Policy, finance and technology in livestock development in sub-Saharan Africa: Some critical issues*

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SUMMARY

THE MAJOR *technical constraints facing the livestock subsector in sub-Saharan Africa are inadequate animal feed and nutrition, diseases, and a genetic structure specially geared to survival. The main non-technical constraints are insufficient non-staff expenditure for both services and research, underinvestment in adaptive research, poor infrastructure, and lack of qualified manpower to conduct research, analyse policies and implement development projects.*

While some progress has been made in the field of animal health, the future development of sub-Saharan Africa's livestock subsector depends largely on the availability of increased investment, more appropriate producer incentives, improved institutions (e.g. for marketing and input supply), stronger capacity to plan and monitor, improved technology and strengthened national research capacity.

ILCA contributes to national and international efforts by making available adoptable livestock-related technology and relevant information to improve policy formulation and planning. The Centre plans to strengthen its partnership with national institutions through more collaborative research, intensified training and better information exchange.

INTRODUCTION

The Lagos Plan of Action, Africa's Submission to the Special Session of the United Nations' General Assembly on Africa's Crisis, and the ensuing Programme of Action for African Economic Recovery and Development, provided both explicit and implicit references for the development of the livestock subsector in sub-Saharan Africa. These three international initiatives differed in some elements and emphasis, but shared a number of perceptions of the means needed to achieve common objectives.

The common objectives relevant to the livestock subsector were increased domestic food output, reduced dependence on food imports, and higher producer incomes. Among the shared perceptions of the means required to improve the livestock subsector were increased investment; improved producer incentives, including prices; improved institutions for marketing, credit, input supply and land tenure; improved capacity to plan and monitor; improved technology, particularly in the area of livestock diseases; and strengthened African research capacity.

This paper examines the performance of the livestock subsector in sub-Saharan Africa during the past two decades. The major constraints limiting livestock production are highlighted, as well as the means perceived to form the basis for future progress.

THE ROLE OF THE LIVESTOCK SUBSECTOR

Livestock produce food (e.g. meat, milk) and non-food commodities (e.g. hides, wool), and provide draught power and manure for food and cash crop production, thereby helping to generate income for livestock owners and their employees. Because livestock grow in number and in individual size, they also constitute a form of profitable investment/savings which can be drawn on in time of need. In good years, savings invested in livestock can earn considerably higher rates of return than those obtainable from money deposited in interest-earning bank accounts. However, in times of drought or disease, such savings can be swiftly wiped out.

The livestock subsector accounts for about 5% of the total gross domestic product (GDP) in sub-Saharan Africa, and for 18% of the agricultural GDP which ranges from 2% for Gabon to 99% for Mauritania. Its contribution to the gross domestic product excludes draught power and manure. The proportion contributed by livestock to the agricultural GDP has risen by about two percentage points over the last decade, while in the developed countries livestock account for 45–50% of the agricultural GDP (World Bank, 1982).

Table 1 shows the relative contributions of different forms of livestock output (including draught power and manure but excluding skins and fibre) to the gross value of livestock production in sub-Saharan Africa as a whole and its regions. Meats of all kinds contribute 47% of the total for the subcontinent, traction 31%, and milk only 15%. The proportions for regions vary markedly from the total; for example, draught power accounts for only 3% of the livestock output in central Africa, but for 39% in East Africa.

Table 1. *Relative contributions of food and food-related outputs[1] to the gross value of total and regional livestock production, sub-Saharan Africa, 1975.*

Output	Percent of gross value[2] of output				
	West Africa	Central Africa	East Africa	Southern Africa	sub-Saharan Africa
Animal traction[3]	21	3	39	26	31
Manure[4]	4	1	3	2	3
Meat[5]	56	79	38	58	47
Milk	11	12	17	9	15
Eggs	8	5	3	5	4
Total	100	100	100	100	100
(Total[6])	(1460)	(349)	(3747)	(930)	(6486)

[1] Includes both marketed and non-marketed outputs.
[2] Output is valued at uniform, continent-wide prices in 1975. The prices used are: meat = US$ 1000 t^{-1}, milk = US$ 150 t^{-1}, and eggs = US$ 750t^{-1}. Animal traction is valued at US$ 5.2 per ox-day worked.
[3] Field operations by bovines.
[4] Valued at the equivalent commercial fertilizer prices of the plant nutrients contained.
[5] Includes beef, goat meat, mutton, pork and poultry meat.
[6] Figures in parentheses indicate gross values in 1975 US$ millions.
Sources: FAO (1978); FAO (1979); ILCA (1981).

Exports of livestock and their products can be an important source of foreign exchange. In the mid-1980s, such exports accounted for 2% (by value) of all sub-Saharan Africa's merchandise exports, while for Somalia and Mali they were as high as 55 and 75% respectively (FAO, 1986a; World Bank, 1986).

African livestock production systems are often described as 'subsistence oriented': this may have been true in the past but is much less so now. Forty years ago, pastoralists in northwestern Africa derived about 80% of their calorie intake from food from their livestock (Swift, 1979). About 20 years later, the typical figures for pastoralists were 30–50%, compared with an average of about 8% for sub-Saharan Africa's total population, and world average of 16%.

Table 2 shows the proportion of the total value of livestock output sold from various African farming systems. In pastoral systems, 50–60% of livestock output is sold and 40–50% is retained for household use. In mixed crop-livestock systems, the proportion of livestock output retained for the household is higher.

Table 2. *Examples of sales as proportions of the value of household output of livestock commodities[a], sub-Saharan Africa, various years.*

Region/Country	Zone	Year	Production System	Percent of total output sold (by value)	Source
East Africa					
Ethiopia	Highland	1980/81	Mixed	55	(1)
Kenya	Semi-arid	1980/81	Pastoral	59[b]	(2)
Southern Africa					
Zimbabwe	Semi-arid	1974	Mixed	35	(3)
Botswana	Arid	1981	Pastoral	55	(4)
West Africa					
Nigeria	Humid	1981	Mixed	65[c]	(5)
Niger	Semi-arid	1976/77	Mixed	26[d]	(6)
Niger	Arid	1963	Pastoral	52[e]	(7)

[a] Include live animals, meat, milk and butter.
[b] On 'underdeveloped' group ranches.
[c] Unweighted average of forest and derived-savanna subsystems.
[d] 'Bush Tuareg' system.
[e] Unweighted average of Fulani and Tuareg systems.
Sources: 1. ILCA (Addis Ababa, Ethiopia, unpublished data); 2. White and Meadows (1981); 3. Dankwerts (1974); 4. Botswana –Ministry of Agriculture (1982); 5. Sempeho (1985); 6. Eddy (1979); 7. Niger (1966).

