LPU WORKING PAPER No. 2

What causes supply levels from African livestock sectors to change?

JOHN McCLINTOCK

AUGUST 1983

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA (ILCA)
ADDIS ABABA, ETHIOPIA

LPU

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CONTENTS

SUMMARY

1. The purpose of this study was to explain differences between the performances of the livestock sectors of the countries of sub-Saharan Africa. This was done by examining correlations between aggregate national data on livestock output and possible causal factors. (1.1).

2. Throughout the study, exceptionally high values for some variables were encountered for particular countries. These countries would thus exert a major influence on the correlation statistics. In some cases, the exceptional country or countries would be excluded and an adjusted correlation performed which would invariably result in markedly different correlation statistics. Readers are therefore asked to bear this idiosyncracy of the data in mind where it has not been explicitly examined in the text. (1.3.4).

3. Significant positive correlations exist between increases in output of all livestock products considered in the study (with the exception of pigmeat) and increases in cereal output. For all products, increases in output are positively correlated with increases in cereal area but only two of these correlations (for all milk and sheep and goat milk) are statistically significant at the 10% level.
Increases in output of sheep and goat meat, all meat and all milk are positively correlated with increases in cereal yields, although these correlations are highly dependent on one or two countries. For other products no correlations, significant at the 10% level, exist betweeen increases in output and increases in cereal yield. (1.3.4.)

4. The growth rate of GNP is not significantly associated with growth in meat supply, but is moderately associated with growth in milk supply albeit at a modest level of statistical significance (6%). This suggests that the livestock sector is not very responsive to demand stimulation, although GNP may be a poor proxy for economic incentives due to market distortions.
However it should be noted that the milk correlations are highly dependent on the inclusion of Kenya and Botswana. When these countries are excluded the correlations are not statistically significant. (2.2)

5. None of the following factors, which are conventionally held to remove supply constraints, are associated with increases in supply of livestock products.

a) Public expenditure on agriculture (3.1.1)
b) Number of scientists in agriculture (3.1.2)
c) Density of scientists in agriculture (3.1.3)
d) Increases in the number of scientists in agriculture (3.1.4)
e) Increases in the density of scientists in agriculture (3.1.5)
f) Absolute research expenditure in agriculture (3.1.6)
g) Relative research expenditure in agriculture (3.1.7)
h) Increases in absolute research expenditure in agriculture (3.1.8)
i) Increases in relative research expenditure in agriculture (3.1.9)
j) Veterinary expenditure, 1965 (3.1.10)
k) Veterinary expenditure, 1977 (3.1.11)
l) Increase in veterinary expenditure (3.1.12)

The suggestion that the number of scientists, the magnitude of the research effort and the level of veterinary expenditure do not have any effect on increases in supply is very serious. It is possible however that the effects of research require more than four years (as assumed in this analysis) to be bear fruit.
The suggested lack of impact of the veterinary services seems a more definite finding and since health interventions are often seen as a sine qua non for livestock improvements, veterinary services would merit serious evaluation.

6. It appears that none of the following macro-economic variables are associated with increases in supply of livestock products:

a) Level of gross domestic investment (3.2.1)
b) Change in level of gross domestic investment (3.2.2)
c) Level of public consumption (3.2.3)
d) Growth rate of public consumption (3.2.4)
e) Public expenditure on roads (3.2.5)

The reason for the lack of correlations remains rather obscure but could be due to the use of inappropriate time periods in the analysis and the dual nature of many African economies in which the livestock sectors may be poorly integrated into the modernising sector where the bulk of investment and public consumption is likely to be made.

7. Whether marketing of agricultural inputs is handled by governments, by private operators or by a combination of the two, seems to make no difference to the supply level of livestock products, with the exception of poultry meat. For this product, large increases in supply are associated with a mixture of government and private marketing, small increases in supply with marketing conducted solely by governments (3.2.6)

8. The study found changes in supply levels for all products, except pig meat and cow milk, to be associated with the rate of livestock population growth (Section 4). A 1% increase in population is correlated with increases in supply as follows:

Beef	0.68%
Sheep and goat meat	1.32%
Poultry meat	0.14%
All meat	1.18%
All milk	1.55%

This suggests that the growth of livestock numbers has provided a significant part of the increased supply of products. African countries, however, can ill-afford further increases in animal populations and therefore a radical shift away from reliance on increasing numbers and towards finding appropriate technology and policies that will increase the efficiency of resource use is urgently required.(Section 4).

9. The possibility of inaccurate data, causing misleading results, must not be overlooked. In one case, that of Mozambique chicken populations, the data were obviously inaccurate.
While it is possible that there really is no causal relationship between the factors examined in this paper and livestock output, it is also highly probable that a major reason for the lack of statistically significant correlations is that the data are simply very inaccurate. (Section 5).

WHAT CAUSES SUPPLY LEVELS FROM AFRICAN LIVESTOCK SECTORS TO CHANGE?

1. Introduction

1.1 Purpose of the paper

This paper gives the results of a desk-study by John McClintock which examined changes in supply levels of livestock products from 1965 to 1980 and attempted to explain them. The purpose of the study was to try to discover why some countries in sub-Saharan Africa have performed appreciably better than others in terms of increasing their supply of livestock products. This was done by examining easily available aggregate data on livestock output (from FAO Production Yearbooks) and on factors that may affect it (from the previous and additional sources). The study covered 35 countries and seven products were considered: beef, sheep and goat meat, pig meat, poultry meat, all meat, cow milk and all milk (ie. cattle,sheep and goat milk).

During the analysis of these data it was assumed that they were sufficiently accurate for any relationships that exist between them in the real world to be reflected in statistical correlations at levels of significance less than 10%. However in section 5 of this study the quality of data is discussed and the possible impact of poor data on the results of the study is considered.

1.2. Livestock in the Context of Africa's Food Crisis

Table 1 below, shows the annual rates of increase for cereal, meat and milk supply during the 1970s for sub-Saharan Africa. While the output level of each commodity rose, their rates of increase were less than that of the human population which expanded at the rate of 2.9% p.a.
This consequent deterioration in output per head is the cold, statistical manifestation of Africa's food crisis.

Table 1: Growth rates in agricultural supply (% p.a.) 1970-1980

Cereals	1.16
Meat (all types)	1.84
Milk (cow only)	1.27

If food output per head is not to deteriorate still further during the present decade, then governments, development agencies and research institutes must have a clear understanding of how they can best promote increases in supply levels from both the crop and livestock sectors.

1.3 Review of the Recent Performance of Livestock Sectors.

Before introducing the approach used in this analysis, and the results of the analysis itself, it is useful to briefly review the performance of livestock sectors since 1965.
Tables A4 - A10 in the Appendix give output levels, by country, for 1965 and 1980,together with the proportional increase from 1965 to 1980, for each of the sever products considered in this study. The period from 1965-80 adequately spans the period of the Sahelian drought so as to provide a reasonable representation of long term trend divorced from the perturbation caused by the drought. (See also Appendix A.1)

In 1.3.1 performance by country and product is briefly described while the rest of this first section deals with the effects of climatic zone and size of livestock population before concluding with an analysis of the relationship between increases in output of livestock products and increases in cereal production.

1.3.1 Recent Performance 1965-1980

The first noteworthy feature is that countries seem to have performed better with pigs and poultry meat than with meat or milk from ruminants. Unweighted mean increases for pig and poultry meat are 153% and 125% respectively, compared to those for beef, 59%, and sheep and goat meat, 84%. The unweighted mean increase for cow milk is the lowest of all products at 28% while that for all milk is 64%. Although the coverage of countries is much lower for pig and poultry meat, it is notable that none of the countries for which data exist recorded decreases in either of these two products.

A second important feature is that reductions in output have occurred in some countries and what is particularly surprising is that these deteriorations have tended to occur outside the Sahel. The most serious reductions for meat products occurred in Uganda and Lesotho for sheep and goat meat, output falling by one half. Both those countries also suffered reductions in beef output - by a third in Lesotho and a fifth in Uganda.

Tanzania also experienced a fall in sheep and goat meat of 19%. Two other countries suffered decreases in beef output - Madagascar, 28%, and Ethiopia, 6% (the continent's most important beef producer).

Reductions in milk output have been even more common - for both cow milk and all milk 40% of countries recorded a decrease. Moreover decreases appear to be of a greater magnitude than for meat products: the decrease of 81% in cow milk output in the Central Africa Republic is the largest reduction of any product, and is closely followed by Zaire with a decrease of 70% in cow milk. Decreases in cow milk supply occurred in a further 11 countries. Data for all milk is available for fewer countries - and of these Guinea (40%), Mali (29%) Upper Volta (27%), Sudan (24%), Niger (23%) and Rwanda (12%) experienced reductions.

On the brighter side, increases have occurred - the largest being that of pig meat for Ivory Coast (333%). Indeed, Ivory Coast appears to have been remarkably successful in terms of all meat products with the following increases: beef (213%), sheep and goat meat 100%, poultry meat 258%, and all meat 228%. Increase in cow milk, however, was only 22%.

Somalia also appears to have achieved good results in both meat and milk products (although data do not exist for poultry meat). Increases are as follows: beef 196%, sheep and goat meat 316%, all meat 259%, cow milk 86% and all milk 310%.

Sudan and Rwanda appear as rather unusual cases. Both these countries have made notable progress in improving supply of beef and sheep and goat meat. But they have both experienced decreases in cow milk and all milk, suggesting a shift from milk production to meat production.

Finally Kenya and Botswana: unfortunately data on 1965 meat output does not exist for Kenya, and only in the case of beef for Botswana, which attained an increase of 81% in the output of this product. These two countries appear, however, to have achieved the highest increases of all sub-Saharan countries in output of cow milk: Kenya 266% and Botswana 255%. In terms of all milk they are surpassed only by Somalia where sheep and goat milk is very important and increased substantially, resulting in an increase in all milk of 310%, compared to 280% for Kenya and 267% for Botswana.

In conclusion, therefore, Lesotho and Uganda appear to be the poorest performers on the meat front, with Central Africa Republic and Zaire suffering the greatest falls in milk output. The most successful countries in meat production are Ivory Coast and Somalia. Somalia is also the most successful producer of all milk. Kenya and Botswana have achieved the highest increases in cow milk. Sudan and Rwanda have increased meat output substantially but have simultaneously reduced their milk output.

