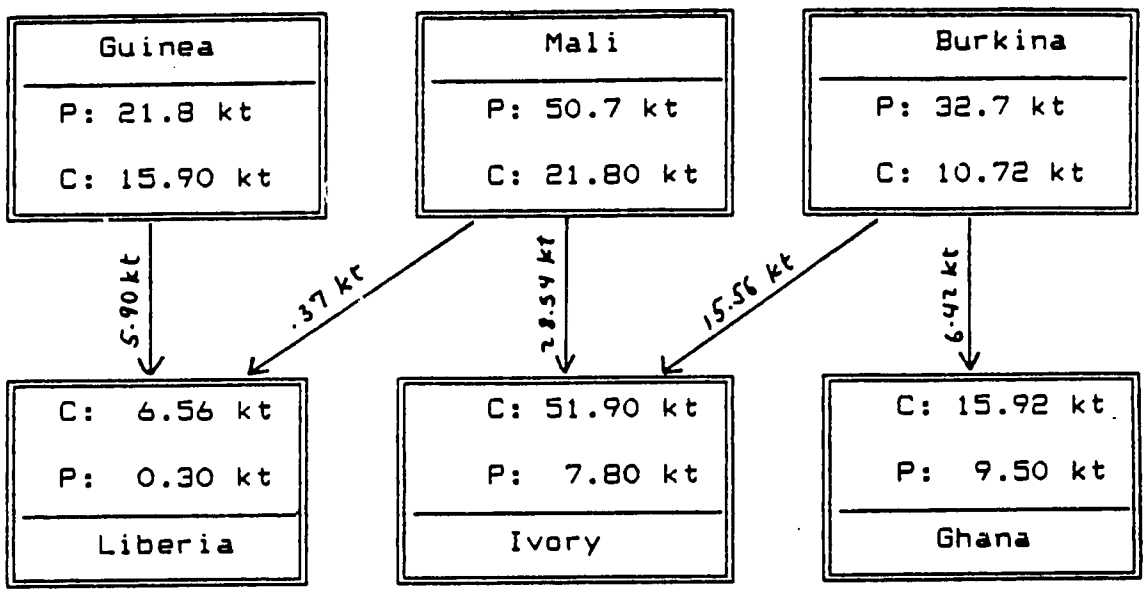
Elsewhere in this report, in the process of analyzing the economics of animal health, we have found that herd growth is a parameter very sensitive to the rates of mortality, fertility, and culling ages for females. When overall mortality was reduced by 10 percent from average levels, cattle herds can grow as fast as 3 percent per year. During the coming five years the cattle herd in Mali and other Sahelian countries will be recovering from recent drought conditions. It is expected therefore that herd growth will achieve very favorable rates. We have adopted 3 percent per annum for cattle herds in all countries, in the absence of more specific information about each country. This means that domestic production in all six countries would increase by 16 percent over a five-year period.

Figures 5 and 6 present the anticipated results of a competitive market situation under two alternative cases, namely, in the absence of EEC beef exports, and with a 10-kt EEC gift.

In the absence of outside supplies from EEC or South America, the Ivorian domestic production will contribute 7.8 kt of the total 51.9-kt beef consumption. Mali on the other hand, while increasing its production to 50.7 kt, will maintain its consumption at 21.8 kt, i.e., close to its current level. Prices received by Malian livestock owners will increase dramatically, to $3.67 per kilo carcass, reflecting the combined impact of urban growth in Ivory Coast, higher income per capita, and the withdrawal of EEC beef. Beef prices in all capitals will rise as a result of the faster increase of beef demand over the increase in cattle numbers. In Ivory Coast for example, with 49 percent more people in cities, and a 10 percent rise in total income, beef demand would increase by 68 percent. Cattle numbers, by contrast, only increase by 16 percent in all countries during the same period. Beef price in Abidjan

Figure 5. PRODUCTION, CONSUMPTION AND TRADE FLOWS:

CASE: FIVE YEAR FORECAST WITHOUT EEC EXPORTS



PRICE RELATIONSHIPS IN IMPORTING AND EXPORTING COUNTRIES

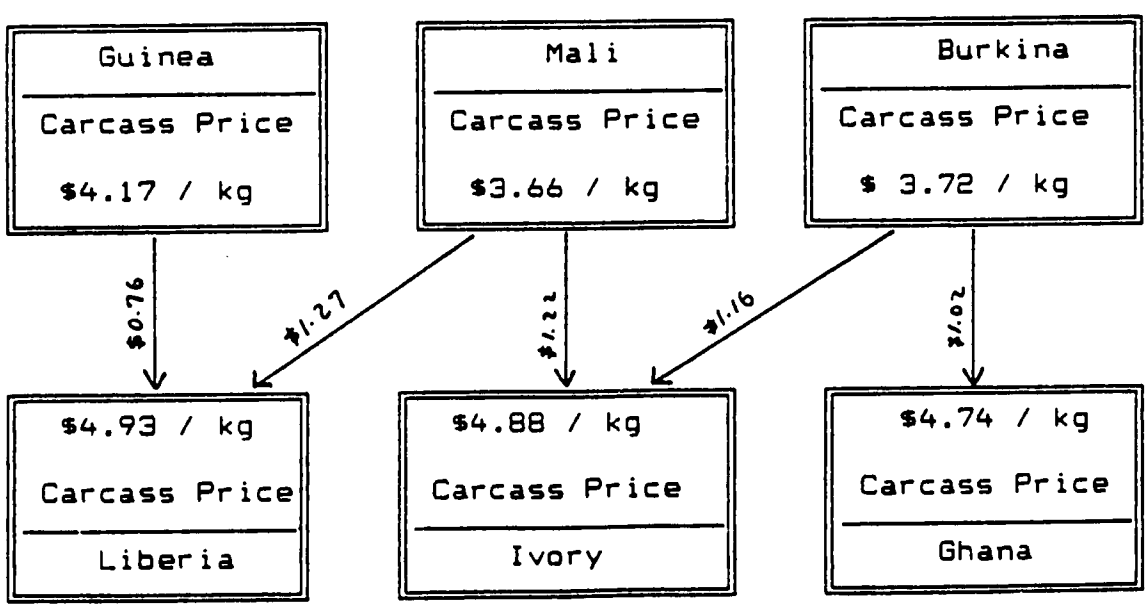
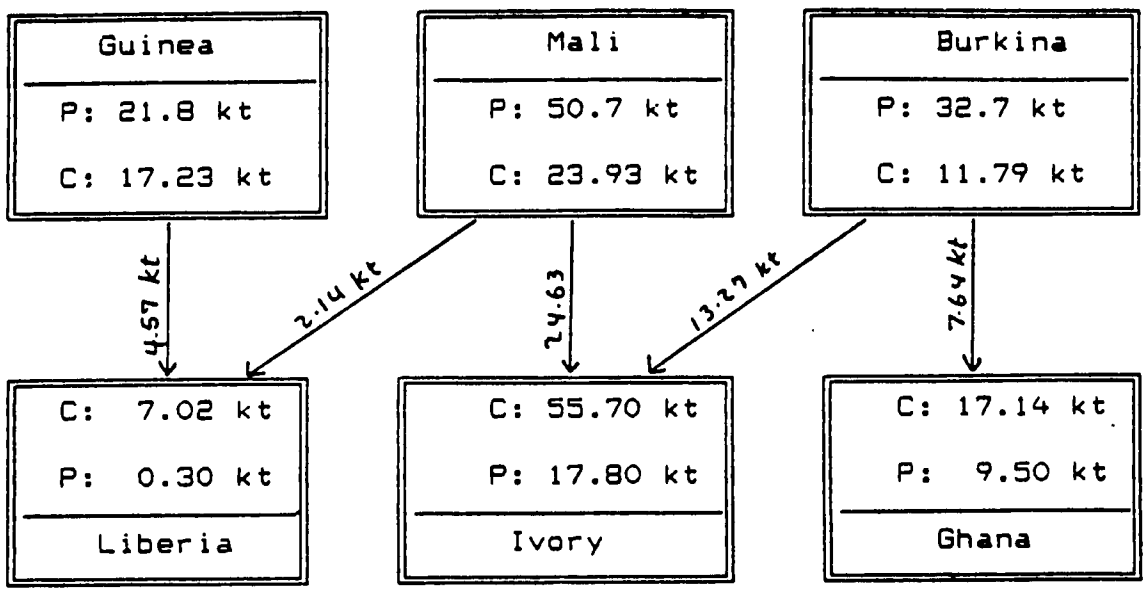
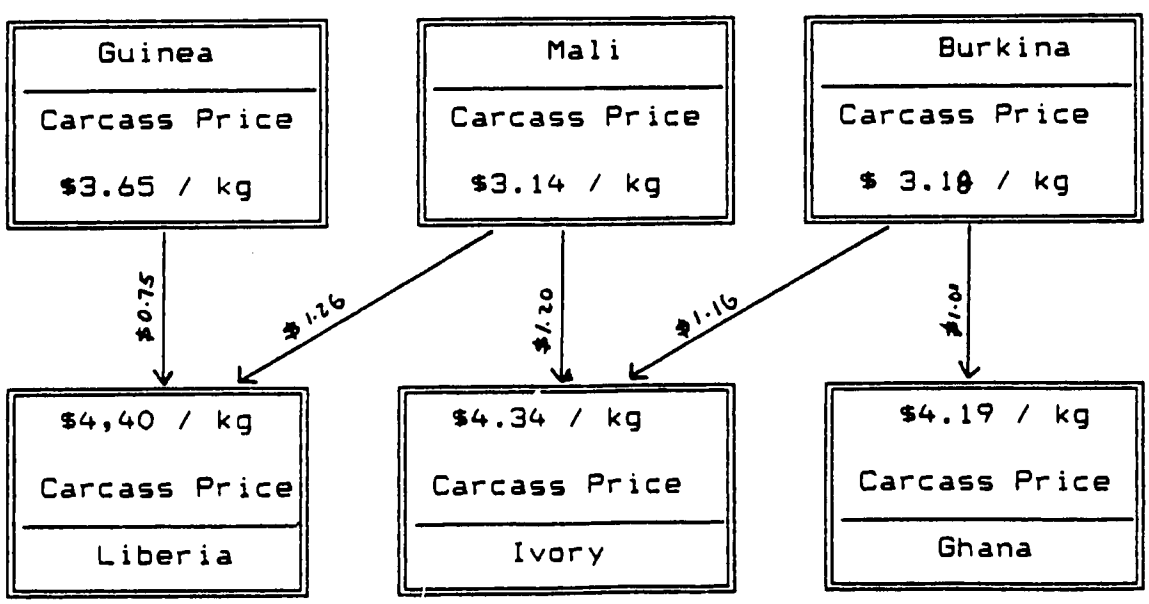


Figure 6. PRODUCTION, CONSUMPTION AND TRADE FLOWS:

CASE: FIVE YEAR FORECAST WITH 10 KT EEC EXPORTS



PRICE RELATIONSHIPS IN IMPORTING AND EXPORTING COUNTRIES



would increase to $4.88, and in Accra to $4.74. However, when beef prices reach such high prices in the coastal markets, commercial imports from the world market become possible.

In the event that the EEC continues supplying the West African coastal market with, say 10 kt of carcass beef, the results would be lower prices and higher consumption in all countries (see diagram). Beef consumption in Ivory Coast will increase by 3.8 kt to a total of 55.7 kt, at a carcass price of $4.33 per kilogram. In Mali also, consumption increases to 23.9 kt and prices decline to $3.14 per kilo carcass.

Despite the considerable increase in prices and changes in the pattern of consumption, it should be pointed out that the overall pattern of cattle flows remains basically unchanged: Guinea exports to Liberia, Burkina Faso exports to both Ghana and Ivory Coast, and Mali exports to both Ivory Coast and Liberia.

To close, we may conclude that Malian cattle producers at the moment face rather favorable demand prospects for their product over the next five years. Current prices are exceptionally low, mainly as a result of sizeable disposals of EEC beef in the coastal countries, and the end of a period of mediocre or poor economic growth in the area.

Continued rapid urban growth and a modest increase in consumer income are expected to lead to a vigorous increase in demand for beef, especially in the coastal countries. The darkest cloud in the horizon is the disposal of EEC beef surpluses on the coastal market at give-away prices. It is essential that Malian and other Sahelian countries protest the harm done to their livestock sector by such EEC donations. Reasonable controls on the volume of EEC exports to coastal countries should be seeked.

We can confidently anticipate over the next five years, (assuming a leveling of EEC exports at 10 kt per year), a gradual improvement of cattle prices for Malian cattle, reaching up to $3.00 per kilo carcass at the end of the period, a 50 percent increase over the $2.00 prevailing now in Bamako.

VOLUME VI

DOMESTIC MEAT MARKET PROSPECTS IN MALI

I. Meat Production and Distribution by Species

A. Sources of Information

The Office Malien du Betail et de la Viande (OMBEVI), is the official entity responsible for assembling data regarding the production and distribution of meat in Mali. OMBEVI publishes a yearbook of statistical information on the sector, the latest one being Statistiques du Betail de la viande 1986, (November 1987). OMBEVI also issues monthly bulletins entitled Synthese des Rapports des Controleurs de Foires et Marches, the latest of which is for November 1987, a three-month delay in publication.

B. Quality of the information

OMBEVI tries to keep track of all livestock slaughter throughout the country, but understandably, a great deal of domestic slaughter takes place without being officially registered. This is especially the case for small ruminants, which are regularly killed in villages, and even within the compounds of rural and urban households. Official slaughter statistics monitor, therefore, only operations in the controlled abattoirs in the principal cities and towns where agents from OMBEVI or the Livestock Service are present.

C. Confidence in Cattle Counts

Slaughter of cattle is more likely to be registered in official statistics since most cattle are killed in controlled abattoirs, particularly in the larger cities. Slaughter of cattle in rural areas is rare and usually takes place only on very special occasions or when dying animals cannot be walked to market. Nevertheless, many slaughter slabs in small towns are used occasionally to kill a cow without necessary official notice. Moreover, since official slaughter in controlled abattoirs is subject to fees and taxes, there is an incentive for butchers (and controllers) to undercount the actual number of animals killed.