The data presented in Table 2 do not show changes over time from a more subsistence to a more commercial orientation. To demonstrate this we use as an example the data for the Maasai of Kenya, who are often thought of as very traditional. The offtake of Maasai livestock for sale had risen from less than 1% in 1953 to about 8% in 1977 (Meadows and White, 1979), and by mid-1980s, offtake increased to 10–14% (Bekure et al, 1988). In comparison, the sales offtake from European commercial beef ranches in Zimbabwe during 1964–81 averaged about 13% (Sandford, 1982).

An important, but often neglected, aspect of the so-called 'subsistence-oriented' African livestock subsector is the contribution of livestock to the cash income of their owners (Table 3), thereby enabling them to buy both household necessities (e.g. food grain) and production

inputs. It is not surprising that pastoralists, who engage in few economic activities other than livestock husbandry, derive a high proportion of their cash income from livestock. It is remarkable, however, that in some of the mixed farming systems, where livestock provide only a proportion of the total value of output (including that consumed on the farm), they are sometimes by far the biggest source of cash. In the Ethiopian highlands, for example, livestock provide about 53% of the value of total farm output[1], but more than 80% of the farmers' cash income (Gryseels and Getachew Asamenew, 1985).

[1] Excluding the value of draught power.

Table 3. *Proportion of total household cash income derived from livestock in selected farming systems, sub-Saharan Africa, various years.*

Production system/country	Ecological zone[1]	Predominant species kept	Percent of cash income derived from livestock	Source
Pastoralists				
Mali	Dry	Cattle	96	(1)
Niger	Dry	Sheep/Goats	96	(2)
Kenya	Dry	Cattle	76	(3)
Agropastoralists				
Kenya	Dry	Sheep/Goats	>90	(4)
Mali	Dry	Cattle	39	(5)
Mixed farmers				
Ethiopia	Highland	Cattle	83	(6)
Northern Nigeria	Subhumid	Pigs/Goats	56	(7)
Southern Nigeria	Humid	Sheep/Goats	2–13	(8; 9)
Zimbabwe	Dry	Cattle	<4	(10)

[1] Defined on the basis of plant growth days (pgds) per year: dry zone = <180 pgds; subhumid zone = 180–270 pgds; and humid zone = > 270 pgds.
Sources: 1. Swift (1985); 2. Swift (1984); 3. Bekure et al (1988); 4. Little (1983); 5. Fulton and Toulmin (1982); 6. Gryseels and Getachew Asamenew (1985); 7. Ingawa (1986); 8. Sempeho (1985); 9. Lagemann (1977); 10. Collinson (1982)

Investment in livestock can have a high rate of return in years without epidemics. Mixed farmers often invest cash surpluses in livestock if their crop output exceeds current needs for subsistence and operating expenses. In bad years, however, livestock are sold to purchase food for household consumption.

Dicko (1986) found in southwest Niger that up to one third of the capital invested in livestock originated from sales of crop produce. In the 1984/85 drought year, the proceeds of about 75% of the livestock sales made by farmers in the same area were used to purchase cereals. This disinvestment resulted in a 45–80% (median about 70%) decline in herd sizes, depending on species and village.

Data provided by Vierich (1979), and quoted in Vierich and Sheppard (1980), show a moderate positive correlation (r =0.62) between average group income from sorghum production 'lost' due to drought and the average group income 'gained' by 'extra' cattle sales. About 42% of the 'lost' sorghum income was recuperated through extra livestock sales; Vierich and Sheppard (1980) inferred from this that "access to cattle buffers a household against the impact of drought".

THE PERFORMANCE OF THE LIVESTOCK SUBSECTOR

In sub-Saharan Africa, but particularly in its drier areas, livestock output is strongly influenced by weather conditions which give rise to considerable year-to-year fluctuations. Consequently, the estimates of growth in output are markedly dependent on the choice of period over which the growth rate is calculated. Drought affects output not only in the years of its occurrence, but also in subsequent years; output declines as a result of loss of livestock, especially breeding stock, and lower calving rates.

The average annual changes in livestock output over two periods during the past 20 years are compared in Table 4. During 1975–84, the aggregate ruminant livestock output in sub-Saharan Africa as a whole and in most of its regions grew faster than during 1963–75. The same trend was observed in the output of separate commodities within the totals.

Table 4. *Annual changes in the livestock output and human population of sub-Saharan Africa, 1963–75 and 1975–84.*

Period	Output/human population	Annual change (%)				
		West Africa	Central Africa	East Africa	Southern Africa	Sub-Saharan Africa
1963–1975	Beef	1.0	5.2	2.4	1.1	2.0
	Mutton	2.3	1.9	0.7	4.0	1.3
	Goat meat	2.3	2.7	2.0	5.6	2.3
	Cow's milk	0.6	1.0	1.5	0.8	1.2
	Human population	2.7	3.0	2.9	2.8	2.9
1975–1984	Beef	2.2	1.4	3.1	1.3	2.4
	Mutton	3.6	0.7	3.0	2.5	3.1
	Goat meat	3.4	1.9	1.9	0.9	2.5
	Cow's milk	2.2	1.8	4.3	1.7	3.5
	Human population	3.6	3.2	3.3	3.3	3.4

[a] The 1963–75 trends are computed on the basis of multi-year averages, i.e. 1961/65 compared with 1974/76. The 1975–84 trends are based on 3-year averages, i.e. 1974/76 compared with 1983/85.
Source: FAO (1963–1986).

Although output during 1975–84 was significantly affected by the droughts in the early 1970s and in 1983/84, the performance of the livestock subsector in this decade was better than in the preceding one. Nevertheless, per caput production of most commodities declined during both periods in most regions and in the subcontinent as a whole; for many products and regions the rate of decline during 197584 was lower than in the preceding decade (Table 4).

The rate of self-sufficiency[2] in the main livestock products has also tended to decline, although there are considerable fluctuations in the ratio in both directions between consecutive years. Self-sufficiency rates in West Africa have improved slightly in recent years, but the decline in imports has been due more to an acute shortage of foreign exchange than to increased domestic production. In fact, per caput consumption has tended to decline during 1975-84, and particularly since 1982.