1.3.2 The Effect of Climatic Zone

After Jahnke (1982) countries were classed according to six different climatic zones: arid, semi-arid, humid, subhumid, highland and Sahelian (see Appendix A.7). An analysis of variance (ANOVA) was then performed to test for significant differences in supply increases between zones, the results being given in Table 2, below. In this table "p" denotes the probability of differences in changes in output occurring by chance, while "n" is the number of countries included in the analysis.
The climatic zone into which the largest proportion of a country's animals fell was taken as representing the zone for the entire country. Since separate distributions were available for cattle, sheep, goats and all ruminants, four different classifications were possible. In the case of beef and cow milk, the classification according to the distribution of cattle was used. For "all milk" the classification according to ruminant distribution was used, while for sheep and goat meat two different classifications were possible: one according to sheep distribution, the other according to goat distribution. The ANOVA results from both these classifications are given below. As no distributions of pigs or poultry were given the analysis does not extend to either pigmeat or poultry meat. Finally, "all meat" is not considered because of the importance, in many countries, of these two latter products in total meat output.

Table 2. Increases in supply and climatic zone: ANOVA statistics

Product	p.	n
Beef	0.38	20
Sheep and goat meat(1)	0.06	17
(2)	0.12	17
Cow milk	0.02	29
All milk	0.02	16

1. Climatic zone according to distribution of sheep.
2. Climatic zone according to distribution of goats.

Table 2 suggests that increases in supply are related to climatic zone only for cow milk and all milk. For both these products, the F statistic is significant at the 2% level.
Table 3 (cow milk) and Table 4 (all milk) below give unweighted mean increases by zone together with standard deviations and the number of countries falling into each zone.

Table 3. Increases in supply of cow milk and climatic zone: group means, standard deviations and number of countries in each zone.

Climatic zone	Percentage increases	Standard deviation	Group size
Arid	170	120	2
Highland	86	126	4
Sahelian	26	52	6
Subhumid	14	32	8
Semi-arid	5	17	5
Humid	-35	65	4

Table 4. Increases in supply of all milk and climatic zone: group mean, standard deviation and number of countries in each group.

Climate zone	Percentage increases	Standard deviation	Group size
Arid	208	156	4
Subhumid	99	72	2
Highland	25	36	3
Sahelian	-8	21	6
Humid	-44	*	1

* = not applicable as only 1 country in this zone

For both cow milk and all milk it appears that arid zone countries have been the highest performers, and humid zone countries the poorest performers. The performance of zones is detailed below, but readers should note that variation within zones is large and reference should be made to Tables A4 to A10 for the increases for individual countries.

a) arid zone countries have achieved a mean increase of around 200% in milk production and are thus the highest performers in sub-Saharan Africa. For cow milk, these countries are Botswana and Somalia, whilst for all milk the relevant countries are Botswana, Somalia, Kenya and Sudan.
b) countries in the humid zone have suffered serious deteriorations in both cow milk and all milk and thus rank as the lowest performers. For cow milk, these countries are Central African Republic, Ghana, Guinea and Zaire. The humid zone is represented by Guinea alone in the case of all milk.
c) semi-arid countries have achieved, on average, very low increases in cow milk (no cases exist for all milk). The countries concerned are Angola, Madagascar, Mozambique, Nigeria and Zambia.
d) subhumid countries have also achieved on average very low increases for cow milk. The eight countries concerned are Benin, Cameroon, Ivory Coast, Mali, Sudan, Tanzania, Uganda and Zimbabwe.
e) in terms of cow milk the six Sahelian countries appear to have recovered from the 1968-74 drought and have increased output by a quarter. But 1980 output of all milk was still slightly below 1965 levels.
f) the four highland countries (Burundi, Ethiopia, Kenya and Rwanda) on average almost doubled their output of cow milk but only achieved an increase of a quarter in all milk. (In terms of all milk, Kenya is classed as an arid zone country.)

1.3.3 The Effect of the Size of Livestock Population.

Have countries with small livestock populations found it easier to increase proportional output than countries with larger populations? This question was investigated by correlating increases in output with size of population in 1965. The correlation statistics are given in Table 5 below.

Table 5. Increases in supply and size of livestock populations in 1965: Correlation statistics

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	-0.35	0.11	22	77.00	*
Sheep and goat meat	0.01	0.95	18	83.01	*
Pig meat	-0.21	0.65	7	175.48	-0.10
Poultry meat	-0.55	0.13	9	177.87	*
Cow milk	0.06	0.73	31	24.68	*
All milk	-0.09	0.75	16	71.94	*

* less than 0.01

Table 5 suggests that there is no association between increases in supply and the size of population in 1965. This implies that countries with small populations have not found it any easier to increase proportional output than countries with large populations. This perverse trend is illustrated for beef output by Swaziland and Sudan. Swaziland had a cattle population in 1965 of some 0.5 million and attained an increase in beef output of 22%. On the other hand, Sudan had 20 times more cattle, and increased beef output by 106%.

1.3.4. Livestock and Cereal Production.

It is pertinant to test the available data for any relationship that may exist between the performance of the livestock sector and that of the cropping sector, since it is important to recognise any complementarity or competitiveness that may exist between the two. In this section, therefore, the existence of correlations between increases in output and increases in cereal production, cereal area and cereal yields is examined.

Livestock and Cereal Output

Correlations were performed between increases in supply of livestock products and increases in cereal output, both increases being for the period 1965-1980. The correlation statistics are given in Table 6:

Table 6. Increases in supply (y) and increases in cereal production (x): Correlation Statistics

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.44	0.04	22	43.42	0.34
Sheep and goat meat	0.74	*	18	45.40	1.25
Pig meat	0.28	0.54	7	108.48	1.28
Poultry meat	0.75	0.02	9	77.01	2.53
All meat	0.78	*	17	40.00	1.06
Cow milk	0.44	0.01	31	8.05	0.44
All milk	0.68	*	16	22.49	0.80

* less than 0.01

Table 6 suggests that significant positive associations exist between increase in output of all livestock products (except pig meat) and increases in cereal output.
The slopes of the regression lines indicate the percentage increase in cereal output that is associated with a 1% increase of each of the livestock products. Various questions arise for these statistics:
- why are increases in output of poultry meat associated with increases in cereal output, while the same does not hold for pig meat?
- why is the percentage increase in cereal output that is associated with a 1% increase in sheep and goat meat output very high at 1.25%, while the equivalent figure for beef output is low at 0.34%?
- what is the nature of these relationships? In other words, what is the direction of causality or are both variables influenced by a third, resulting in statistical correlation without causality?
These three questions were examined slightly further by correlating increase in supply of livestock products with increases in cereal area and yields.
Table 7 gives the statistics for the correlations between increases in supply and increases in cereal area.

Table 7. Increases in supply and increases in cereal area: Correlation statistics.

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.32	0.15	22	48.26	0.27
Sheep and goat meat	0.46	0.06	18	55.13	1.05
Pig meat	0.38	0.40	7	116.34	1.11
Poultry meat	0.55	0.12	9	86.85	1.75
All meat	0.49	0.05	17	48.35	0.92
Cow milk	0.27	0.15	31	15.89	0.27
All milk	0.30	0.27	16	46.09	0.40

The statistics show that for all products, increases in output are positively correlated with increases in cereal area. However, only two of these correlations (those for sheep and goat meat and all meat) are statistically significant at the 10% level. Table 8, below, gives the correlation statistics between increases in supply and increases in cereal yields.

Table 8. Increases in supply and increases in cereal yield: Correlation statistics.

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.16	0.48	22	57.03	0.20
Sheep and goat meat	0.40	0.10	18	78.28	0.82
Pig meat	-0.44	0.32	7	166.55	-2.47
Poultry meat	0.24	0.53	9	125.78	1.57
All meat	0.41	0.10	17	70.29	0.67
Cow milk	0.22	0.24	31	25.23	0.34
All milk	0.70	*	16	46.09	0.40

* less than 0.01

Whereas, in general, increases in meat output is more closely correlated with increases in cereal area than are increases in milk output, the converse is the case with cereal yield. However, except in the case of pigmeat, all the correlations are positive.

It is at this point that the phenomenon of the "exceptional country" is encountered. When the scattergrams of these correlations are examined, one country is sometimes found to lie so far away from the remainder that the magnitude and sign of the correlation coefficient is determined solely by the presence of this single country. In less extreme cases, the exclusion of one country does not alter the sign of the correlation but alters the coefficient enough to render the correlation insignificant at the 10% level. In other instances the removal of two or three countries has the same effect on the correlation statistics.

Two different reasons may explain this phenomenon:

Firstly, the exceptional country may be the only manifestation of a real association that applies to all countries. As the dispersion of the remaining group is so small, within this group the association is obscured by other influencing factors. If it were not for the existence of the exceptional country, the association would never be revealed. In other words, the exception proves the rule.

Secondly, the exceptional country may really be an exception, by virtue of a different production function applying. Thus, for example, because of its policy background, a particular country may have highly effective veterinary services. In constrast, the policies of all other countries may hinder their veterinary services, and a lower "economic efficiency" parameter will apply to the veterinary services in these other countries. In such a case, the association that is observed when all countries are considered together is not the true association that applies to any of these countries.

This phenomenon was encountered quite frequently during the course of this study. In many cases, correlations were re-run after excluding exceptional countries and the adjusted correlation statistics are given. This slight tampering with the data was justified by the second consideration above and by a reluctance to accept statistics carte blanche without examining them in any depth. Thus readers are asked to bear in mind the possibility of this phenomenon influencing the correlation statistics where it has not been made explicit in the report and to exercise their judgement in interpreting the results.

In this particular case the sheep and goat meat correlation and the all meat correlation together with that of all milk, appear from the scattergrams to be strongly influenced by the case of Somalia which recorded an increase in cereal yields of 181%, greatly in excess of the modal increase. For instance, when Somalia is excluded from the all meat correlation, the statistics are modified as shown below:

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
All meat	-0.26	0.33	16	61.92	-0.75

It would therefore appear that the data do not provide any evidence to suggest that an association exists between increases in supply of livestock products and increases in cereal yield.

2. The Effect of Economic Incentives on Supply

Livestock output may be stimulated both by giving producers greater incentives to produce and by providing them with the technology and material inputs necessary to remove constraints on supply. This section considers economic incentives while section 3 deals with technology and inputs (3.1) and the general economic climate surrounding livestock production (3.2).