D. Importance by Species

Table 1 presents the number of animals officially slaughtered in Mali, distributed by region and by species. During 1986, a total of 159,000

Table 1
Registered Slaughters in Mali, by Region and Species
1986 (heads)

Species:	Cattle		Sheep & goats		Camels		Pigs	
Regions:	Heads	Percent	Heads	Percent	Heads	Percent	Heads	Percent
Kayes	14,536	9	16,234	5	--	--	--	--
Koulikoro	17,235	11	33,845	11	22	1	54	6
Bamako (1)	73,968	47	68,627	22	--	--	871	94
Sikasso	15,980	10	47,421	15	--	--	--	--
Segou	24,294	15	87,624	28	14	1	--	--
Mopti	8,266	5	44,263	14	32	2	--	--
Tumbuctu	1,299	1	2,407	1	763	50	--	--
Gao	3,310	2	13,623	4	695	46	--	--
Total 86	158,888	100	314,044	100	1,526	100	925	100
Total 1985	196,209	100	391,396	100	2,227	100	848	100

Note: (1) Bamako District includes surrounding towns. In 1986 one horse was also slaughtered.
Source: National Livestock Service.

cattle were slaughtered, compared with 314,000 sheep and goats. Assuming an average carcass weight of 120 kilos for cattle and 11 kilos for small ruminants, their relative contribution to red meat production would be 19,000 tons of beef and 3,500 tons of mutton and goat meat. Camels also make a small contribution to the official national meat supply, amounting to some 300 tons annually. Total officially recorded domestic red meat supply, therefore, adds up to roughly 23,000 metric tons.

E. Declining Meat Supplies

From the same table, we can see that regional slaughter levels were consistently lower in 1986 than in 1985 for all species. Complete data for 1987 are not yet available but figures for Bamako indicate that the decline might possibly have continued and accelerated in 1987. For 1985, 196,000 head of cattle and 391,000 small ruminants were slaughtered according to official records, and yielded an estimated total of 23,500 tons of beef and 4,300 tons of mutton and goat meat. Adding camel meat, the total red meat supply was roughly 28,2000 metric tons nationwide. This means that beef supply in 1986 declined by about 20 percent relative to 1985 supplies, and total red meat availability declined by 18 percent over the same period. The reduced numbers of livestock slaughtered and the reduced availability of meat in 1986 and 1987 are obviously the after-effects of the 1983-84 drought, which not only forced the distress slaughter of many cows but also reduced the number of calves reaching markets in the years following the drought.

II. Beef Consumption Distribution by Region

A. Dominance of Bamako

Forty-seven percent of cattle slaughter in 1986 was done in Bamako (see Table 1). Another 45 percent was distributed about evenly between the cities of Segou (15 percent), Sikasso, Kayes, and Koulikoro (10 percent each). Mopti, Gao, and Tombuctu together account for only 8 percent of the official cattle slaughter. Bamako also has a higher average carcass weight for cattle killed. Only cattle exported to the coastal countries are consistently heavier than those killed in Bamako.

Small ruminant slaughter is more evenly distributed. Segou accounts for the largest number of sheep and goats slaughtered (28 percent), followed by Bamako (22 percent). Mopti, Sikasso, and Koulikoro combined account for another 40 percent. However, these are the officially registered slaughter totals, which in the case of small ruminants vastly under-report actual levels. Small ruminants account for a very high percentage of red meat consumed in rural areas, including small towns, and almost all of this slaughter goes unreported.

In the more northerly areas of Tombuctu and Gao, slaughter of camels in city abattoirs is common. In Bamako, about 1000 pigs are killed each year and sold to non-Moslem clientele.

III. Beef Consumption in Bamako

A. Sources of Information

Controlled cattle slaughter in the Bamako area takes place at the city's abattoir and also at slaughter slabs in suburbs and towns surrounding the capital. Separate statistics are kept by OMBEVI for these facilities. Figures cited for the abattoir are more reliable than those for the suburbs since controllers from the veterinary service and OMBEVI are present each day the abattoir and only sporadically at the other sites. Since taxes and fees are higher at the abattoir, butchers may prefer to divert some of their business to the nearby slabs. Some Bamako residents may go as far as Kati, for example, to procure meat on Saturdays. Given the integration of the suburbs into the Bamako market, cattle slaughter figures and beef production are combined in the subsequent analysis.

A. Evolution of Beef Consumption

Figure 1 and Table 2 trace beef production in the Bamako area on a monthly basis from January 1984 to November 1987. The first observation one can make is the consistent downward trend since 1984 in numbers of animals slaughtered and in quantities of beef produced. It is uncertain at this point whether this trend will continue in 1988 (refer to the ILCA report by Camila Toulime about herd reconstitution after drought). Although there was a total of 10,800 tons of beef (9,300 from abattoirs plus 1,400 from the suburbs) in the Bamako market in 1984, by 1986 that total had declined to 9,500 tons and for 1987 this figure will be even lower.

B. Seasonality

It is difficult to detect any pattern in the fluctuations observed in Table 2 or in Figure 1. A different graph, Figure 2, presents the same information but arranged by month of the year. It is evident here that lower monthly outputs for 1987 are lower and that the drop in beef output is steepest in the middle of the year between June and September, the months often referred to as the hungry period - soudoure - between one cropping season and another. The following figure makes the pattern still clearer as it condenses the same information by averaging each month over the four years. Starting in October, output begins to increase. From December through May, high levels of slaughter are maintained, followed by a drop in June to September. There is a noticeable and consistent secondary dip in beef production during February of each year. But this could well be because this month has only 28 days. The drop in slaughter during the rainy season could also reflect a drop in demand when a large portion of the expatriate community and Malian professionals go away on vacations and schools are out. Many herds are in long distance transhumance at this time of the year.