[2] Defined as percent of total consumption covered by domestic production.

Figures 1 and 2 show per caput production and consumption of meat and milk for sub-Saharan Africa and two of its most important livestock production and consumption regions – West Africa and East Africa. During most of the 1972–85 period, meat and milk production fell short of consumption in both regions. After the mid 1970s, sub-Saharan Africa changed its position from a net exporter of meat to a net importer (Figure 1), while being a net importer of cow's milk over the whole period (Figure 2).

Figure 1. Per caput production and consumption of all meat, 1972–85.

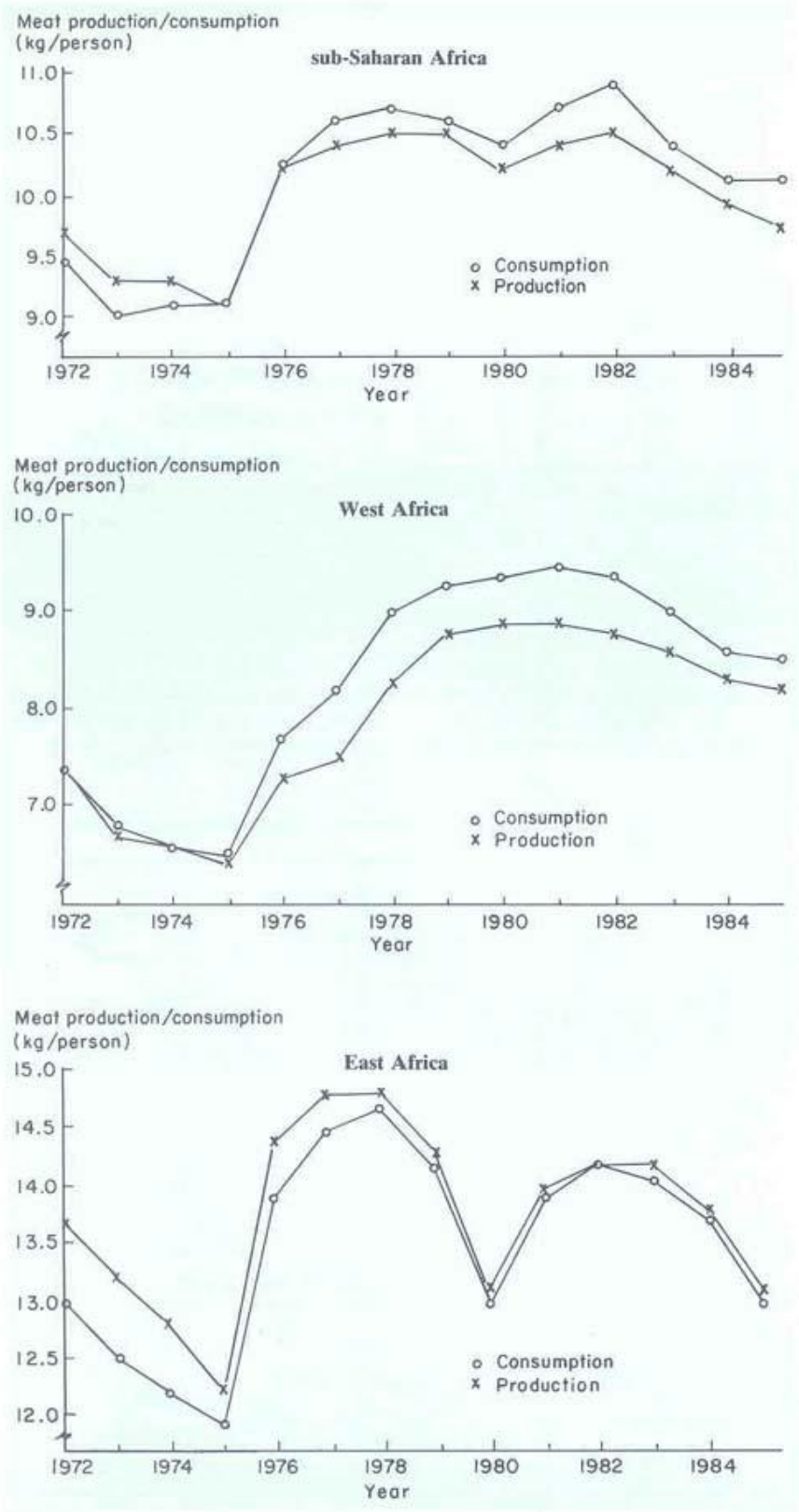
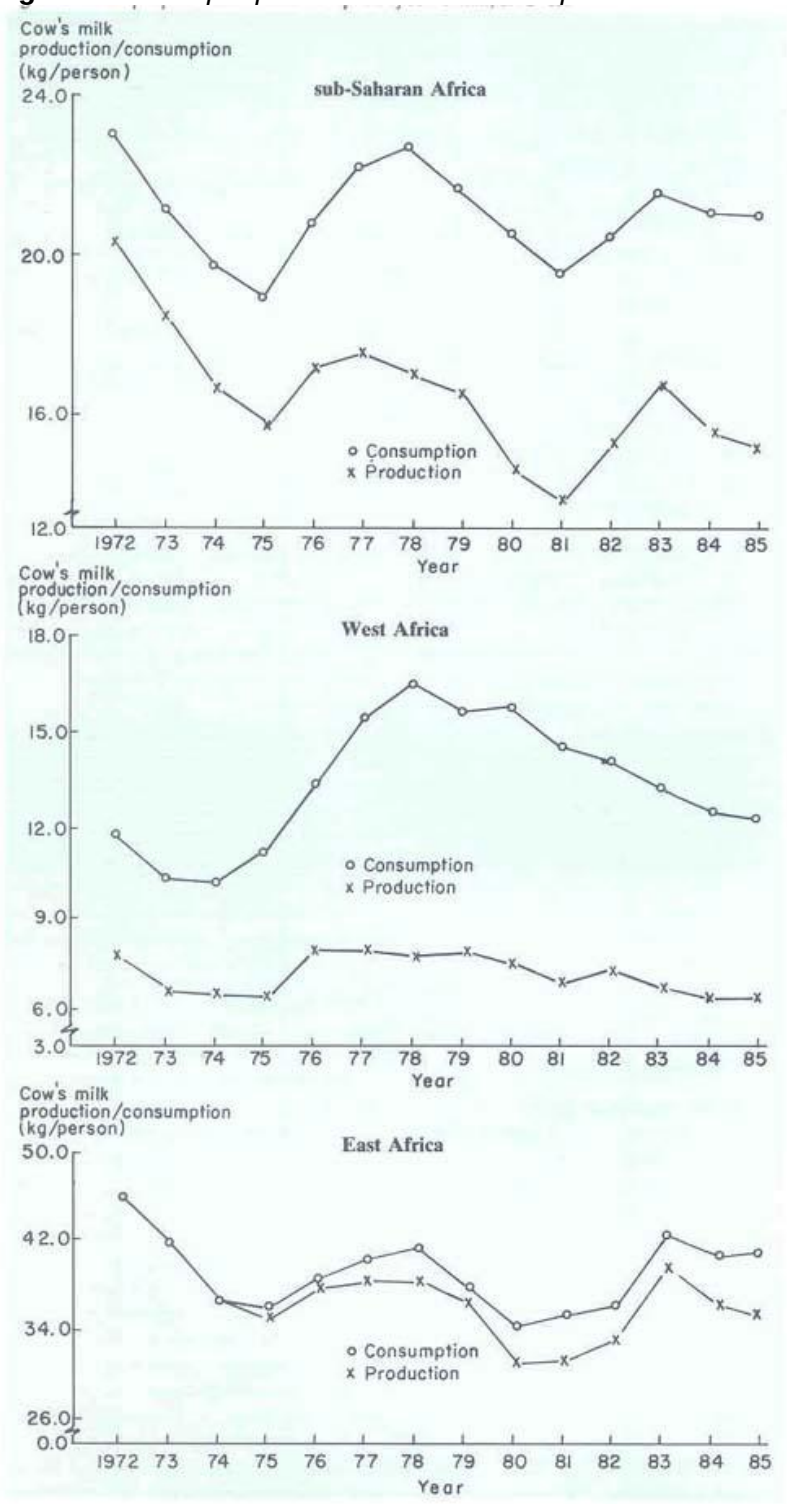