2.1 GNP and Human Population Growth as Proxies for Economic Incentives

For an accurate representation of economic returns to livestock producers it would be desirable to analyse data on the volume of demand, on the prices of outputs and inputs, on the ease and convenience of marketing outputs and purchasing inputs and lastly on the risks involved in livestock production. Such data are not readily available for any significant number of African countries. Instead two variables for which data do exist are used as proxies for economic incentives. The growth of GNP will be associated with changes in the volume of demand, through the effect of the elasticity of demand, and probably also with the provision of better facilities for marketing products and inputs, and with an upward pressure on output prices. The second proxy considered, that of human population growth, is directly associated with the volume of demand. It has not been possible, however, in this study to take into account changes in external trade, either imports or exports, which for some countries has become substantial.

2.2 Increases in Supply Correlated with Growth in GNP

The values of the correlation coefficients, shown in Table 9, between changes in livestock output and GNP, suggest that there is no strong association except possibly for poultry meat. In the case of sheep and goat meat and all meat the coefficient unexpectedly has a negative sign. Only for milk are the correlations statistically significant at a modest level.

Table 9. Increases in Supply (y) and GNP growth rate (x): correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	0.01	0.96	22	58.27	0.27
Sheep and goat meat	-0.30	0.23	18	140.49	-15.01
Pig meat	0.22	0.64	7	93.31	13.52
Poultry meat	0.55	0.12	9	-28.39	36.42
All meat	-0.06	0.81	17	85.49	-2.57
Cow milk	0.42	0.02	31	-22.83	12.68
All milk	0.49	0.06	16	-27.16	24.12

However, the correlation coefficients for cow milk shown in Table 9 are wholly dependent on the cases of Botswana and Kenya which recorded exceptionally high GNP growth rates and increases in cow-milk supply, as shown in Table 10:

Table 10. GNP growth rate and increase in cow milk supply

	GNP growth rate (% p.a.)	Increase in cow milk supply (%)
Botswana	11.15	255
Kenya	6.00	266

For all milk, the correlation coefficients are wholly dependent on the case of Botswana which recorded an increase in supply of 267%. Table 11 below shows the coefficients after the removal of Botswana and Kenya which suggest that no association exists between increases in milk supply and GNP growth rate.

Table 11. Increases in supply (y) and GNP growth rate (x): correlation statistics adjusted for the exclusion of Botswana and Kenya.

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Cow milk	0.05	0.81	29	8.42	1.00
All milk	0.23	0.41	15	-6.99	17.43

This apparent lack of significant associations may be due to two factors:

1) the existence of market imperfections which do not allow the transmission of economic demand to producers in the form of economic incentives, or 2) non-economic behaviour by livestock producers - contradicting the hypothesis promoted by the school of economic incentives. Non-economic behaviour by livestock producers may exist because of the social functions that livestock frequently play (bridewealth, prestige), in addition, to its role as an insurance policy against crop failure. This, of course, is not to deny that some producers in some circumstances may be responsive to profit levels, and the true situation may be that a range of different behaviorial responses exist over the continent, according to the exact circumstances in which producers are operating.

2.3 Human Population Growth

The growth of human population may be an important motive stimulating livestock producers to increase supply, especially in countries with sizeable pastoral populations. Such populations are largely or wholly dependent on animal products for their nourishment, and therefore express a biological, rather than simply an economic, demand for livestock products. Table 12 below gives the correlation statistics for increases in supply with population growth rates for the period 1970-80. The results, however, suggest that no strong or statistically significant association exists between increases in supply and population growth rates: supply does not appear to be sensitive to human population growth rates.

Table 12. Increases in Supply and Population Growth Rate: Correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	0.34	0.12	22	-26.37	32.10
Sheep and goat meat	-0.03	0.92	18	92.83	-3.20
Pig meat	0.46	0.30	7	1.43	48.50
Poultry meat	0.39	0.30	9	13.16	39.06
All meat	0.32	0.20	17	-14.32	32.94
Cow milk	0.06	0.73	31	8.63	7.26
All milk	0.11	0.68	16	-4.77	26.71

3. The Removal of Supply Constraints

Measures to remove supply constraints were categorised into two broad types: those which are specific to the agricultural sector (or one of its two components: livestock and crop production) and those which affect the economy as a whole on a wider front.

3.1 Sector Specific Measures to Remove Supply Constraints

Three types of sector specific measures were examined:

i) The level of public expenditure in the sector
ii) Government efforts to develop technology in the sector, as evidenced by the absolute number of research scientists, the density of scientists (measured as the ratio of scientist numbers to livestock numbers, and expenditure on research).
iii) The level of veterinary expenditure.

Unfortunately, for the first two types the data relate not to livestock production alone, but to the agricultural sector as a whole. Hence these data are proxies for the true data and, moreover, are appropriate only if the proportion of expenditure and scientists that are devoted to livestock production is constant both across countries and over time. This is a strong assumption to make and its improbability may account for the low levels of correlation and significance revealed below.

3.1.1 Public Expenditure on Agriculture

Data on the proportion of public expenditure devoted to agriculture relates only to 1978. Assuming that the proportion has remained reasonably constant over the period under consideration, it would seem worthwhile to test for any association between increases in supply and public expenditure on agriculture. Table 13 gives the correlation statistics, and suggests that no such association exists.

Table 13. Increases in supply and public expenditure devoted to agriculture (1978): Correlation statistics

Dependent variable(y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	-0.33	0.19	17	115.80	-4.86
Sheep and goat meat	0.05	0.86	15	90.46	0.92
Pig meat	-0.19	0.68	7	188.19	-5.70
Poultry meat	-0.13	0.76	8	-73.17	-0.37
All meat	0.10	0.73	14	41.48	1.92
Cow milk	0.23	0.32	21	4.45	3.56
All milk	0.24	0.48	13	13.09	6.52

3.1.2 The Number of Scientists

It may be permissable to believe that the more scientists a country has working in agricultural research, then the higher its performance in both livestock and crop production. (Analysis of impact on crop production is given in Appendix A10). This hypothesis was tested and the statistics of the correlations between increases in supply and the number of scientists are given in Table 14, below. The data have been taken from Oram and Bindlish (1981). Increases in supply refer to the proportional increases over the period 1974 to 1980, three year means being used in both cases. The starting point of 1974 was chosen in order to allow a 3-year lag for the fruits of research to take effect. (Increases in supply were calculated from 1972 to 1980 thereby allowing a 1-year lag, and from 1973 to 1980, for a 2-year lag but in all cases correlations using 72-80 and 73-80 increases in supply were very similar to those for 74-80 and are therefore not given in this report). Since this starting period coincides with the end of the Sahelian drought, all Sahelian countries have been excluded since their levels of increase in output from 1974 to 1980 would be higher than if the drought had not occurred.

Table 14. Increases in supply and absolute number of scientists in 1971: Correlation statistics.

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.14	0.57	18	17.52	0.06
Sheep and goat meat	0.28	0.25	18	14.89	0.12
Pig meat	-0.16	0.62	12	60.83	-0.11
Poultry meat	0.44	0.07	18	32.05	0.43
All meat	0.19	0.46	17	10.80	0.08
Cow milk	0.04	0.87	18	4.02	0.02
All milk	-0.13	0.83	5	7.82	-0.04

The conclusion suggested by these statistics is that the absolute number of scientists working in research in 1971 made no consistent difference to the subsequent performance of the livestock sector, in terms of output. However, this may not be surprising given that density of scientists (defined here as the number of scientists per 1000 animals) varied greatly between countries. It may therefore be more realistic to expect greatest increases in output in those countries where density of scientists was highest.

3.1.3. The Density of Scientists

Correlations were thus run to test this second hypothesis: that changes in output are associated with the density of scientists. The statistics are given in Table 15 below. Correlations were not performed for "all meat" or "all milk" because of the problem of aggregating populations of different species.

Table 15. Increases in supply and the density of scientists: Correlationstatistics.

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.04	0.89	18	20.78	53.97
Sheep and goat meat	-0.53	0.02	18	39.96	-535.17
Pig meat	-0.20	0.53	12	63.08	-28.13
Poultry meat	-0.20	0.46	16	80.88	-866.00
Cow milk	-0.57	0.01	24	26.94	-794.54

This table suggests that density of scientists and changes in both sheep and goat meat output and cow milk output are negatively associated. Extreme values do exist in both cases, and their exclusion renders the correlations significant only at levels greater than 10%, viz:

The Removal of Zimbabwe, in the case of sheep and goat meat:

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Sheep and goat meat	-0.39	0.12	17	40.97	-588.52

The Removal of Zaire, in the case of cow milk:

Cow milk	-0.35	0.17	17	19.90	-397.73

These statistics therefore provide little evidence to support the hypothesis that the density of scientists is associated with changes in the output of livestock products. This rather disturbing finding was examined in slightly more depth by testing for associations between increases in scientist numbers, since scientists' effectiveness in increasing output may vary between countries due to the different conditions surrounding agriculture which are outside the influence of scientists - (price relationships, marketing policies etc).

3.1.4. Increases in the Number of Scientists

Table 16 gives the statistics of correlations between increases in supply 1974 to 1980 and increases in the number of scientists.

Table 16. Increases in supply and increases in the number of scientists: Correlation statistics.

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	*	0.99	10	25.68	*
Sheep and goat meat	0.04	0.93	8	25.24	0.01
Pig meat	0.71	0.81	5	23.58	0.12
Poultry meat	0.75	0.02	9	10.20	0.70
All meat	0.33	0.47	7	2.08	0.17
Cow milk	0.48	0.22	8	-18.52	0.23

(Only two cases exist in the case of all milk, therefore statistics cannot be computed).

The statistics in the case of poultry meat are strongly influenced by the values for Nigeria and Togo. When these are excluded the correlation statistics are as follows:

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Poultry meat	-0.29	0.53	7	49.45	-0.24

The above statistics suggest little association between increases in supply and increases in the number of scientists. Again, this may be due to different densities of scientists between countries. Hence, it is perhaps more appropriate to correlate increases in supply with changes in density of scientists.