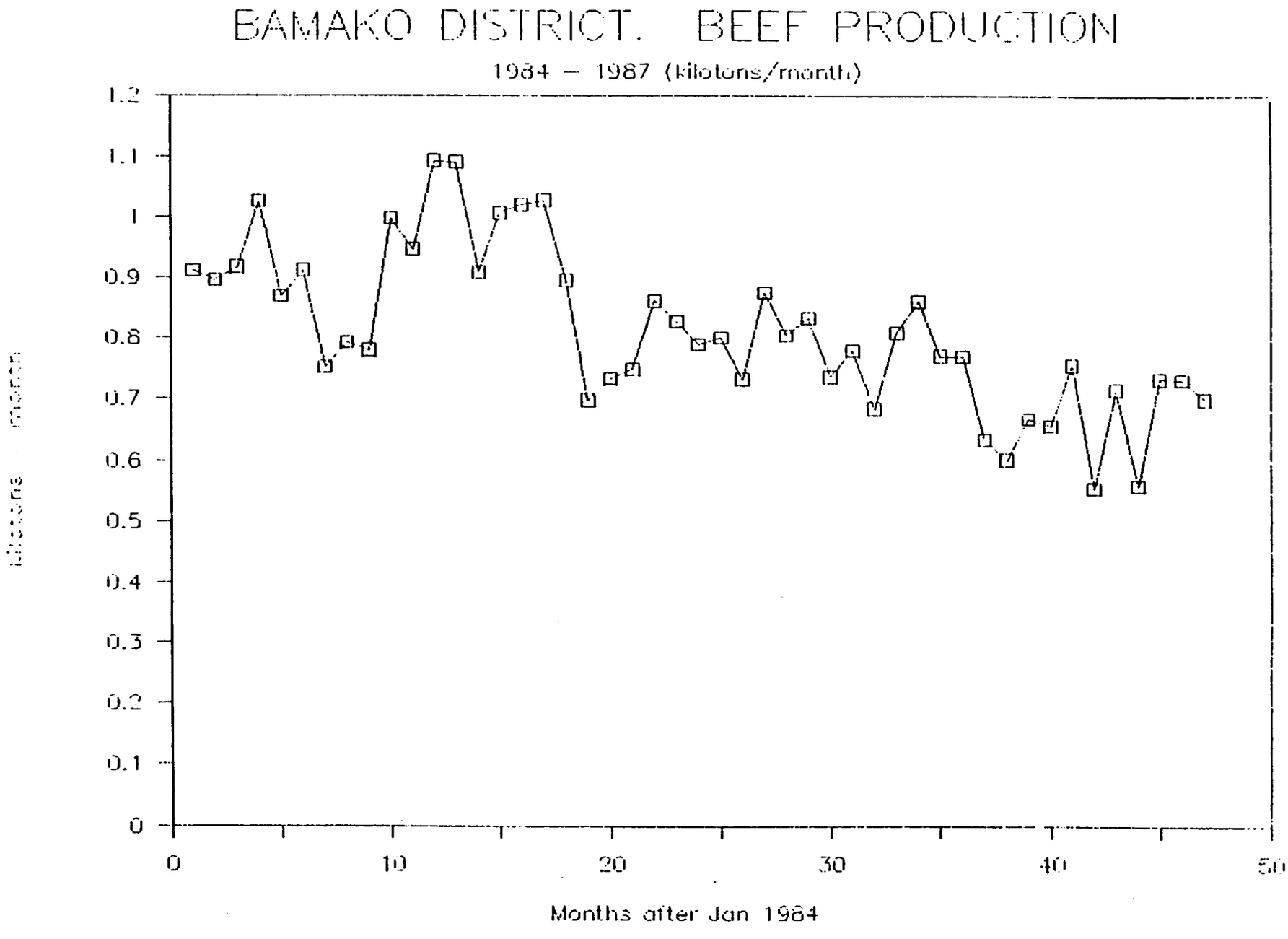
The pattern observed above makes good economic sense. When the rains start and grass grows on the range, cattle owners would be reluctant to sell when their animals are about to start recouping weight losses incurred during

Table 2
Monthly Beef Supplies and Average Carcass Prices of Slaughter Cows in the Bamako Market (January 1984 to November 1987)

	1984		1985		1986		1987	
Month	FCFA	Tons	FCFA	Tons	FCFA	Tons	FCFA	Tons
January	419	911	475	1,091	561	800	650	634
February	439	897	411	910	517	732	658	602
March	431	918	439	1,007	628	875	672	669
April	432	1,027	442	1,021	649	804	683	657
May	436	869	434	1,027	686	833	702	755
June	449	913	464	895	717	737	582	555
July	480	753	490	698	711	779	728	715
August	427	793	489	733	658	684	704	559
September	472	780	471	749	709	809	683	733
October	453	999	476	861	679	862	661	731
November	458	947	463	828	686	771	675	700
December	466	1,093	495	789	673	770		

Source: OMBEVI, statistical yearbooks. OMBEVI, monthly bulletins.

FIGURE 1

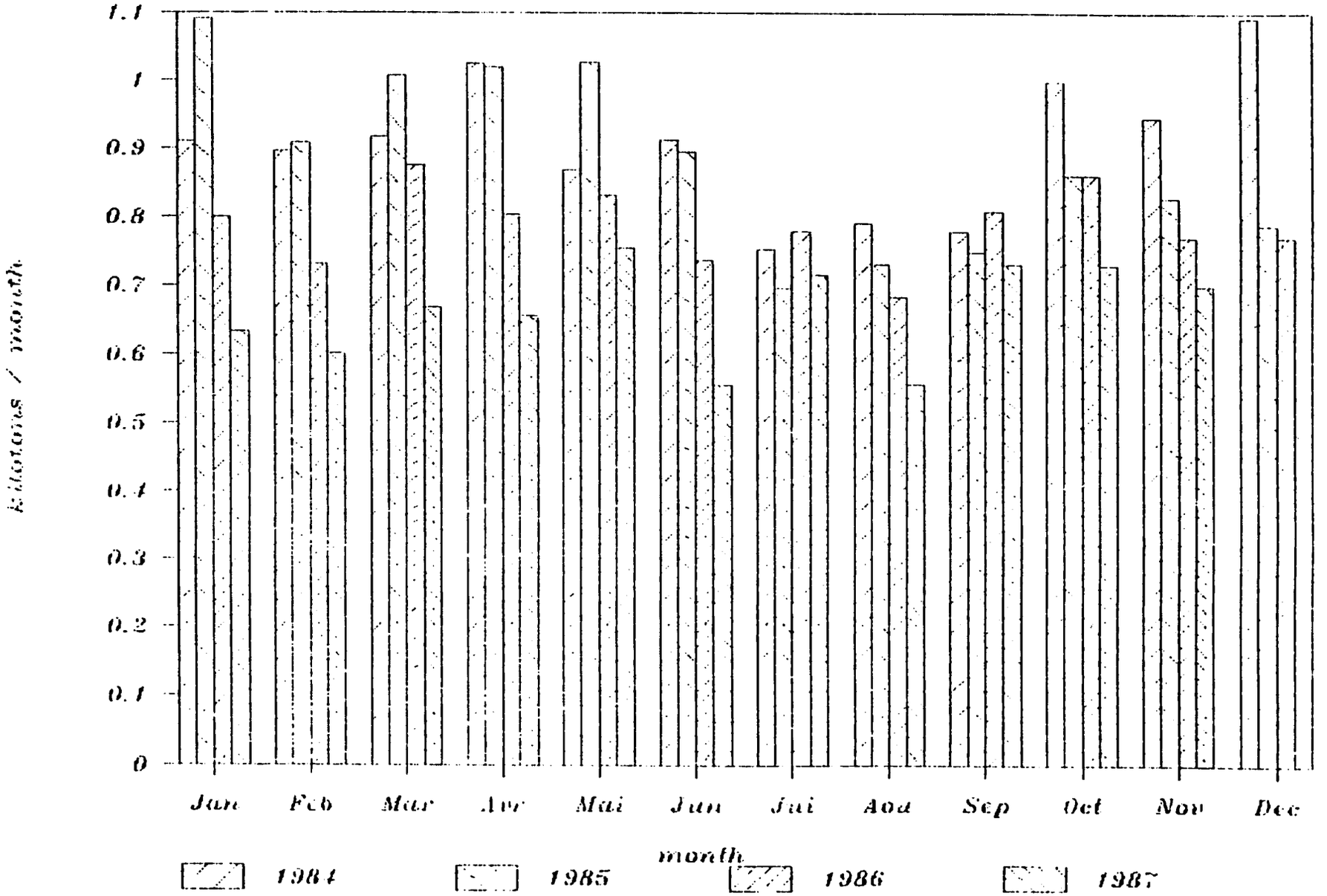

BAMAKO DISTRICT. BEEF PRODUCTION
1984 – 1987 (kilotons/month)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
Months after Jan 1984