Figure 2. *Per caput production and consumption of cow's milk, 1972–85.*



The production/consumption gap is wider for cow's milk than for meat. West Africa depends heavily on imports for its dairy consumption; and, if the recent declining production and

increasing consumption trends in East Africa persist, the gap is likely to grow in this region as well.

Data on the contribution of livestock products to farm income are scarce, because estimates for output prices and production costs mostly do not exist. And the evidence available does not depict this contribution favourably. Over the last decade, world market prices for meat and dairy products have declined substantially in real terms, affecting African meat exports directly, while the availability of cheap imports in Africa's internal markets has also depressed domestic prices.

Africa's livestock subsector does not make much use of purchased inputs, but the real prices of those that are used (e.g. veterinary drugs and fencing wire) have tended to rise. The data available for seven sub-Saharan African countries show that in most of these countries the ratio between livestock prices and feed grain has changed in favour of livestock, but this has had limited impact on incomes since very few livestock enterprises use grain as feed anyway. However, a comparison of trends in the producer prices for livestock with trends in domestic prices generally shows that the real prices of livestock products have been declining, in some countries since 1974 (Table 5).

Table 5. *Trends in the ratios between prices received by beef producers and general retail prices, sub-Saharan Africa, 1974–1983.*

Year	Ratio trends				
	Kenya[1]	Zaire[2]	Zambia[2]	Zimbabwe[3]	Zimbabwe[4]
1974	1.000	1.000	1.000	1.000	1.000
1975	0.849	0.946	0.858	1.018	1.045
1976	0.826	2.448	0.734	0.887	0.855
1977	0.936	2.215	1.284	0.817	0.767
1978	0.816	2.282	1.224	0.764	0.708
1979	0.872	2.000	1.116	0.796	0.671
1980	0.926	2.785	1.066	0.869	0.782
1981	0.946	2.331	1.108	0.958	0.890
1982	0.815	2.288	1.052	1.106	0.929
1983	0.706	2.270	n.a.[5]	0.907	0.808

[1] Based on prices paid by the Kenya Meat Commission.
[2] Based on farm gate prices.

[3] Based on prices paid by the Storage Commission.
[4] Based on auction prices in communal areas.
[5] n. a. = data not available.
Sources: FAO (1984); IMF (1986);Agricultural Marketing Authority (1980, 1982, 1984); Central Bureau of Statistics (1985).

Overall, the performance of sub-Saharan Africa's livestock subsector has not been impressive, and the relatively better performance over most of the recent decade compared with the previous one is largely due to the very low base from which it started. Moreover, almost all of the increase in output which has occurred arose from increases in the number of animals, rather than from increased yield per animal.

Table 6 gives yield indices for 1963–85 estimated in two ways: the first shows yield per productive animal, i.e. per lactating cow or per animal slaughtered, while the second gives yield as total output divided by all the animals of that species in sub-Saharan Africa's herd. The second index takes into account better than the first one does changes over time in the age and sex structure of the herd. The picture is fairly uniform for both indices and for every commodity: yield per animal has increased at most by 10–15% since 1960, or at a maximum of 0.5 % of the annual compound rate.

Table 6. *Yield changes and contribution of yield and numbers to changes in livestock output in sub-Saharan Africa, 1963–85.*

	Beef			Sheep and goat meat			Cow's milk		
	1970	1980	1985	1970	1980	1985	1970	1980	1985
Relative yield[1]									
• per productive animal[2]	102	102	101	103	106	104	99	102	110
• for all animals in herd	109	112	113	104	110	112	97	98	113
	1963–70	1970–80	1970–85	1963–70	1970–80	1970–85	1963–70	1970–80	1970–85
Relative contribution (%) of change in									
• numbers	60.6	80.2	80.3	87.1	69.3	68.1	129.6	94.6	47.7
• yield [3]	39.4	19.8	19.7	12.9	30.7	31.9	–29.6	5.4	52.3

[1] 1960 = 100.
[2] Productive animals are cows in milk and animals slaughtered for meat.
[3] Includes the interaction effect of yield and numbers.
Sources: Addis Anteneh (1984) and data tapes for *FAO Production Yearbooks 1970–1985.*

The changes in total output can be divided into two groups (Table 6): those which would result from changes in the total number of animals while their yield remained the same, and those arising from changes in yield per animal. Table 6 shows that except in the case of cow's milk during 1970-85, changes in output have mainly been due to changes in the number of animals.