3.1.5. Increases in the Density of Scientists

The statistics of the correlations between increases in supply and increases in the density of scientists are given in Table 17:

Table 17. Increases in supply and increases in the density of scientists: Correlation statistics

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.05	0.91	8	26.66	0.02
Sheep and goat meat	0.29	0.48	8	18.94	0.09
Pig meat	0.63	0.25	5	30.09	0.13
Poultry meat	0.55	0.20	7	56.64	0.76
Cow milk	0.49	0.21	8	-11.14	0.22

While this table indicates that a moderate association exists in the case of some products, in no cases is the association statistically significant at even modest levels.

3.1.6 Absolute Research Expenditure.

Data on research expenditure is given by Oram and Bindlist (1981) for the seventies in constant dollars. It might be expected that either the level of research expenditure or increases in the level or both would influence supply levels. The data were examined for evidence to support these hypotheses.

As with scientists numbers, four different measures of research expenditure were computed: absolute level, level relative to livestock population (known here as relative level), increase in absolute level and increase in relative level. The correlation statistics are given in Table 18 - 21, below:

Table 18. Increases in supply and absolute research expenditure: Correlation statistics.

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.10	0.68	18	14.09	*
Sheep and goat meat	0.44	0.07	18	10.37	*
Pig meat	-0.09	0.77	13	55.77	*
Poultry meat	0.65	*	18	28.53	0.01
All meat	0.18	0.49	17	5.66	*
Cow milk	0.18	0.48	18	-1.70	*
All milk	-0.23	0.77	4	2.69	*

When the case of Nigeria is removed from the poultry meat correlation, the statistics are as follows:

Poultry meat	-0.29	0.26	17	75.64	-0.01

3.1.7 Relative Research Expenditure

Table 19. Increases in supply and relative research expenditure: Correlationstatistics

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	-0.01	0.97	18	16.56	-0.14
Sheep and goat meat	-0.33	0.17	18	31.03	-9.80
Pig meat	*	1.00	13	52.29	*
Poultry meat	-0.07	0.80	16	77.30	-16.75
Cow milk	-0.50	0.04	18	13.56	-7.70

* less than 0.1

When Zaire and Ghana are excluded the correlation statistics for cow milk are as follows:

	-0.05	0.86	16	7.80	-0.89

3.1.8 Increase in Absolute Research Expenditure

Correlations were made between increase in absolute research expenditure and supply increases. The statistics are given in Table 20 below.

Table 20. Increase in supply and increase in absolute research expenditure: Correlation statistics

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.68	0.04	9	8.49	0.12
Sheep and goat meat	0.81	0.01	9	5.30	0.15
Pig meat	0.38	0.46	6	36.46	0.08
Poultry meat	0.35	0.32	10	58.22	0.21
All meat	0.78	0.02	8	-16.26	0.19
Cow milk	0.55	0.12	9	-12.83	0.10

(Only two cases exist for all milk, therefore statistics cannot be calculated).

When Kenya is excluded, the beef correlation statistics are as follows:

0.26	0.53	8	11.65	0.95

Again, when Kenya is excluded, the sheep and goat correlation statistics are substantially modified, as follows:

0.62	0.10	8	6.28	0.14

Finally, when Kenya is excluded the all meat correlation statistics are as follows:

0.70	0.08	7	-18.09	0.22

3.1.9 Increases in Relative Research Expenditure

Lastly, correlations were run between increases in supply and increases in relative research expenditure. The statistics are given below:

Table 21. Increase in supply and increase in relative research expenditure: Correlation statistics.

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.67	0.05	9	12.11	0.14
Sheep and goat meat	0.82	0.01	9	12.38	0.12
Pig meat	0.35	0.50	6	39.20	0.09
Poultry meat	0.16	0.71	8	82.94	0.15
Cow milk	0.58	0.10	9	-10.57	0.13

When Kenya is excluded from the beef correlation, the statistics are as follows:

0.26	0.53	8	13.00	0.05

When Kenya and Nigeria are excluded from the sheep and goat meat correlation the statistics are:

0.01	0.98	7	9.73

The above four tables, like those focussing on scientist numbers, do not provide much support to the hypothesis that expenditure on research is associated with increases in supply of livestock products. Although in some cases the correlation coefficient is in excess of 0.5 and significant at modest levels, the correlations are highly dependent on the values of one or two countries. Only in the case of the association between the supply of sheep and goat meat and the absolute level of research expenditure is the result fairly robust after excluding exceptional cases. It is notable that this general finding applies also to cereal output - see Appendix A.10.

The suggested lack of impact of increases in output may be due to either the statistical method used for the analysis or to shortcomings in the research establishment. In the analysis a 3-year lag period was used to allow for the maturation of the fruits of scientific endeavour. This, however, may be unrealistic, considering the slow rate of design and adoption of most innovations. Furthermore, as pointed out in 3.1 above, the data relate to the agricultural sector as a whole and not to livestock production alone.

3.1.10. Veterinary Expenditure, 1965

Data are available for veterinary expenditure in 1965 for some countries. Expenditure per 1000 animals was computed and correlated with increases in supply. Table 22 gives the results.

Table 22. Increases in Supply and Veterinary Expenditure per 1000 head, 1965

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	0.83	*	9	10.03	57.57
Sheep and goat meat	0.10	0.81	8	63.28	10.03
Pig meat	-0.06	0.96	3	271.90	-0.25
Poultry meat	-0.67	0.21	5	-68.23	29.37
Cow milk	-0.07	0.84	11	19.73	-3.73

* = less than 0.01

The strong correlation that is suggested for the beef correlation is wholly dependent on the case of Ivory Coast which recorded an expenditure level of $3.5 per 1000 cattle, greatly in excess of other countries. When Ivory Coast is excluded from the analysis the correlation statistics are as shown in Table 23.

Table 23. Increases in Supply of Beef and Veterinary Expenditure per 1000 head, 1965: Correlation statistics adjusted for the exclusion of Ivory Coast.

Dependent variable (y)	Correlation coefficient	p	n	Intercept	Slope
Beef	0.49	0.22	8	15.09	47.39

It appears, therefore, that 1965 levels of veterinary expenditure were not associated with increases in supply of livestock products at significance levels less than 10%.

3.1.11. Veterinary Expenditure 1977

The correlation was performed between veterinary expenditure per 1000 head in 1977 and increases in supply. Table 24 gives the results.

Table 24. Increases in supply and veterinary expenditure per 1000 head, 1977: Correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	0.79	0.03	7	40.24	19.32
Sheep and goat meat	0.39	0.38	7	57.25	15.25
Pig meat	0.81	0.40	3	193.54	6.02
Poultry meat	0.55	0.63	3	-108.12	96.62
Cow milk	0.07	0.85	9	15.31	1.52

The strong and fairly significant correlation suggested for beef is again due to the case of Ivory Coast, which recorded a level of expenditure of $9.0 per 1000 head of cattle in 1977. When this country is excluded, the correlation statistics are as shown in Table 25.

Table 25. Increases in supply of beef and veterinary expenditure per 1000 head, 1977: adjusted for the exclusion of Ivory Coast.

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	-0.15	0.78	6	64.36	-14.89

Tables 24 and 25 suggest that no association exists between increases in the supply of any livestock product and 1977 veterinary expenditure.

3.1.12. Increase in veterinary expenditure

The suggestion that the level of veterinary expenditure does not influence level of supply was investigated further by correlating proportional increase of veterinary expenditure from 1965 to 1977 with increase in supply. Table 26 gives the results, which only serve to re-inforce the suggestion that veterinary services have had no consistent impact on the supply of livestock products.

Table 26. Increase in supply and proportional increase in veterinary expenditure 1965-1977: Correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	-0.30	0.52	7	97.64	-0.18
Sheep and goat meat	0.52	0.23	7	45.28	0.25
Pig meat	0.85	0.35	3	261.49	0.71
Poultry meat	0.97	0.15	3	-88.01	0.12
Cow milk	0.57	0.11	9	-8.60	0.28

3.2 General Measures for Removing Constraints

The general progress of a nation's economy can affect the supply of livestock products, not only by providing economic incentives on the demand side (as already examined in section 2) but also by improving the general infrastructure in a way that makes supply reponses easier. This section therefore tests the data for associations between livestock output and four macroeconomic variables:

i. The level of gross domestic investment.
ii. The level of public consumption, which is a proxy for the extent of state participation in the economy.
iii. Public expenditure on roads
iv. Government control of marketing agricultural inputs. Clearly in the case of these inputs, the causal chain between independent and dependent variables is not sharply defined.

3.2.1 Level of Gross Domestic Investment

Table 27 below, gives the results of correlating increases in supply with the level of gross domestic investment expressed as the mean percentage of GDP over the period 1960-1979. The correlation statistics suggest that there is no association between increases in supply and the level of gross domestic investment.

Table 27. Increases in supply and level of gross domestic investment: Correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	0.15	0.55	19	27.60	2.12
Sheep and goat meat	-0.11	0.69	16	124.93	-2.54
Pig meat	-0.03	0.95	6	155.04	-0.67
Poultry meat	0.55	0.13	9	-69.56	11.31
All meat	0.01	0.97	17	74.13	0.08
Cow milk	0.31	0.11	28	-48.67	4.78
All milk	0.40	0.16	14	-93.73	10.64

3.2.2 Change in Level of Gross Domestic Investment

Since the 1960s, some countries have experienced increases in the level of gross domestic investment, while others have suffered decreases. An examination was made of the effect of this factor on supply of livestock products - the correlation statistics being given in Table 28 below. It appears that the two variables are not closely associated except in the case of poultry meat: implying that increases in the supply of livestock products are not influenced by changes in the level of gross domestic investment.

Table 28. Increases in supply and change in level of gross domestic investment: Correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	0.11	0.64	20	55.39	1.20
Sheep and goat meat	-0.01	0.97	16	90.23	-0.15
Pig meat	0.40	0.38	7	114.51	6.44
Poultry meat	0.66	0.05	9	-3.21	18.24
All meat	0.12	0.64	17	65.80	1.59
Cow milk	0.17	0.41	27	18.56	2.15
All milk	0.38	0.20	13	15.41	11.34

3.2.3 Level of Public Consumption

An examination was also made of the association between the level of public consumption, expressed as percentage of 1979 GDP and increases in supply. The results are shown in Table 29 below, and suggest that increases in supply occur independently of the level of public consumption, with the possible exception of cow milk.