117

FIGURE 2

BAMAKO DISTRICT. BEEF PRODUCTION

1984–1987 (kilotons/month)



18

the dry season and resuming overall growth. They increase their sales and net revenues when their animals grow fat in October, November, and December. Prices increase consistently during the dry season which encourages herders to retain their animals for a while, even when they are losing weight. One additional advantage of selling at the end of the year is that sales revenues are generated when the prices of staple cereals are at their lowest immediately after the harvest.

The above pattern of slaughter does not correspond as well with the hypothesis that herders sell animals mainly under duress when their households are under great stress. Of course, some of them do, but in general, needs are greatest during the months at the end of the dry season and before the next harvest. But this is precisely when the level of sales for slaughter are lowest. At any rate, the amplitude of swings in numbers of animals slaughtered between the highest and lowest months seem rather modest and certainly are not a cause for alarm. Such swings can be logically explained by seasonal changes in demand for red meat, in actual availability of animals during transhumant periods, in prices for staple cereals, and in net revenues generated by sales.

IV. Beef Prices in Bamako

A. Information Sources

There is an official controlled pricing system for beef in Bamako, with meat prices announced periodically through the District municipal authorities. At the moment the official prices are 700 FCFA per kilo of beef with bone and 1,000 FCFA for boneless meat. These are of course, the official prices quoted in the official statistics of OMBEVI. There are indeed market stalls that sell meat at these prices. There are, however, many other meat outlets that charge higher prices for better quality meat. Expatriate households shopping in elite butcher shops could pay, for example, 2,500 FCFA for lean hamburger meat for barbecue. Alternately, sellers often sell for the official price but vary the meat, bone, and fat proportions of the purchases to accommodate their real costs.

B. Homologation

Under the official system of price controls in Mali, it is the prerogative of the Ministry of Finance and Commerce to assign a given product to one of three categories, free floating prices, rigid controls ("homologation rigide"), and flexible controls ("homologation soupple"). Under the latter two categories, enterprises are given a reference price, which they can exceed only if they can submit evidence to authorities that their costs justify the higher price. If beef is classified under "homologation soupple," a butcher can sell his meat at a price commensurate with the actual purchase prices for the live animals, plus allowances for processing, distribution, and return on his labor and capital.

C. There is Beef and There is Beef

Even under an unambiguous system of price controls, the nature of beef makes it a rather difficult product to control. It is often sold in markets in piles rather than by weight, although in Bamako sales by kilo are more normal. Since a carcass has different parts, some more appetizing than others, a butcher can play with the composition of a pile to match a particular price. Customers buying at 700 FCFA then are often buying a lot of bone with tendons and a bit of meat, with some chunks of flank, lungs, and tripe added. Some stalls end up selling the less valued front quarters of old cows for the official price, while the rear quarters and meat from animals in better condition are directed toward a more affluent clientele for higher prices.

D. Fussy Retail Prices

Clearly, the official retail prices that are published by OMBEVI do not reflect accurately the real conditions in local markets, and since these official prices are maintained for months and even years without adjustment, their usefulness for gauging the value of beef in local markets is nil. One of the improvements that could be made under any project MIS system for livestock is to agree to collect price information in a more reliable fashion without penalty to market informants. Unfortunately, at present there are no alternative sources of retail price data among the official statistics. Since there is no market for carcasses, or at least it is not monitored, the next obvious level for investigation is prices of live animals going into the abattoir. An additional incentive to look at live animals is that on-the-hoof prices are not controlled. In this regard, OMBEVI has been understandably unsuccessful in their long-standing effort to introduce the use of market scales to weigh animals before sale. Butchers are justifiably afraid that this move would generate the next step of GOM control of the prices for live animals.

E. Live Animal Prices

Another section of OMBEVI is charged with monitoring livestock markets on a regular basis, partly to collect taxes, but also to record numbers of animals presented and actual sales, and to sample transactions to determine the average prices received for different categories of animals. Fortunately, the daily cattle market in Bamako, which starts after 4:00 p.m. afternoon and is right next to the abattoir, is one of the markets regularly sampled by OMBEVI. On the basis of reported prices for live animals and visual estimates of the likely carcass weights, OMBEVI arrives at average prices per kilogram of carcass. For the Bamako district, there are such price estimates for oxen, cows, bulls, and heifers, differentiated by breed (i.e., Fulani, Maure, and N'Dama) and ultimate use (i.e., slaughter, export, fattening, raising, or resale).

F. The Winner: Fulani Cow

Given the diversity in prices of live animals, it should be a simple matter to obtain a weighted average price for animals destined for slaughter. Unfortunately, neither the abattoir nor OMBEVI actually have the number of

cows, bulls, or oxen slaughtered, much less differentiated by breed. [This would be another good item to include in the MIS for the Livestock Service.] Ironically, the abattoirs in all the other smaller urban centers record and report that information to OMBEVI; only the Bamako abattoir neglects to break down the total head count by type of animal.

Faced with the problem of finding a representative price to serve as a barometer of the beef market in Bamako, the price of Fulani cows was selected. Most of the cattle slaughtered in Bamako are cows and the Fulani breed predominates. If a single price need to be selected, Fulani cows are the logical choice.

G. Recent Evolution of Prices

The movement of prices of Fulani cows in the Bamako market is presented in Table 3 and graphically in Figure 3. Superimposed in the same figure is the evolution of overall beef production month, as presented in figure 3. The striking feature is the upward trend exhibited by prices during the period January 1984 to November 1987, contrasted with the downward trend of beef supplies. No significance should be attached to the fact that the two lines come almost together in November 1987, since they have separate scales, one given in CFA Francs and the other in tons. It just happened that in November 1987 nearly 700 tons of beef were supplied, and the average carcass weight of Fulani cows is just below 700 FCFA per kilo. Prices have increased rather rapidly in the past four years from a starting point of just over 400 FCFA per kilo in January 1984.

H. Seasonality

In order to better appreciate interannual price movements, Figure 4 presents the monthly averages of prices, compared with monthly averages of total beef availabilities. Several things can be pointed out from this figure. First, prices are stable through the year, both in absolute terms and relative to the variations observed in beef availabilities. It is difficult to understand, therefore, why the authorities worry so much about presumably excessive price variations from one month to another, when the recorded prices by OMBEVI show no such variations. The record of price stability is all the more surprising considering that it occurred following the major shock produced by the 1983-84 drought. [On the other hand it could be argued that the observed price stability is itself an indication of the success of the price control system at the retail level.]