CONSTRAINTS TO LIVESTOCK DEVELOPMENT

Socio-economic and institutional constraints

Both technical and non-technical factors constrain livestock development in sub-Saharan Africa. We shall first discuss the non-technical constraints, i.e. those involving socio-economic and institutional issues.

Investment. Investment is usually an essential accompaniment to successful economic development. During the last two decades much of the monetised investment in the livestock subsector of sub-Saharan Africa (other than in indigenous animals) has been financed by foreign aid. This external capital aid to the subsector averaged US$ 80 million year^{-1} in the decade up to 1983 (FAO, 1986b), or just over 1% of the annual total value of output at the beginning of the period (see Table 1). This is an insufficient amount to have had a significant impact.

However, the shortage of investment funds for livestock development has probably not been a critical constraint, even though the funds provided would have been inadequate for significant development if other constraints had not been limiting. If it had been, one would have expected to see a high rate of return to those investments in livestock projects which did take place. This has not occurred, at least in donor-financed projects.

In the World Bank's 'pure' livestock projects, the average rates of return were negative, and most projects (including both 'pure' and those with a livestock component) yielded unacceptable rates of return (<10%). The record of livestock projects in sub-Saharan Africa has on the whole been worse than that of livestock projects elsewhere in the developing world, and of other agricultural projects in the subcontinent.

Recurrent expenditure. Insufficient recurrent expenditure on government livestock services has probably been a more serious constraint than shortage of investment. Lack of satisfactory data on output makes it difficult to demonstrate any causal relations, but a deterioration in animal health services over the last 15 years is evident.

Although average expenditure per animal has risen, recurrent expenditure usually gets a much lower proportion of the total agricultural budget than would be justified by livestock's share in total output. Moreover, much of the increase in real expenditure per animal has been rendered ineffective by the rising share of staff costs in total costs, which have increased at the expense of essential non-staff costs such as veterinary drugs and transport. More numerous and more expensive staff have tended to become less effective (Addis Anteneh, 1987) because of inadequate operating budgets.

Investment in research. A major cause of the poor return to investment in livestock development projects has been the lack of appropriate technical packages into which to channel this investment. This is partly because most of the investments were made in dry zones of low

productive potential, and partly because planners overestimated the extent to which the available technology was appropriate to African conditions. Consequently, they underinvested in adaptive research, spending on it proportionately much less in livestock projects than they did in comparable other agricultural projects (Sandford, 1981).

Infrastructures. In some countries there are other problems, including relatively low density of the human population, underdeveloped infrastructures (e.g. roads), and distant final markets. Added to these are high temperature and, in some areas, high humidity, which lead to rapid spoilage of meat and milk. The consequences of all these factors are high costs of transport, storage, processing, and wastage, rendering, for example, surplus milk production in pastoral areas virtually unmarketable.

Economic environment. The economic environment over the last decade has not been conducive to successful livestock development. Many African governments have tried to keep retail prices of meat and dairy products down (see Table 5), and although such attempts were often unsuccessful, they could not but shake the confidence of potential investors. At the same time, ill-judged attempts by donors and governments to interfere in marketing systems have widened the gap between producer and wholesale or retail prices, except where heavy government subsidies have been incurred (for example see Sandford, 1983, Chapter 9). Declining real prices in world markets, aggressive protection and other trade policies by developed countries have upset Africa's export markets for meat and intensified competition for dairy products in its domestic markets. In addition, the real prices of production inputs have risen substantially.

Other major constraints. Lack of adequately qualified and experienced manpower to conduct research, analyse policies and implement development is one of them. Because of worsening economic conditions, governments have been unable to make their planned financial contributions to livestock development. The designs of livestock projects were often grandiose and unrealistic (especially in the light of the lack of qualified and experienced staff), and donor agencies failed to provide firm but flexible supervision of implementation. Institutions set up to provide credit and production inputs have often been neither financially viable nor sensitive to producers' needs. Moreover, several important livestock-producing areas have been affected by war and insecurity.

Technical constraints

The technical constraints to livestock development can be divided into four broad categories: feed and nutrition, genetic structure, health and disease problems, and other constraints.

Feed and nutrition. Adequate livestock nutrition depends on the availability of adequate feed supplies and on good management. Because of poor soil fertility and scant, unreliable and markedly seasonal rainfall, feed supplies in Africa fluctuate in both quantity and quality (digestibility and protein content). Conservation and storage of feed from the time of its growth to the time of its use is therefore a critical issue. In some areas, deficiencies in specific minerals also occur.

In drier areas, feed is widely dispersed in space, involving high energy expenditure in harvesting it by grazing or other means. In wetter areas where soil fertility is often poor, the concentration of nutrients in the dry matter produced is inadequate, such that livestock cannot eat enough to achieve optimum production.

Genetic structure. The genetic structure of African livestock has evolved largely as a result of natural selection, influenced by environmental factors and the level of technology. Selection has been for survival under high disease challenge and fluctuating feed and water supplies, rather than for high levels of production.

In some higher-potential areas of East Africa, where disease control and artificial insemination are commonly used, a changed genetic structure has emerged, sometimes incorporating exotic genes and resulting from selection for high production. In lower-potential and marginal environments the ability to survive is still the dominant selection criterion. This is reinforced by social institutions (particularly land tenure) which encourage competition for scarce feed and water resources, rather than adjustment of herd size.

Health and disease problems. Although modern technology has reduced some disease risks, animal health problems still form a major category of constraint. For example, trypanosomiasis transmitted by tsetse flies is considered to be a serious problem over 46% of sub-Saharan Africa's surface area. Internal and external parasites can also be important causes of low productivity and high mortality, and there are often significant interactions between nutrition, disease and reproductive performance.

In some instances, technical solutions to health problems are available (e.g. control of internal parasites) but only at an uneconomic cost, such that the problem is better tackled through improved herd management rather than new technology. In others, for example streptothricosis, new technology may be the only way to substantially improve productivity and profitability.

Sometimes the disease issue may not relate to physical productivity but to price and market outlets. Unless the disease is eliminated in a particular way (e.g. by slaughter and quarantine rather than by vaccination, as in the case of foot-and- mouth disease), relatively high-priced export markets cannot be entered, and much lower prices will be received in domestic or more saturated export markets.