Table 29. Increases in supply and public consumption levels: Correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	-0.09	0.73	20	79.16	-0.85
Sheep and goat meat	-0.15	0.59	16	129.01	-2.00
Pig meat	0.25	0.64	6	30.10	8.33
Poultry meat	-0.25	0.55	8	266.90	-8.09
All meat	-0.14	0.61	15	111.21	-1.57
Cow milk	0.35	0.07	28	-38.81	4.13
All milk	0.19	0.50	15	9.40	3.23

3.2.4 Growth Rate of Public Consumption

It is possible, that the livestock sector is affected more by changes in public consumption levels, than by the level itself. Table 30 gives the results of correlating increases in supply with the growth rate in public consumption over the period 1970-79.

Table 30. Increases in supply and growth rate in public consumption: Correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	0.12	0.63	19	55.68	1.32
Sheep and goat meat	0.08	0.76	16	85.17	1.39
Pig meat	0.29	0.58	6	92.80	6.05
Poultry meat	0.31	0.49	7	87.73	11.10
All meat	0.12	0.66	15	72.09	1.65
Cow milk	0.43	0.02	28	-0.88	5.53
All milk	0.37	0.21	13	28.51	6.96

From Table 30, it can be seen that there is a significant positive correlation between increases in supply of cow milk and the growth rate of public consumption. However, three individual countries exert a major influence on this relationship, since they have exceptionally high values for both variables, as shown in Table 31:

Table 31. Growth rate of public consumption and increase in cow milk supply

	Growth rate of public consumption (1970-1979)	% change in cow milk supply (1965-1980)
Kenya	9.00	266
Botswana	16.90	255
Mauretania	18.90	121

When these countries are excluded from the correlation, the statistics are modified as shown in Table 32.

Table 32. Increases in supply and growth rate of public consumption: Correlation statistics adjusted for the exclusion of three countries.

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Cow milk	0.12	0.58	25	4.71	0.90

This suggests that increases in the supply of cow milk are not generally associated with the growth rate of public consumption. Moreover Table 30 suggests that for all other products, increases in supply are not associated with the growth rate of public consumption.

3.2.5 Public Expenditure on Roads

Unfortunately data on the proportion of public expenditure devoted to roads is available only for 1978. However, on the assumption that the proportion for individual countries has not changed markedly over the period under consideration, it was felt worthwhile to test for an association between this factor and increases in supply. Table 33 gives the results, which suggest that no association, in fact, exists.

Table 33. Increase in supply and public expenditure devoted to roads (1978): Correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	-0.13	0.63	17	79.23	-2.26
Sheep and goat meat	-0.21	0.44	15	130.34	-5.60
Pig meat	-0.42	0.35	7	236.96	-10.29
Poultry meat	0.48	0.23	8	33.67	14.25
All meat	-0.12	0.68	14	103.21	-2.55
Cow milk	0.27	0.23	22	2.11	5.57
All milk	0.31	0.32	12	20.13	11.68

3.2.6 Government Control of Marketing of Agricultural Inputs

Data are available on the marketing policies of African governments with respect to fertilizer, seed, chemicals and farm equipment. Three different marketing policies are distingushed: government controlled, private and a mixture of private and government.

For each of these four inputs, an analysis of variance (ANOVA) was performed to test if marketing policy had any significant influence on increase in supply of livestock products. Whilst it can be contested that the marketing policy concerning these four crop inputs may be irrelevant to the livestock sector, it was felt that a close correspondence was likely between crop input marketing policies and livestock marketing policies.

Tables 34 to 37 give the ANOVA statistics. In these tables p denotes the probability of differences in increases in supply between groups being due to chance, while n denotes the number of countries in the analysis.

Table 34. Increases in supply and fertilizer marketing policy: ANOVA statistics

Product	p	n
Beef	0.57	22
Sheep and goat meat	0.50	18
Pig meat	0.59	7
Poultry meat	0.01	9
All meat	0.40	17
Cow milk	0.08	29
All milk	0.16	16

Table 35. Increases in supply and seed marketing policy: ANOVA statistics

Product	p	n
Beef	0.86	22
Sheep and goat meat	0.40	18
Pig meat	0.10	7
Poultry meat	0.46	9
All meat	0.97	17
Cow milk	0.07	29
All milk	0.12	16

Table 36. Increases in supply and chemicals marketing policy: ANOVA statistics

Product	p	n
Beef	0.20	22
Sheep and goat meat	0.39	18
Pig meat	0.44	7
Poultry meat	0.01	9
All meat	0.32	17
Cow milk	0.41	29
All milk	0.12	16

Table 37. Increases in supply and farm equipment marketing policy: ANOVA statistics

Product	p	n
Beef	0.55	22
Sheep and goat meat	0.83	18
Pig meat	0.70	7
Poultry meat	0.04	9
All meat	0.73	17
Cow milk	0.78	29
All milk	0.53	16

Tables 34-37 suggest that government policy towards the marketing of crop inputs has an effect only on increases in poultry meat supply, although this does not apply in the case of seed marketing. Group means are shown in Table 38.

Table 38. Percentage increases in supply of poultry meat, 1965-1980: group means according to marketing policy. Standard deviation and number of countries in each group in parentheses.

	Private	Government	Mixed
Fertilizer		34 (26,4)	198 (87,5)
Chemicals		34 (26,4)	198 (87,5)
Farm Equipment	178 (*,1)	34 (26,4)	200 (100,4)

* = not applicable since only one country in this group

The conclusion suggested by Table 38 is that substantially higher increases in poultry meat production occur when marketing of fertilizer, chemicals and farm equipment is in the hands of government and private enterprises, rather than under the control of government enterprises alone.

4. The Effect of Livestock Population Growth

So far, the study has found few factors that explain the increases (and in some cases, decreases) that have occurred in the supply of livestock products from 1965 to 1981. The question, inevitably, arises as to whether changes in supply are largely a function of changes in animal populations. Thus increase in supply was correlated with population increases, and strong correlations were found in all cases except pig meat and cow milk. The statistics are given in Table 39.

Table 39. Increase in supply and increase in population: correlation statistics

Dependent variable (y)	Correlation coefficient	p.	n.	Intercept	Slope
Beef	0.58	*	22	25.77	0.68
Sheep and goat meat	0.76	*	18	1.63	1.32
Pig meat	0.59	0.16	7	57.70	0.51
Poultry meat	0.84	*	9	27.72	1.41
All meat	0.78	*	17	13.76	1.40
Cow milk	0.08	0.69	31	22.44	0.10
All milk	0.69	*	16	-8.82	1.55

* = less than 0.01

The above statistics suggest that increases in livestock populations have been an important factor in the increase of all products except pig meat and cow milk. The percentage of variation explained by this single factor, the square of the correlation coefficient above, is given in Table 40, below.

Table 40. Percentage of variation explained by increases in population.

	% of variation
Beef	34%
Sheep and Goat meat	58%
Poultry meat	71%
All meat	35%
All milk	48%

The slope of the regression line shown in Table 39 is equivalent to the percentage increase in output that is associated with a 1% increase in livestock population.
Perhaps the surprising point suggested by Table 39 is the lack of any correlation between increases in the output of cow milk and increases in cattle population.

However the implication of this conclusion is very serious for it implies that increases in population have been a major cause of increased supply. Without a major breakthrough in the control of trypanosomiasis, few countries in Africa can continue to support expanding livestock populations, and thus cannot continue to rely so heavily on this factor as they appear to have done in the past.

Unfortunately, this study has not estimated improvements in the efficiency of livestock production per se, but the evidence presented above (in the sections on research and veterinary services) would point to a small improvement, if any. Whatever the improvement in efficiency of resource use in livestock systems, the point remains that increases in output must come from higher efficiencies and not from a natural expansion of populations as in the past.

5. The Quality of the Data and its Effect on the Results of this Study

In this study output and livestock population data were taken from FAO Production Yearbooks. The data on climatic zone were from Jahnke (1982) while those concerning veterinary services was provided by Addis Antennah (1983). Oram and Bindlish (1981) provided the data on scientist numbers and research expenditure. The remainder of the data, i.e. the macro-economic data, were taken from World Bank (1981) and (1982), (see Appendix A.9).
IFPRI (1981) draws attention to the problem of inaccurate data on African agriculture. It points out that estimates compiled by alternative bodies can be markedly different. The example is given of FAO and USDA estimates of cereal production in Africa where, for the countries reported in common by the two systems, differences "reached 14% for wheat in 1975, 21% for maize in 1970 and as high as 45% for millet in 1965".

In this study, three year means (1964,65,66 and 1979,80,81) were used wherever possible. This improves the efficiency of estimates and reduces the influence of freak years. Where a run of three years was not available, a mean of two years was computed or a single estimate was used.
A second measure taken in this study to counter spurious results due to poor data, was the exclusion of countries with small livestock populations. This was done on the grounds that rounding estimates to the nearest thousand units can distort other variables based on them. For instance, the pig population for Botswana was reported at 1 000 in 1965 and 6 000 in 1980, indicating an increase of 500%. However the real,"unrounded" populations may have been 1 450 in 1965 and 5 550 in 1980, giving an increase of only 283%. By setting a minimum population condition, which is described in Appendix A.2, it is hoped that this type of distortion is generally avoided.
However the possibility of poor data quality for countries with sizeable populations remained and it was evident that serious inaccuracies did indeed persist. For instance, for Mozambique the chicken population in 1965 was reported to be 148 000; by 1980 this had grown to 16 833 000, a purported increase of over 11 000% in 15 years and greatly in excess of all other countries. These data were obviously suspect and were thus excluded from the analysis. This was the only case of exclusion of data on grounds of suspicion during the study.

Other examples encountered of suspect data included:

Botswana increase in cow milk:	255%
Somalia increase in cereal yield:	181%

The exclusion of such countries, and others with exceptional values, from the correlations was discussed in 1.3.4 on the grounds that they may be countries for which a different production function applies. However their removal may be equally valid on the grounds that the estimates are very inaccurate. In such a case the adjusted correlations would more truly reflect the real situation.
Despite these three measures, serious inaccuracies are likely to persist in the data. Indeed it is felt that a major reason for the lack of correlations found in this study is likely to be the poor quality of the data. This perhaps is one of the few important findings of the study and, considering the vital need for good quality data, warrants serious attention.