Nevertheless, the pattern of seasonal price movements is unmistakable, with a high point in August when supplies are lowest and lowest in December when supplies are abundant. Clearly, the observed prices correlate strongly and inversely with the volumes of beef in the market. Such a correlation is to be expected in a well-functioning market. Its presence in the Bamako market indicates that this livestock market is functioning normally and in response to seasonal supply and demand conditions.

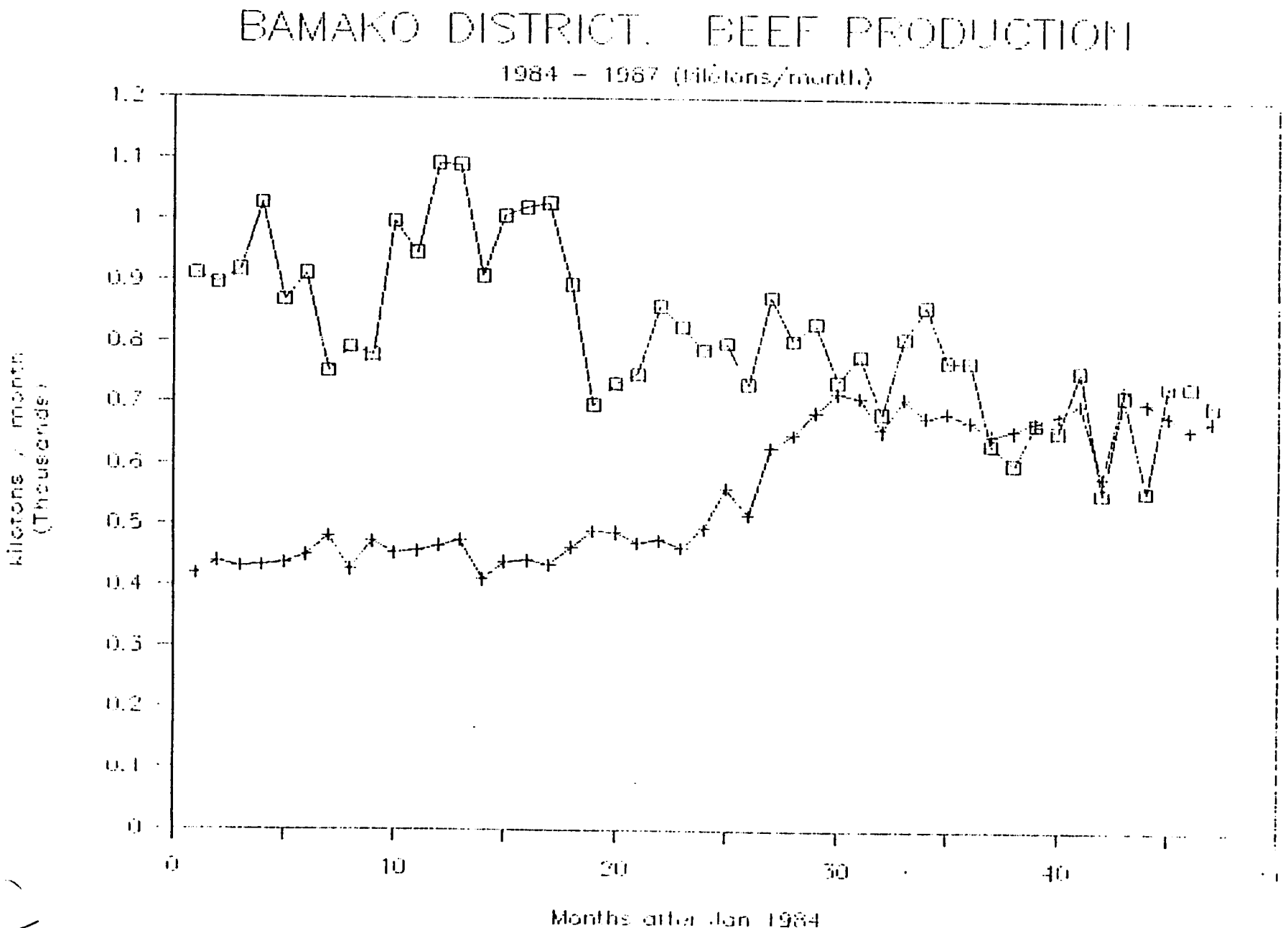
Table 3

MONTHLY BEEF SUPPLIES AND AVERAGE LIVEMASS PRICE OF SLAUGHTER COWS IN THE DAKAR MARKET (JAN 1984 - NOV 1987)

Month:	1984		1985		1986		1987	
	FCFA	tons	FCFA	tons	FCFA	tons	FCFA	tons
January	419	911	475	1091	561	800	650	634
February	439	897	411	910	517	732	658	602
March	431	918	439	1007	628	875	672	669
April	432	1027	442	1021	649	804	683	657
May	436	869	434	1027	686	833	702	755
June	449	913	464	895	717	737	582	555
July	480	753	490	698	711	779	720	[illegible]
August	427	793	489	733	658	684	701	[illegible]
September	472	780	471	749	709	809	683	[illegible]
October	453	999	476	861	679	862	661	[illegible]
November	458	917	463	828	686	771	675	[illegible]
December	466	1093	495	789	673	770		