Other constraints. These include particularly water shortage, toxicity and poor management. The first constraint has been addressed in water development programmes in most of sub-Saharan Africa. However, although lack of watering points is no longer as serious a problem as it used to be half a century ago, the unreliability of water supply and equipment and poor maintenance continue to cause crises from time to time. The persevering water shortage is as much an institutional as a technical issue.

Poor management can also be a major problem, although this is often caused more by shortage of herding labour (a social or economic problem) than by ignorance or inefficiency. Nevertheless, differences in productivity are sometimes extremely large between herds and flocks with apparently equal access to the same feed and water resources and equal exposure to the same health risks. They may be due to differences in management practices not yet properly identified, and our ignorance of these constitutes a constraint.

PAST DEVELOPMENT OF TECHNOLOGY

Some of the constraints mentioned in the previous section have been at least partly overcome by 'non-traditional' technologies which have been tried over the last half-century. Among those which were wholly or largely 'developed' (i.e. designed, researched and applied) in sub-Saharan

Africa are rinderpest vaccination, tick control (especially for theileriosis), control of tsetse and trypanosomiasis by bush-clearing, and control of trypanosomiasis by chemotherapy.

Rinderpest vaccination, which is applicable across zones and regions of sub-Saharan Africa, can by and large be considered a success. Tick control, which has been most important in combatting East Coast fever (ECF–a form of theileriosis) in subhumid and semi-arid East Africa, has been a partial success, but with continuing problems of implementation. Tsetse/trypanosomiasis control is still under development and, if successful, could have a substantial impact throughout the humid and subhumid zones. Most of these 'African' technologies were developed during and immediately after the colonial period and implemented mainly in the post-colonial period.

A number of other technologies largely developed outside sub-Saharan Africa have been adapted and applied within it. Modern techniques of water extraction (boreholes) and storage (stockponds) have, together with rinderpest vaccination, been largely responsible for the increase in livestock numbers and output in sub-Saharan Africa over the last half-century. Naturally, water technology was of greatest use in the drier areas, with outstanding impact in Botswana, Sudan and the Sahel. Vaccinations against anthrax, foot-and-mouth disease, blackquarter and contagious bovine pleuro-pneumonia (CBPP) were developed outside sub-Saharan Africa, but were also applied with some success within it.

Natural genetic change in Africa's livestock herds has occurred as a result of human migration, inter-tribal theft, market exchange of stock, and livestock diseases such as trypanosomiasis and rinderpest. Deliberate genetic change has occurred only on a small scale, principally on ranches in Botswana, Zaire and Zimbabwe, and on smallholder dairy farms in highland Kenya. The proportion of sub-Saharan Africa's total cattle herd which has been significantly affected by such deliberate change is probably less than 3% (i.e. less than 5 million head).

Widespread scientific evaluation of the performance and potential of different exotic and indigenous cattle breeds and their crosses (see Brumby and Trail, 1986) shows that introducing exotic genes concurrently with improved animal health and nutrition can increase milk production. This has not, however, been demonstrated in increased meat production and draught power in any of the ecological zones.

Particularly in East and southern Africa, research and extension departments made considerable efforts to improve livestock feed supplies from forage crops and natural range or pasture. Where a commercial dairy sector has emerged, it has usually done so in conjunction with the development of forage crops. Otherwise, this effort has not led to much on-farm/on-range adoption, except in the irrigated areas of Sudan and on commercial ranches. Range management research has not led to the development of economically viable techniques enabling substantial increases in primary or secondary productivity per hectare.

The discussion of technology so far has dealt mainly with single components rather than complete production systems. Three 'modern' systems – commercial feedlots, commercial ranching (including parastatal ranching), and commercial dairying –have been tried on a fairly large scale in sub-Saharan Africa in the last half-century. Commercial feedlots appeared promising initially, but were badly hit by the collapse of international beef prices in the mid-1970s.

Commercial ranching was adopted in Angola, Botswana, Kenya, Nigeria, Tanzania, Zaire, Zambia and Zimbabwe. Well-managed ranches have higher productivity per animal than traditional African livestock systems in similar environments, but apparently not higher productivity per hectare (de Ridder and Wagenaar, 1986). As a rule, ranches have been successful only when there is privileged access to land, and where no opportunity cost has to be paid for diverting that land from other uses.

Commercial dairying, which involves a complete package of breed, health, feed and other production innovations, as well as modern transport, marketing and processing facilities, has been successful on large farms in Zimbabwe, and on large and small farms in Kenya. Otherwise, the system has not been successful for a variety of political, economic and technical reasons, such as low producer prices, shortage of breeding stock, and disease problems, particularly dermatophilosis.

THE BASIS FOR FUTURE DEVELOPMENT

The relevant means required to increase livestock production in sub-Saharan Africa include:

- increased level of investment
- better producer incentives
- improved institutions
- improved capacity to plan and monitor, and
- strengthened research capacity to generate technology

These means are discussed below in detail.

Investment pattern

No published data are available on aggregate *investment* in sub-Saharan Africa's livestock subsector. We can make some very crude guesstimates, at any rate in relation to ruminant livestock species which account for about 80% of the value of domestic livestock output in the subcontinent. We assume that ruminant meat is worth US$ 1300 t^{-1} carcass weight (at international prices), which is equivalent to about US$ 600 t^{-1} liveweight, or US$ 150 per tropical livestock unit (TLU) of 250 kg. Valuing livestock as breeding animals or milk producers might raise this amount slightly.

In 1985 there were about 145 million TLUs in sub-Saharan Africa, growing in number at 1.7% per annum, so the capital stock was worth about US$ 22 billion. The annual net investment in 1985 was worth US$ 370 million, having grown (assuming unchanged real prices) from just over US$ 300 million 10 years ago.

Over the last decade, the value of donor assistance (which we shall define as being all investment) to the livestock subsector averaged US$ 80 million per annum at current prices, with some decline in real terms. There are no data on the value of the public sector's direct investment financed from domestic sources, but it is our impression that it cannot be more than 50% of donor-financed investment and is probably of the order of 20% (ECA, 1987). Similarly, no estimate is available of producer-financed investment other than in the livestock themselves, but most livestock enterprises in Africa involve very little investment in anything except animals. Even in modern ranching enterprises the ratio between investment in livestock and in non-

livestock assets other than land is 4:1 (Jarvis, 1986). A very rough estimate of the pattern of investment in sub-Saharan Africa's livestock subsector over the last 10 years is given in Table 7.