APPENDIX

A.1. Time period

The study covers the period 1964/6 to 1979/81. The starting point of 1964/6 was chosen in preference to 69/71 to avoid exaggerating output and population growth rates for those countries that were affected by the Sahelian drought 1968-73. It must be noted however that by 79/81, the ruminant populations in these countries had not fully recovered to their pre-drought levels, let alone attained the level that they may have reached had the drought not occurred. Output levels, and particularly output rates, for 79/81 will therefore be less than their 'no-drought level' since producers were still restocking. Thus, although the starting point of the study (64/6), which is described, for short, as 1965 in the text, precedes the drought, the end point (79/81), which is decribed as 1980 in the text, occurs when producers are still reacting to its long-term effects.

A.2. Countries Included

The analysis does not extend to all 47 countries in Sub-Saharan Africa, which is taken as excluding Namibia. Rather, it focusses on five different 'country sets' which range in size from 21 to 31 countries. To be member of a country set, a country had to satisfy two conditions:

a. inclusion in World Bank (1981) since this was the main source of macro-economic data. The report covers 39 countries, and excludes those with human populations of less than half a million (St.Helena, Reunion) and those for whom macro-economic data is particularly deficient (Cape Verde, Comoros, Djibouti, Equatorial Guinea, Sao Tome and Principe, and Seychelles).

b. support a 'reasonably sized' population of animals from which the product in question is derived. This condition was set to avoid distorting the analysis with spurious estimates of computed variables (such as growth rates, offtake rates, etc.) derived from small base estimates, since the latter are subject to large proportionate errors due to rounding. (See the example given for the pig poplation of Botswana in section 5, above.) By setting a minimum population condition it is hoped that this type of distortion is generally avoided.

The minimum populations specifying each country set and the size of the country set are given below in Table A1. It will be noted that the same country set is used for beef and cow milk. For the commodity 'all meat' minimum populations were specified for cattle and small ruminants only, since for all countries, except Nigeria, the great majority of meat is produced by these species. If pig and poultry population conditions had been applied the country set would have comprised only 15 members which was felt to be unsatisfactorily low. The country set for all meat is therefore the same as that for all milk. The members of each country set are listed in Table A2.

Table A1. - Minimum population conditions (1979/81) and size of country sets

Commodity	Minimum population	Size of country set
1. Beef	0.5 m cattle	31
2. Sheep and goat meat	0.5 m sheep and goats	29
3. Pig meat	0.1 m pigs	21
4. Poultry meat	2.0 m chickens	29
5. All meat	0.5 m cattle and 0.5 m sheep and goats	28
6. Cow milk	0.5 m cattle	31
7. All milk	0.5 cattle and 0.5 sheep and goats	28

Table A2. Members of Country Sets

Beef Cow Milk	Sheep and Goat Meat	Pigmeat	Poultry meat	All meat All Milk
Angola	Angola	Angola	Angola	Angola
Benin	Benin	Benin	Benin	Benin
Botswana	Botswana			Botswana
Burundi	Burundi		Burundi	Burundi
Cameroon	Cameroon	Cameroon	Cameroon	Cameroon
C.A.R.	C.A.R.	C.A.R		C.A.R.
Chad	Chad		Chad	Chad
Ethiopia	Ethiopia		Ethiopia	Ethiopia
Ghana	Ghana	Ghana	Ghana	Ghana
Guinea	Guinea		Guinea	Guinea
		Guinea-Bissau		
Ivory Coast	Ivory Coast	Ivory Coast	Ivory Coast	Ivory Coast
Kenya	Kenya		Kenya	Kenya
Lesotho	Lesotho			Lesotho
		Liberia	Liberia	
Madagascar	Madagascar	Madagascar	Madagascar	Madagascar
Malawi	Malawi	Malawi	Malawi	Malawi
Mali	Mali		Mali	Mali
Mauritania	Mauritania		Mauritania	Mauritania
Mozambique		Mozambique	Mozambique	
Niger	Niger		Niger	Niger
Nigeria	Nigeria	Nigeria	Nigeria	Nigeria
Rwanda	Rwanda	Rwanda		Rwanda
Senegal	Senegal	Senegal	Senegal	Senegal
			Sierra Leone	
Somalia	Somalia		Somalia	Somalia
Sudan	Sudan		Sudan	Sudan
Swaziland				
Tanzania	Tanzania	Tanzania	Tanzania	Tanzania
	Togo	Togo	Togo	
Uganda	Uganda	Uganda	Uganda	Uganda
Upper Volta	Upper Volta	Upper Volta	Upper Volta	Upper Volta
Zaire	Zaire	Zaire	Zaire	Zaire
Zambia		Zambia	Zambia	
Zimbabwe	Zimbabwe	Zimbabwe	Zimbabwe	Zimbabwe
(31)	(29)	(21)	(29)	(28)

A.3. Definition of Output

The output data has been taken from FAO Production Yearbooks. Output refers to indigenous production and therefore includes the meat equivalent of exported live animals, and excludes that of imported live animals. Output and supply are synonomous.

A.4. Data Availability

The country sets represent the maximum number of observations for the analysis of sector performance. Unfortunately, data for the period 1964-66, particularly, is far from complete. This makes it impossible to compute 65-80 growth rates (of population, output, expenditure etc...) from some countries and thus severely restricts the study's dynamic analysis. Table A3 below shows the availability of output data in 1964-66 for each of the seven commodities.

Table A3. - Number of countries for which 64-66 output data is available

Commodity	Size of country set	Countries with available data
1. Beef	31	22
2. Sheep and goat meat	29	18
3. Pig meat	21	8
4. Poultry meat	29	7
5. All meat	29	24
6. Cow milk	31	31
7. All milk	28	28

It is very important to bear in mind the paucity of data when interpreting the tables and correlations. Thus it is not necessarily true to conclude that Ivory Coast of all countries in sub-Saharan Africa has recorded the largest proportionate increase in beef output since 1965. The conclusion is restricted to "of those countries with more than 0.5 million cattle and for which data are available, Ivory Coast has recorded the largest increase in beef output".

A.5. Climatic zone.

The data on climatic zone were taken from Jahnke (1982): Livestock Production Systems and Livestock Development in Tropical Africa, Annex Tables 7 to 10. Five climatic zones are identified: arid, semi-arid, subhumid, humid and highland. For each country, the cattle sheep and goat populations are disaggregated according to the climatic zone in which they are found.
The zone containing the greatest proportion of the species population has been taken as the zone for the whole country. Pig and poultry were not broken down by climatic zone, and therefore these two products, together with all meat, cannot realistically be included in the analysis. The Sahelian zone was added and was taken as including Senegal, Mali, Mauretania, Niger, Chad, and Upper Volta. Data on climatic zone were not given for Lesotho or Swaziland.

A.6. All milk.

In 1964, 1965 and 1966, estimates were made of cow milk and all milk and covered all countries. By 1979 this had changed to cow milk and sheep and goat milk. Whilst 1979, 1980 and 1981 estimates of cow milk covered all countries, this was not true for the estimates of sheep and goat milk. Thus estimates for 1979, 1980 and 1981 all milk, which have been calculated as the sum of cow milk and sheep and goat milk, do not extend to all countries, as can be seen in Table A10.
FAO give values for all milk for 1965 which results in a complete data set. However, by 1979 two separate products, sheep milk and goat milk, appear in the production yearbooks, although estimates are absent for some countries. Since cow milk, sheep milk and goat milk are all felt to be important components of all milk their omission would cause all milk 1980 to be underestimated, distorting the increases 1965-80. Therefore if values for any one of these three components was missing, a value for all milk was not computed. It is this condition that causes Table A10 to appear anomalous: normally, more estimates for 1980 all milk would be available than for 1965 all milk. The condition that estimates for all three components of 1980 all milk must be available has caused the converse.

A.7. All meat

a) All meat for 1965 is the sum of beef, sheep and goat, pig and poultry. However, it is only computed for those countries for which values for both beef output and sheep and goat meat output exist. This is because both these were felt to be the major outputs, and without either of them, then a value of all meat would be misleading.
If values for pig and poultry meat are missing, then the value for all meat is still computed. Hence all meat always includes beef and sheep and goat, and will include pig and poultry when these are available.
In the calculation of the percent change in all meat 1965-80, it was important to compare like with like. For instance, for country X, all meat 1965 may consist of beef and sheep and goat only, because values for pig and poultry were not available. For all meat 1980, only beef and sheep and goat will be included, irrespective of whether pig and poultry are available. The reason for this is that for some countries pig and poultry meat is, proportionately, very important: this applies to Ghana (pigs) and Nigeria (poultry). In such cases, when 1965 values for pigs and poultry do not exist, all meat 1965 will not include them. If they exist for 1980, however, they are excluded, otherwise the all meat value for 1980 will not compose the same elements as all meat 1965, and therefore the magnitude of the increases will not be based on the same set of products.
The consequence is that all meat 1980 may be less than the sum of beef, sheep and goat, pig and poultry. But the size of the increase is based on the same set of products, which is the more important consideration.
The 1980 population conditions that prescribe the all meat country set are not applied for the calculation of all meat. Thus, for a country with less than 100 000 pigs, pig meat will be an element in all meat output, for both 1965 and 1980.
The values of all meat for 1972,73 and 74, used for the analysis of research expenditure and scientist numbers, were calculated as three year means. The values for individual years, i.e. 1971-75, were taken from directly from FAO Production Yearbooks for which values were given.

For the change in all meat 1972-80, 1973-80, and 1974-80, the uncorrected all meat 1980 value was used - this being the sum of all products, where values existed, and not having been corrected for missing elements in 1965, as is the case with change in all meat 1965-80. The reason for this is that it was felt that all meat values (1971-75) given by FAO would include an estimate of the four products.

A.8. Research and Cereal Output

The question arose during the course of this study as to whether cereal yields were influenced by research expenditure and scientist numbers. It has been seen earlier that increases in output of livestock products were not consistently correlated with these two crucial factors, and this may be due to the tendency for the bulk of agricultural research to be devoted to the cropping sector.
Table A16 below gives the statistics for the correlation of increases in cereal yields and research expenditure (both 1971 absolute level, and proportional increase in constant dollar terms from 1971 to 1979). Increase in cereal yield was calculated as the proportional change from 1973 to 1980 (three year means being used for both dates) thus allowing for a two year lag.