Source: OMBEVI, Statistical Yearbooks
OMBEVI, Monthly Bulletins

FIGURE 3

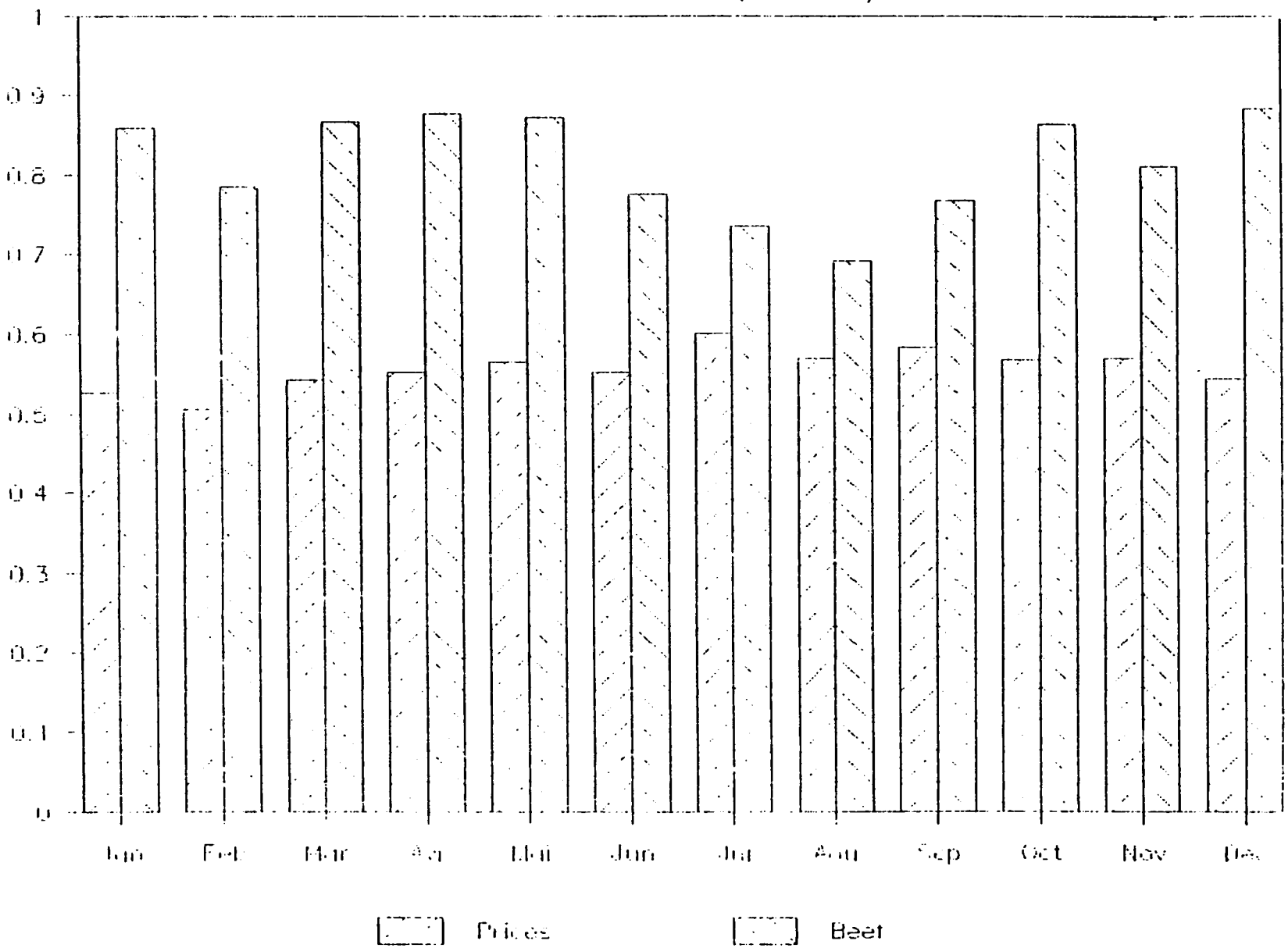

BAMAKO DISTRICT. BEEF PRODUCTION
1984 - 1987 (Kilotons/month)
Kilotons / month (Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
Months after Jan 1984

123

FIGURE 4

BAMAKO DISTRICT. SEASONALITY OF

BEEF OUTPUT AND PRICES (1984-87)



V. Price-Consumption Function for Beef in Bamako

Natural calamities offer unique opportunities to economists to observe relations among economic variables which under ordinary circumstances are difficult to sort out. The evolution of beef supplies and prices in the aftermath of the 1983-84 drought, as seen in the previous graphs and statistics, presents one such opportunity.

In view of the strong correlation between beef supply and live cattle prices, it seemed worthwhile to attempt to estimate a demand function for beef in Bamako. More strictly speaking, we estimated a price-consumption function for cattle in the Bamako area that reflects not only demands for slaughter by other markets but cattle used for export, traction, and fattening, and other economic variables, such as household income, and prices of competing products.

A. First Approximations

We are working with the two basic variables discussed above, namely the monthly volumes of beef reaching the Bamako market (i.e., **Quantity**) and the price of Fulani cows for slaughter in the Bamako market, (i.e., **Price**).

Using these two variables, we hoped to derive a quantitative formula relating the amount of beef consumed in Bamako as a simple function of the price. The regression procedure available in the Lotus 1-2-3 software program was used to perform the appropriate statistical manipulations.

1. Linear Form

The simplest functional form to link two variables corresponds to the formula for a straight line, namely

$$Y = a + b * X$$

where **Y** is called the dependent variable, **X** is called the independent variable, and **a, b** are two constants to be estimated by the least-squares method.

In our case, the dependent variable is **Quantity**, the monthly supply of beef, and the independent variable is **Price**, the average carcass price. The following equation is then generated by the Lotus program:

$$\textbf{Quantity} = 1227 - 0.74 * \textbf{Price}$$

The statistical results for this equation show that **Price** variations alone manage to account for 40 percent of the variations observed in the **Quantity** of beef consumed - i.e., the R-Square value for the regression is 0.40. The value of the coefficient **-0.74** is statistically highly significant since its standard error is only **0.14**, that is, it has a Student-t value of 5.5.

Figure 5 plots the observed values for **Price** and **Quantity**, together with the predicted values from the above linear equation. Clearly, a great deal of variations in **Quantity** remains to be explained.

Further calculations allow us to compute the price elasticity of consumption for beef in Bamako. At the mid-point of the observed data, that is for an average price of 557.1 FCFA per kilo and an average consumption of 747.5 tons per month, the elasticity value is -0.51:

$$\text{P-Elasticity} = -0.74 * 557.1 / 747.5 = -0.51$$

This value indicates that, say, a 5.1 percent increase in consumption will result from a 10 percent drop in price. Such a value is relatively high for most ordinary foods, but two factors make it a rather reasonable elasticity for beef in Bamako. First of all, beef is a relatively luxurious food in the diet since it is consumed mainly by the upper income strata. Second, price elasticities tend to be higher in lower income markets, i.e., the high value reflects the low income per capita of Bamako inhabitants.

Unfortunately, there are no other values in the available documentation, regarding the price elasticity of beef consumption for Bamako or a comparable city, to compare with the above value. The importance of this elasticity value will become apparent further on, when making projections regarding potential price changes expected from alternative amounts of beef reaching the market.

2. Log-Linear Form

An alternative functional form favored by economists to represent the price-consumption relationship is a linear expression of the same type as the above but run with the corresponding variables expressed in decimal or natural logarithms, rather than in their natural numbers. This form corresponds to a function of the type

$$Y = k + c * X$$

where **Y** corresponds to the natural log of **Quantity**, and **X** to the natural log of **Price**, while **k** and **c** are constants to be estimated by the least-squares technique.