Table 7. *Investment[1] pattern in sub-Saharan Africa's livestock subsector, 1975–85.*

Source of investment	1985 US$ million[2]	
	1975	1985
Producers' incremental investment in livestock	310	370
B. Other investment by producers (10% of A)	30	40
C. Donor-financed investment[3]	140	90
D. Public-sector-financed investment from domestic sources (25% of C)	30	20
Total	510	520

[1] Excluding investment inland.
[2] Rounded to the nearest 10 million.
[3] FAO (1986b). Values are adjusted to 1985 prices according to the industrial countries' GDP deflator index. The 'current prices' value for 1975 is US$ 70 million.

Different sources and approaches suggest that, excluding land, the overall capital: gross output ratio in the livestock subsector is between 3.5:1.0 and 5.0:1.0, but is perhaps more in the region of 2:1 with modern dairy enterprises. These ratios are based on aggregated data for sub-Saharan Africa, on studies of specific systems (e.g. see Sandford, 1983, p.125), and on comparisons with other developing countries (e.g. see Jarvis, 1986).

The value of the food, traction and manure output of the subsector is of the order of US$ 7000 million year^{-1} (estimated at 1985 prices); it needs to grow by about 3.1% year^{-1}, which is about US$ 220 million, just to keep up with population growth. Unless current capital:output ratios are substantially reduced, the present level of investment in the subsector will need to be about doubled to achieve the required level of output.

The general economic crisis, particularly the debt problem, has adversely affected the trends in savings and investment rates in sub-Saharan Africa in recent years. Consequently, investment levels are unlikely to be doubled, unless a substantial amount of the investment funds currently used elsewhere in the economy is diverted to the livestock subsector.

If the performance of the subsector can be improved, such diversion would be justified. For example, although the livestock subsector contributes about 15% to the agricultural GDP in developing countries collectively, it receives only about 3% of the donor aid to the agricultural sector (FAO, 1986b), and the proportion has declined over the last decade. Separate data are

not available for sub-Saharan Africa, but the position is probably the same and is unlikely to change until there is evidence of improved performance.

Producer incentives

Producer incentives can be directly affected by prices of inputs and outputs, by factors which raise or lower risk, and by levels and methods of taxation. African governments have some influence on all of these, but prices and risks are also greatly affected by other factors, principally developments in the international financial and commodity markets, and weather. For example, the world market price (in current US$) for skim milk powder (which Africa imports) fell from about US$ 900 to US$ 600 t^{-1} between 1974 and 1985, a decline of about 70% in real terms. In 1985, the price for beef (which some African countries export) in non-protected world markets was at almost exactly the same level in current US$ (i.e. US$ 1300 t^{-1} carcass weight) as in 1974, which corresponds to a decline in real terms of about 56% (FAO, 1985).

Not surprisingly, the producer prices for beef in the countries that export it (e.g. Botswana, Ethiopia, Kenya, Sudan, Zimbabwe) are fairly well in line with the world market prices[3]. For this to be otherwise would require either an export subsidy, which no African government could afford, or a devaluation of the local currency. In countries which do not export meat, producer prices are often considerably higher than the price at which meat could be imported (ILCA, Addis Ababa, Ethiopia, unpublished data). The situation is the same for milk of which there are no significant African exporters.

[3] Based on data in the first half of the 1980s.

African governments have tended to give substantial protection (in absolute terms) to domestic livestock production against the depressed world prices. Whether they have protected it relatively more or less than other forms of production is an issue which has been insufficiently studied. In Kenya, where such a study was made (Schluter, 1984), the nominal protection rates varied markedly between different kinds of commodities, but not in a systematic way.

Prices determined in world markets will continue to exert a very strong influence on the incentives for African livestock producers, particularly those that sell to these markets. The agricultural policy of the EEC, which is currently the major determinant of world prices, offers little prospect of significant price rises in the short and medium terms (FAO, 1986c). A calculation of the potential effect of a full liberation of agricultural trade policies by the world's market economies indicates that dairy prices might rise by up to 67%, and beef and lamb prices by 15% (World Bank, 1986, quoting Tyers and Anderson, 1986). Such a complete liberalisation is unlikely to take place in the foreseeable future, but the calculation shows the direction and ultimate limits to which (other things being equal) trade liberalisation might lead.

Institutions

Land tenure. This was identified as a constraint in a number of studies. In the drier areas, where several imaginative experiments have been carried out, it is still unclear which forms of land tenure will be efficient and equitable. In the higher-potential areas, where the solutions are clearer, many governments have not yet grasped the nettle of land reform.

Marketing institutions. During the 1960s it was fashionable to decry the operations of 'traditional', i.e. existing, marketing institutions and to seek to impose much closer government control on them, or to establish new parastatal substitutes or competitors. Thanks to several academic studies of traditional livestock and meat marketing systems, and some painful experiences with parastatals (reviewed, for example, in Sandford, 1983), there is now greater recognition of both the merits of the traditional system and the difficulties government intervention may entail. Nevertheless, given the present degree of government intervention in the international meat trade in all the economic blocs, a totally 'hands-off' position by the governments of African meat exporting countries is not feasible.

The nature and performance of dairy marketing systems in sub-Saharan Africa are not well understood. ILCA has started some studies on these systems, but more work by others on the subject is desirable.

Input-providing institutions. Except for ranches in Kenya and Zimbabwe, ruminant livestock production in sub-Saharan Africa tends to use few inputs besides land, natural forage or crop residues, herding labour, and capital in the form of livestock. A partial exception to this are veterinary services: there have been some experiments with using 'para-professionals' to deliver such services, and some use of professionals in the private sector. On the whole, however, the method of delivering veterinary services has not changed much over the last two decades, while the delivery of other inputs has not been developed, partly for lack of economic demand, and partly because appropriate organisational forms have not been devised.

Capacity to plan and monitor

Progress in planning and monitoring has been patchy. The technical abilities of many African officials have been improved by relevant academic courses, and about 80 individuals have had specific training in livestock planning issues, provided in the past by the joint ILCA/World Bank Project Planning Course and, more recently, by ILCA's annual Livestock Policy Analysis Course.