Table A16. Increases in cereal yields (y) and research expenditure (x): Correlation statistics

Independent variable (x)	Correlation coefficient	p	n	Intercept	Slope
Absolute expenditure	-0.10	0.64	26	12.45	*
Increase in expenditure	0.31	0.35	11	-2.32	0.05

It thus appears that the absolute level of expenditure on research is not associated with improvements in cereal yields. Countries which made the largest committment to agricultural research in 1971 did not necessarily obtain the largest increases in cereal yields and may, in fact, have suffered deteriorations.
Furthermore, it appears that increases in research expenditure do not promote corresponding increases in cereal yields. Indeed, some countries that have increased research expenditure have experienced decreases in cereal yields, while the converse applies to some countries that have decreased expenditure.
Table A17 below gives the statistics for correlations of increases in cereal yield and 1971 scientist numbers (both absolute number and proportional increase from 1971 to 1980).

Table A17. Increases in cereal yields (y) and scientist numbers (x) correlation statistics.

Independent variable (x)	Correlation coefficient	p	n	Intercept	Slope
Absolute numbers	-0.17	0.40	26	14.71	-0.06
Increase in numbers	0.42	0.23	10	-4.91	0.09

The disturbing conclusion concerning the impact of research on cereal yields is only reinforced by Table A17. This suggests that neither the absolute number of scientists in the agricultural sector, nor increases in their number, had any consistent impact on cereal yields.
This suggested lack of impact may be due to a variety of reasons concerning the agricultural research establishment, and to the statistical method used in this study. Firstly the research establishment in Africa may simply have been ineffectual during the seventies or may have been concentrated in the cash crop sector. Secondly, increase in cereal yields has been calculated as the difference between yields at the beginning and end of the decade. Although three year means were used, poor yields in an individual year, due to drought, will exert some influence on the mean value, and cause a distortion. If the slope of a regression line of yield on time had been used, distortion due to stochastic shocks may be largely avoided. To allow scientists a period of two years before the fruits of research are felt, may be unrealistic. For instance, cereal breeding programmes take at least five years, although not all scientists are confined to breeding programmes.
Lastly, there exists the ever-present possibility of inaccurate data, a worrying prospect considering the cost of data compilation and the reliance generally given to them (see section 5).

A.9. Data sources

The following source were consulted:

1. Addis Antenneh. "Financing Animal Health Services in Some African Countries" ILCA. Unpublished mimeo. 1983
2. FAO. FAO Production Yearbooks, various years.
3. IFPRI. Food Policy Issues and Concerns in sub-Saharan Africa. IFPRI, 1981
4. Jahnke, H. "Livestock Production Systems and Livestock Development in Tropical Africa". KWV 1982
5. Oram and Bindlish "Resource Allocations to National Agricultural Research: Trends in the 1970s" ISNAR,IFPRI. 1981
6. World Bank "Accelerated Development in Sub-Saharan Africa" World Bank 1981.
7. World Bank "World Development Report 1982" World Bank 1982

Table A4. Output of Beef 1965, 1980 and percentage change 1965-1980.

Country	1965 Output ('000 mt)	1980 Output ('000 mt)	Percentage change 1965-80
1. Angola		49	
2. Benin		10	
3. Botswana	22	40	81
4. Burundi	7	14	105
5. Cameroon	25	48	93
6. Central African Republic	7	16	133
7. Chad	44	58	33
8. Ethiopia	299	214	-6
9. Ghana	7	13	86
10. Guinea	17	21	25
11. Guinea Bissau	*	*	*
12. Ivory Coast	4	12	218
13. Kenya		198	
14. Lesotho	12	8	-36
15. Liberia	*	*	*
16. Madagascar	176	127	-28
17. Malawi		12	
18. Mali	43	64	47
19. Mauritania	24	29	18
20. Mozambique		36	
21. Niger	43	46	6
22. Nigeria	133	204	53
23. Rwanda	6	14	126
24. Senegal	25	34	38
25. Sierra Leone	*	*	*
26. Somalia	19	55	196
27. Sudan	100	206	106
28. Swaziland	12	15	22
29. Tanzania	117	130	11
30. Togo	*	*	*
31. Uganda	102	82	-19
32. Upper Volta		37	
33. Zaire		22	
34. Zambia		26	
35. Zimbabwe		113	
Mean (unweighted)			59

* 1980 cattle population was less than 0.5 m, therefore this country is not a member of the country set.
Blanks in the table indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A5. Output of Sheep and Goat meat 1965, 1980 and percentage change.

Country	1965 Output ('000 mt)	1980 Output ('000 mt)	Percentage change 1965-80
1. Angola		3	
2. Benin		5	
3. Botswana		4	
4. Burundi	2	3	67
5. Cameroon	7	15	105
6. Central African Republic		3	
7. Chad	11	21	88
8. Ethiopia	87	132	51
9. Ghana	5	11	113
10. Guinea		2	
11. Guinea Bissau	*	*	*
12. Ivory Coast	4	7	100
13. Kenya		38	
14. Lesotho	10	5	-50
15. Liberia	*	*	*
16. Madagascar		5	
17. Malawi		3	
18. Mali	31	50	59
19. Mauritania	15	19	21
20. Mozambique	*	*	*
21. Niger	24	42	73
22. Nigeria	100	163	64
23. Rwanda	1	4	300
24. Senegal	7	8	25
25. Sierra Leone	*	*	*
26. Somalia	20	85	316
27. Sudan	47	136	188
28. Swaziland	*	*	*
29. Tanzania	32	26	-19
30. Togo		3	
31. Uganda	28	14	-51
32. Upper Volta	6	10	67
33. Zaire		9	
34. Zambia	*	*	*
35. Zimbabwe		6	
Mean (unweighted)			84

* 1980 sheep and goat population was less than 0.5 m, therefore this country is not a member of the country set.
Blanks in the table indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A6. Output of pig meat 1965, 1980 and percentage change.

Country	1965 Output ('000 mt)	1980 Output ('000 mt)	Percentage change 1965-80
1. Angola		13	
2. Benin		12	
3. Botswana	*	*	*
4. Burundi	*	*	*
5. Cameroon	8	26	221
6. Central African Republic		4	
7. Chad	*	*	*
8. Ethiopia	*	*	*
9. Ghana	5	9	80
10. Guinea	*	*	*
11. Guinea Bissau		3	
12. Ivory Coast	3	13	333
13. Kenya	*	*	*
14. Lesotho	*	*	*
15. Liberia	3	3	0
16. Madagascar		25	
17. Malawi		7	
18. Mali	*	*	*
19. Mauritania	*	*	*
20. Mozambique		8	
21. Niger	*	*	*
22. Nigeria	22	42	88
23. Rwanda	1	2	100
24. Senegal	2	7	250
25. Sierra Leone	*	*	*
26. Somalia	*	*	*
27. Sudan	*	*	*
28. Swaziland	*	*	*
29. Tanzania		4	
30. Togo		7	
31. Uganda		11	
32. Upper Volta		4	
33. Zaire		27	
34. Zambia		7	
35. Zimbabwe		9	
Mean (unweighted)			153

* 1980 pig population was less than 0.1 m, therefore this country is not a member of the country set.
Blanks in the table indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A7. Output of Poultry meat 1965, 1980 and percentage change.

Country	1965 Output ('000 mt)	1980 Output ('000 mt)	Percentage change 1965-80
1. Angola		7	
2. Benin		5	
3. Botswana	*	*	*
4. Burundi	1	3	114
5. Cameroon	4	12	178
6. Central African Republic	*	*	*
7. Chad		3	
8. Ethiopia	48	59	25
9. Ghana		17	
10. Guinea		10	
11. Guinea Bissau	*	*	*
12. Ivory Coast	6	22	258
13. Kenya		13	
14. Lesotho	*	*	*
15. Liberia		3	
16. Madagascar	20	44	122
17. Malawi	2	9	315
18. Mali	7	11	45
19. Mauritania		3	
20. Mozambique		16	
21. Niger		7	
22. Nigeria		212	
23. Rwanda	*	*	*
24. Senegal	5	8	62
25. Sierra Leone		5	
26. Somalia		3	
27. Sudan		21	
28. Swaziland	*	*	*
29. Tanzania	17	17	2
30. Togo		6	
31. Uganda		19	
32. Upper Volta		11	
33. Zaire		13	
34. Zambia		11	
35. Zimbabwe		9	
Mean (unweighted)			125

* 1980 poutry population was less than 2.0 m, therefore this country is not a member of the country set.
Blanks in the table indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A8. Output of all meat 1965, 1980 and percentage change.

Country	1965 Output ('000 mt)	1980 Output ('000 mt)	Percentage change 1965-80
1. Angola		72	
2. Benin		31	
3. Botswana		45	
4. Burundi	10	20	100
5. Cameroon	44	100	126
6. Central African Republic		24	
7. Chad	55	79	44
8. Ethiopia	364	406	12
9. Ghana	17	33	94
10. Guinea		34	
11. Guinea Bissau	*	*	*
12. Ivory Coast	17	54	228
13. Kenya		272	
14. Lesotho	22	12	-45
15. Liberia	*	*	*
16. Madagascar		201	
17. Malawi		30	
18. Mali	83	125	51
19. Mauritania	40	48	20
20. Mozambique	*	*	*
21. Niger	67	88	31
22. Nigeria	255	409	60
23. Rwanda	8	20	150
24. Senegal	38	57	30
25. Sierra Leone	*	*	*
26. Somalia	39	140	259
27. Sudan	148	342	131
28. Swaziland	*	*	*
29. Tanzania	166	173	4
30. Togo	*	*	*
31. Uganda	130	96	-26
32. Upper Volta		61	
33. Zaire		71	
32. Zambia	*	*	*
35. Zimbabwe		137	
Mean (unweighted)			76

* 1980 cattle population was less than 0.5 m and 1980 sheep and goat population was less than 0.5m therefore this country is not a member of the country set.
Blanks in the table indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A9. Output of Cow milk 1965, 1980 and percentage change.