Estimation of the log-linear form for beef in Bamako yields

$$Y = 9.94 - 0.52 * X$$

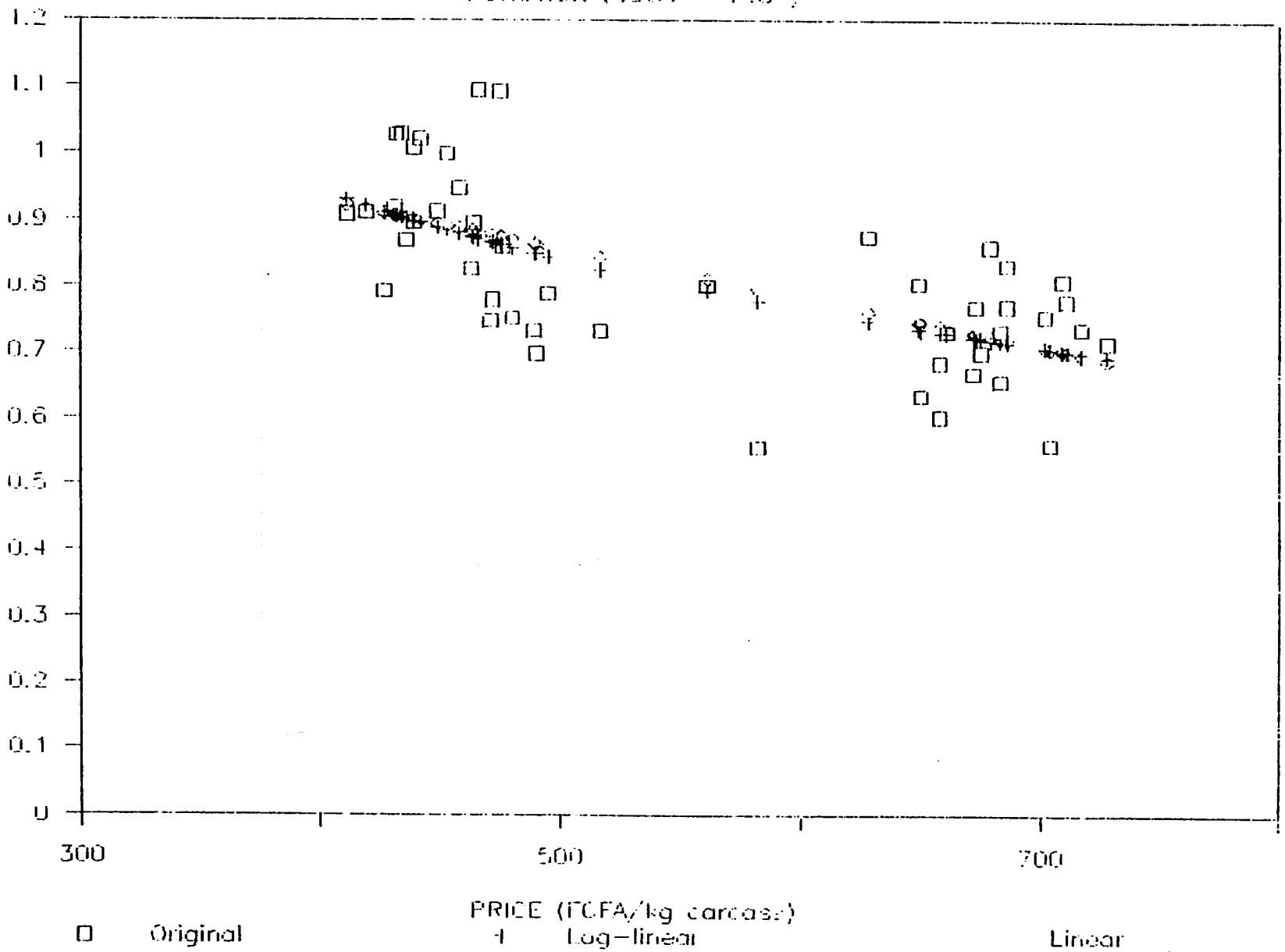
with statistical properties equally encouraging, namely an R-square value of 0.41 and a standard error for the coefficient of 0.09 corresponding to a t-value of 5.6.

One of the nice features of the log-linear form is that the value of the constant **c** corresponds directly to the price elasticity. Hence there is no

FIGURE 5

BAMAKO DISTRICT, BEEF PRICE--CONSUMPTION

FUNCTION (1984 - 1987)



additional computation needed to estimate it. In this case, the price **elasticity** is simply **-0.52**.

B. Adjusting for Population Growth

Since the above time series for **Quantity and Price** cover a period of four years, the short-term relationship that we are trying to determine is obscured in part by the increase in the population of Bamako that took place in the course of those four years. The current number of inhabitants in Bamako District is estimated at 700,000, according to the 1985 Census. For our purposes, however, what is of interest is what rate of growth took place during 1984-87. For lack of a better estimate, we have assumed a 5 percent annual rate of growth and have, therefore, adjusted the level of consumption, i.e. **Quantity**, to reflect such growth. In other words, we obtain a proxy variable for **beef consumption per capita**.

1. Linear Form

When the same functional forms were regressed using the new per-capita variable for beef consumption the result was the equation

$$\text{Quantity} = 1304 - 1.00 * \text{Price}$$

The R-square value increased to 0.55, indicating that price alone explains 55 percent of variation in per capita beef consumption. Similarly, the statistical significance of the regression coefficient increased to a t-value of 7.4.

The price elasticity calculated using the new coefficient and the new average per-capita consumption has increased to **-0.74**.

2. Log-Linear Form

The corresponding adjustment was made to estimate the log-linear equation:

$$Y = 11.4 - 0.76 * X$$

where **Y** is now the natural logarithm of per-capita beef consumption and **X** the **Y**-log of Price. Here again, the R-square jumped to 0.55 and the t-value of the coefficient to 7.5. The price elasticity for per-capita consumption has also increase to **-0.76**.

C. Adjusting for Inflation

The period under observation was one of chronic inflation but the actual rates are hard to establish and none were available on a monthly basis. In order to convert the price values to constant CFA Francs as of say February 1988, the corresponding prices were inflated by a factor proportional to the number of months from February 1988.

1. **Linear Form**

Running the linear regression using both the per capita consumption values and beef prices in constant FCFA as of February 1988, we obtained the equation:

$$\text{Quantity} = 1406.8 - 1.07 * \text{Price}$$

The statistical properties of the new function remain attractive, with a t-value of 6.13 and R-square of 0.45. The price elasticity calculated for the mid-point was evaluated at -0.88, a surprisingly high value.

2. **Log-Linear Form**

An equally high value was generated for the price elasticity when the log-linear form was used on the log of per-capita beef consumption and the log of prices in constant FCFA. The estimated equation was

$$Y = 12.39 - 0.90 * X$$

That is a price elasticity of -0.90 when the relationship is in per capita consumption and the price in constant CFA.

Table 4 summarizes the results of the statistical estimation procedures.

Table 4. Summary Table of Statistical Relations
Between Beef Consumption and Beef Price in Bamako

Dependent quantity		Independent price	Constant	Regression coefficient	Se/t	R^2	Price elasticity
C	on	B	1226.7	-0.74	0.14 5.5	.40	-0.51
E	on	D	9.94	-0.52	0.09 5.6	0.41	-0.52
F	on	B	1304.	-1.00	0.14 7.4	0.55	-0.74
G	on	D	11.40	-0.76	0.10 7.5	0.55	-.76
F	on	H	1406.8	-1.07	0.18 6.13	0.45	-0.88
G	on	I	12.39	-0.90	0.15	0.46	-0.90

where

		Average
A -	Time - months	
B -	Price CFA - current	557.09
C -	Tons - beef Bamako district	814.37
D -	LN (price)	
E -	LN (tons - beef)	
F -	Per capita consumption	747.45
G -	LN (P-C consumption)	
H -	Inflated price (FCFA of Feb '88)	614.02
I -	LN (inflated price)	