Individual training will, however, be ineffective if the right political and organisational environment is lacking. That political support is not yet available can be judged from the fact that the livestock subsector probably receives only 20% of the capital expenditure and 65% of the recurrent expenditure which even its food-commodity contribution to the agricultural GDP would justify (Addis Anteneh, ILCA, Addis Ababa, Ethiopia, unpublished data). If the animal power and manure that livestock contribute to cropping were to be taken into account, the budgetary allocation to the subsector would be even more inadequate.

In many African countries, livestock development has either been inadequately incorporated in the general planning of the agricultural sector, being sometimes left to animal health departments or to commodity-oriented parastatals with objectives that only partially cover the subsector, or else it has been incorporated spasmodically, being sometimes the responsibility of the ministry of agriculture and sometimes of a separate ministry. This spasmodic approach has been inimical to the desirable continuity of planning personnel, methodology, and policy.

Technology and research capacity

Inadequate technical basis is another cause of the unsatisfactory performance of livestock projects in sub-Saharan Africa (see e.g. Sandford, 1981). Technical constraints and past technology development were discussed above; this subsection deals with national research capacity to generate technology in the future.

There are some data of variable completeness and accuracy on agricultural research in sub-Saharan Africa in the first half of the 1980s, and on livestock research within the agricultural total. The total annual expenditure on national agricultural research in the subcontinent was roughly US$ 400 million, and there were about 6000 scientists (defined as having at least a B.Sc. degree) working on agricultural topics and commodities in national research organisations and universities (ILCA, Addis Ababa, Ethiopia, unpublished data).

About 49% of agricultural scientists are in West Africa (which has 42% of the human population), 27% in East Africa (30%), 17% in southern Africa (12%), and 7% in central Africa (16%). About 15% of these scientists have Ph.D. degrees, and a further 35–40% have M.Sc. degrees.

Incomplete data suggest that 18% or 1100 of the 6000 agricultural researchers work in livestock-related fields including veterinary medicine, animal husbandry, and forage crops and pasture. Of these about 30%, say 350 individuals, are working on veterinary issues. Although data indicating expenditure on livestock-related research are not available for most countries, we assume that this expenditure will be proportional to staff costs – of the order of US$ 70 million per annum (at 1980 prices).

There are 24 countries for which the number of scientists involved in livestock-related research is known (ILCA, 1987). These countries account for 64% of sub-Saharan Africa's TLUs. Seven of them (33% of TLUs) have more than 35 livestock scientists, another seven (23% of TLUs) have 15–35 scientists, and the remaining seven (7% of TLUs) have less than 15. No data are available for five countries which account for 37% of the region's TLUs. Of these 'unknowns' Sudan almost certainly has over 35 livestock scientists.

Rather arbitrarily, we define countries with more than 35 scientists as 'well-endowed', i.e. capable of conducting a fairly comprehensive set of adaptive experiments with several components. Countries with 15–35 scientists are defined as 'modestly' endowed, and those with less than 15 as 'ill-endowed'. These terms are used relative to conditions in sub-Saharan Africa, not in an absolute sense.

Implicit in this categorisation is that a certain critical mass is needed to make progress, irrespective of the size or complexity of a country's livestock sector. Given current Ph.D./M.Sc./B.Sc. ratios, a total of 15 'scientists' implies only about three Ph.D. holders, i.e. individuals formally trained to conduct research. This low figure suggests that national research capacity is not yet adequate to generate the required flow of new technology.

The key issue is the rate at which research capacity is being increased in Africa – and on this we have no reliable information. In a number of important livestock-producing countries, brain drain from research, either abroad or into non-research fields, appears to prevent the accumulation of a strong core of experienced livestock researchers. The main reasons for this

drain appear to be frustration over inadequate support (e.g. equipment), inadequate incentives, and lack of performance recognition.

In some countries, researchers lack adequate operating funds to be fully effective.

Several international organisations and donors are now directly involved in livestock research in sub-Saharan Africa. Some of them, including the International Livestock Centre for Africa (ILCA), were established partly in response to the lack of impact of national research on livestock production in the region.

ILCA's efforts

ILCA has now been in existence for 14 years. The first years were spent in institution building and establishing the necessary infrastructure, while the research programme was aimed at acquiring a better knowledge of the factors influencing the performance of different farming systems in sub-Saharan Africa.

Between 1981 and 1986 ILCA concentrated on strengthening technical expertise at headquarters, and on designing and testing technological interventions. Some of the Centre's more successful work has included water-harvesting and soil-conservation techniques using simple animal-drawn implements, simple milk processing technology, improving the cultivation and productivity of Vertisols, studies on the productivity of trypanotolerant livestock, testing of fodder banks and alley farming, collection and distribution of forage germplasm, and provision of training and information services.

In 1987 ILCA recharted its strategy in the light of its past experience. The Centre plans to focus its research on cattle, sheep and goats, on the major food commodities (meat and milk) produced by livestock, and on intermediate livestock inputs (traction and manure) to crop production. Its priority target groups are smallholders and agropastoralists. The research on commodities is supported by 'strategic' research on animal feed resources, trypanotolerance, and issues related to livestock policy and resource use.

ILCA plans to strengthen its partnership with national agricultural research systems (NARS) through applied and adaptive collaborative research, and by providing more training opportunities and better information services. The strengthened partnership with NARS and intensified training are expected to lead to an increased availability of suitable new technology. It is also expected to enhance the exchange and dissemination of relevant information to improve planning and policy formulation in the livestock subsector.

CONCLUSION

The past performance of sub-Saharan Africa's livestock subsector has generally not been impressive. Because of the nature of the production process and the institutional intricacies involved, the constraints facing the subsector are complex, but it would seem that they have been rendered even more so by national and international policies attempting to direct the course of development in the subsector. Yet the problems are not insurmountable, even though past development of technology has had relatively little impact on productivity.

The means discussed in this paper appear to be well-oriented towards solving the constraints identified, but a word of caution is necessary: we should not expect dramatic breakthroughs, rather aim at incremental gains over time to reverse the trend of past performance. A longer-term commitment to increased investment in research and to the development of scientific manpower is essential to achieve common objectives, as is stronger partnership between African and international institutions such as ILCA.

It is in this framework that the role of policy, finance and technology in the development of sub-Saharan Africa's livestock subsector would be more meaningful in the long run. It is also in this framework that intensified national and international efforts to put in place the means necessary to increase livestock production in the region will have the greatest payoff.

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