Country	1965 Output ('000 mt)	1980 Output ('000 mt)	Percentage change 1965-80
1. Angola	135	146	8
2. Benin	7	12	75
3. Botswana	25	90	255
4. Burundi	33	56	68
5. Cameroon	46	43	-8
6. Central African Republic	21	4	-81
7. Chad	155	220	42
8. Ethiopia	453	617	36
9. Ghana	5	8	60
10. Guinea	77	41	-47
11. Guinea Bissau	*	*	*
12. Ivory Coast	8	9	22
13. Kenya	229	840	266
14. Lesotho	25	20	-22
15. Liberia	*	*	*
16. Madagascar	30	36	18
17. Malawi	28	34	21
18. Mali	91	95	5
19. Mauritania	42	94	121
20. Mozambique	51	63	24
21. Niger	97	95	-2
22. Nigeria	388	354	-9
23. Rwanda	35	26	-26
24. Senegal	94	110	17
25. Sierra Leone	*	*	*
26. Somalia	84	157	86
27. Sudan	1117	939	-16
28. Swaziland	23	37	57
29. Tanzania	531	729	37
30. Togo	*	*	*
31. Uganda	391	338	13
32. Upper Volta	59	44	-26
33. Zaire	20	6	-70
34. Zambia	57	47	-17
35. Zimbabwe	221	202	-9
Mean (unweighted)			28

* 1980 cattle population was less than 0.5 m, therefore this country is not a member of the country set.
Blanks in the table indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A10. Output of all milk 1965, 1980 and percentage change.

Country	1965 Output ('000 mt)	1980 Output ('000 mt)	Percentage change 1965-80
1. Angola	135		
2. Benin	7	17	150
3. Botswana	25	93	267
4. Burundi	37	60	61
5. Cameroon	46		
6. Central African Republic	21		
7. Chad	200	232	16
8. Ethiopia	546	693	27
9. Ghana	5		
10. Guinea	77	43	-45
11. Guinea Bissau	*	*	*
12. Ivory Coast	8		
13. Kenya	229	871	280
14. Lesotho	25		
15. Liberia	*	*	*
16. Madagascar	30		
17. Malawi	28		
18. Mali	185	131	-29
19. Mauretania	134	156	17
20. Mozambiqu	*	*	*
21. Niger	218	169	-23
22. Nigeria	388		
23. Rwanda	35	31	-12
24. Senegal	118	118	0
25. Siera Leone	*	*	*
26. Somalia	84	346	310
27. Sudan	1575	1195	-24
28. Swaziland	*	*	*
29. Tanzania	531	784	48
30. Togo	*	*	*
31. Uganda	428		
32. Upper Volta	75	55	-27
33. Zaire	20		
34. Zambia	*	*	*
35. Zimbabwe	221		
mean (unweighted)			64

* 1980 cattle population was less than 0.5m, therefore this country is not a member of the country set.
Blanks in the table indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A11. Cattle Population 1965, 1980 and Growth Rate (% p.a.).

Country	Population 1965 (000 head)	Population 1980 (000 head)	Growth Rate (% p.a.)
1. Angola	1100	3117	7
2. Benin	404	766	4
3. Botswana	1120	2954	7
4. Burundi	506	846	3
5. Cameroon	1741	3195	4
6. Central African Republic	442	1236	7
7. Chad	4000	3900	0
8. Ethiopia	25433	26000	0
9. Ghana	583	943	3
10. Guinea	1660	1753	0
11. Guinea Bissau		200	
12. Ivory Coast	317	690	5
13. Kenya	7613	10652	2
14. Lesotho	300	595	5
15. Liberia	23	39	*
16. Madagascar	8876	10100	1
17. Malawi	430	821	4
18. Mali	4558	4953	1
19. Mauritania	1817	1195	-3
20. Mozambique	1117	1400	2
21. Niger	3890	3206	-1
22. Nigeria	11080	12267	1
23. Rwanda	583	640	1
24. Senegal	2035	2344	1
25. Sierra Leone	200	343	*
26. Somalia	1850	3883	5
27. Sudan	9407	3148	4
28. Swaziland	515	663	2
29. Tanzania	9791	2556	2
30. Togo	165	230	*
31. Uganda	3529	1933	2
32. Upper Volta	2200	2755	2
33. Zaire	838	1183	2
34. Zambia	1281	2152	4
35. Zimbabwe	3525	5370	3

* 1980 cattle population was less than 0.5 m, therefore this country is not a member of the country set.
Blanks in the data indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A12. Sheep Population 1965, 1980 and Growth Rate (% p.a.).

Country	Population 1965 (000 head)	Population 1980 (000 head)	Growth Rate (% p.a.)
1. Angola	121	225	4
2. Benin	441	954	5
3. Botswana	138	146	0
4. Burundi	151	310	5
5. Cameroon	1175	2168	4
6. Central African Republic	110	84	-2
7. Chad	2000	2333	1
8. Ethiopia	11803	23233	5
9. Ghana	688	1683	6
10. Guinea	403	436	1
11. Guinea Bissau		50	*
12. Ivory Coast	594	1200	5
13. Kenya	6700	4333	-3
14. Lesotho	1455	1129	-2
15. Liberia	128	200	*
16. Madagascar	337	590	4
17. Malawi	77	77	0
18. Mali	4833	6200	2
19. Mauritania	2825	5100	4
20. Mozambique	101	106	*
21. Niger	2097	2805	2
22. Nigeria	7500	11683	3
23. Rwanda	167	290	4
24. Senegal	1031	2005	5
25. Sierra Leone	28	260	*
26. Somalia	3933	10100	6
27. Sudan	8949	17708	5
28. Swaziland	38	45	*
29. Tanzania	2820	3782	2
30. Togo	560	810	2
31. Uganda	802	1072	2
32. Upper Volta	1300	1852	2
33. Zaire	557	733	2
34. Zambia	33	49	*
35. Zimbabwe	407	448	1

* 1980 sheep and goat population was less than 0.5 m, therefore this country is not a member of the country set.
Blanks indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A13. Goat Population 1965, 1980 and Growth Rate (% p.a.).

Country	Population 1965 (000 head)	Population 1980 (000 head)	Growth Rate (% p.a.)
1. Angola	372	935	6
2. Benin	531	919	4
3. Botswana	370	625	4
4. Burundi	385	650	4
5. Cameroon	1742	2391	2
6. Central African Republic	500	920	4
7. Chad	2000	2267	1
8. Ethiopia	10949	17177	3
9. Ghana	700	2067	7
10. Guinea	409	405	0
11. Guinea Bissau		120	*
12. Ivory Coast	737	1250	4
13. Kenya	6300	4537	-2
14. Lesotho	823	777	0
15. Liberia	120	200	*
16. Madagascar	424	1308	8
17. Malawi	472	645	2
18. Mali	5183	6750	2
19. Mauritania	2040	2583	2
20. Mozambique	434	335	*
21. Niger	5506	7023	2
22. Nigeria	22000	24567	1
23. Rwanda	415	875	5
24. Senegal	1260	1067	-1
25. Sierra Leone	34	144	*
26. Somalia	4307	16267	9
27. Sudan	7080	12532	4
28. Swaziland	229	262	*
29. Tanzania	4374	5673	2
30. Togo	487	723	3
31. Uganda	2001	2155	0
32. Upper Volta	2129	2794	2
33. Zaire	1407	2751	5
34. Zambia	163	310	*
35. Zimbabwe	593	1107	4

* 1980 sheep and goat population was less than 0.5 m, therefore this country is not a member of the country set.
Blanks indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A14. Pig Population 1965, 1980 and Growth Rate (% p.a.).

Country	Population 1965 (000 head)	Population 1980 (000 head)	Growth Rate (% p.a.)
1. Angola	307	400	2
2. Benin	329	453	2
3. Botswana	1	6	*
4. Burundi	5	34	*
5. Cameroon	266	1196	11
6. Central African Republic	17	132	15
7. Chad		6	*
8. Ethiopia	12	18	*
9. Ghana	280	410	3
10. Guinea	20	39	*
11. Guinea Bissau		115	
12. Ivory Coast	114	340	8
13. Kenya	35	76	*
14. Lesotho	61	83	*
15. Liberia	68	103	3
16. Madagascar	464	671	2
17. Malawi	122	179	3
18. Mali	25	44	*
19. Mauritania			
20. Mozambique	108	120	1
21. Niger	19	31	*
22. Nigeria	720	1100	3
23. Rwanda	31	128	10
24. Senegal	48	190	10
25. Sierra Leone	8	36	*
26. Somalia	5	9	*
27. Sudan	5	8	*
28. Swaziland	8	20	*
29. Tanzania	17	160	16
30. Togo	213	329	3
31. Uganda	29	240	15
32. Upper Volta	123	174	2
33. Zaire	385	716	4
34. Zambia	75	224	8
35. Zimbabwe	130	144	1

* 1980 pig population was less than 0.1 m, therefore this country is not the country set.
Blanks indicate absence of data.
The 1965 estimate is the mean for the three years 1964,1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.

Table A15. Chicken Population 1965, 1980 and Growth Rate (% p.a.).

Country	1965 Population	1980 Population	Growth Rate (% p.a.)
1. Angola		5400	
2. Benin	4000	3917	0
3. Botswana	89	814	*
4. Burundi	1550	3100	5
5. Cameroon	5270	10404	5
6. Central African Republic	900	1551	*
7. Chad		3200	
8. Ethiopia	42500	53000	1
9. Ghana	7835	11833	3
10. Guinea		7083	
11. Guinea Bissau		400	*
12. Ivory Coast	6333	11600	4
13. Kenya	8667	16803	5
14. Lesotho		832	*
15. Liberia	1400	2433	4
16. Madagascar	11367	14667	2
17. Malawi	2586	8050	8
18. Mali	12000	11833	0
19. Mauritania		3093	
20. Mozambique	148	16833	37
21. Niger	5500	7700	2
22. Nigeria	48030	120000	6
23. Rwanda		1100	*
24. Senegal	4937	6666	2
25. Sierra Leone	2000	3723	4
26. Somalia	4400	2900	-3
27. Sudan		26795	
28. Swaziland	322	640	*
29. Tanzania	16206	22357	2
30. Togo	1391	2697	5
31. Uganda	8420	13200	3
32. Upper Volta	3226	11055	9
33. Zaire		14833	
34. Zambia	5000	12667	6
35. Zimbabwe	788	8800	17

* 1980 chicken population was less than 2.0 m, therefore this country is not a member of the country set.
Blanks in the table indicate absence of data.
The 1965 estimate is the mean for the three years 1964, 1965 and 1966.
The 1980 estimate is the mean for the three years 1979, 1980 and 1981.
Source: FAO Production Yearbooks.