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HANS E. JAHNKE

LIVESTOCK PRODUCTION SYSTEMS AND LIVESTOCK DEVELOPMENT IN TROPICAL AFRICA

KIELER WISSENSCHAFTSVERLAG VAUK

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Livestock Production Systems and Livestock
Development in Tropical Africa

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IN MEMORIAM

HANS RUTHENBERG

(1928 - 1980)

FOREWORD

by

Dr.P.Brumby
Director General, ILCA

Livestock are vital to subsistence and economic development in sub-Saharan Africa. They provide a flow of essential food products throughout the year, are a major source of government revenue and export earnings, sustain the employment and income of millions of people in rural areas, contribute draught energy and manure for crop production and are the only food and cash security available to many Africans. The sale of livestock and their products often constitutes the only source of cash income in rural areas, and hence the only way in which subsistence farmers can buy consumer goods and procure the improved seeds, fertilizers and pesticides needed to increase crop yields. Where livestock development has been successfully pursued, a steady increase in the productivity of food grain production and in the growth of service and consumer industries is clearly observable.

Many of the traditional livestock production systems of sub-Saharan Africa are now in decline. Their future survival depends on enhancing their capacity to satisfy the subsistence and income needs of their producers. It also depends on their impact on the land resources they use. The grasslands and browse in the pastoral areas of Africa are characterised by low levels of productivity and high variability in yields, both within and across years. As human and therefore livestock populations increase, pressure on these unpredictable resources grows, and with it the threat of environmental degradation leading to further decline. There is thus an urgent need to find ways to accelerate livestock productivity and output, so that it not only keeps pace with rising population but also creates surpluses for market disposal. Opportunities for substantial progress exist: in the improvement of grazing lands, health control, animal management practices, and marketing and institutional infrastructure.

Research and development studies in more than a dozen institutes in tropical Africa now span several decades. These efforts have resulted in substantial productivity gains in a number of specific situations. However, most of these have been achieved under management conditions which are beyond the means of the majority of livestock producers. Development efforts have often stressed technical innovations without an understanding of the spectrum of consequences that can flow from such interventions in pastoral societies, and the outcome of past investment in livestock development projects has been generally disappointing. The primary cause of failure in most cases has been the lack of adequate understanding of relationships between the biological, economic and social components of each production system.

Based on this premise, the research efforts of the International Livestock Centre for Africa (ILCA) have focussed on the need for a thorough understanding of these relationships before committing scientists and physical resources to detailed field and component research within a given system. Our baseline studies, carried out in areas representative of the wide range of ecological and socio-economic environments of sub-Saharan Africa, support the hypothesis that research on livestock development must consider production systems in their entirety. They provide the rationale for ILCA's systems-oriented research strategy. Hans Jahnke, a staff member of ILCA from its inception in 1975, has been a key figure in the formulation of this strategy, and is in a unique position to provide a synthesis of the information accumulated by ILCA and other research and development institutes, adding his own careful and pragmatic approach to the interpretation of the usually scanty quantitative data available.

The main aim of this book is to improve the planning base for livestock development in Africa. The author's first task has been to provide a quantitative assessment of livestock and land resources, which forms the basis for dividing the continent into ecological zones. Livestock production in each zone is assessed by the products provided, the functions performed and the contribution of livestock to the national economy. This analysis leads to a classification of the predominant production systems in the region, ranging from extensive pastoral systems to intensive landless systems. The classification is justified by its usefulness in identifying livestock development possibilities. The viewpoint expressed here is that of an economist: change and improvement in different production systems depend on relative factor endowments, technology and pricing structure, as well as on the changing nature of producer objectives and managerial skills. A central theme of the book is that livestock development cannot be viewed as a parallel expansion in all existing systems; priorities must be set and development choices made on the basis of the relative importance and potential of each system.

Like other processes of change, livestock development is dynamic and open-ended. Systems at different stages on the development path face widely differing constraints on their further improvement. Dr. Jahnke's book is particularly valuable in this context, as it formulates specific development hypotheses amenable to empirical testing in specific production environments. The research task implied by this analysis is therefore one of ILCA's major objectives. It is our hope that this book, which synthesizes much of the material in other ILCA publications, will prove a valuable source of information for improving food production and economic development in sub-Saharan Africa.

Addis Abeba, Ethiopia
January 20, 1982

Acknowledgements

This book has arisen from my work at the International Livestock Centre for Africa (ILCA) between 1975 and 1981. Without implicating anybody in errors and omissions and without claiming to present a synthesis or consensus of views held there, the book is a product of the work of that organisation, drawing on resources provided by the Consultative Group on International Agricultural Research.

The complete list of direct and indirect contributors at ILCA simply is too long for inclusion here and I can only ask the staff of ILCA as a whole to accept my sincere thanks for their general support and for their valuable inputs. The book was started and brought to conclusion under the directorship of Mr. David Pratt and it is to him that I owe my major debt for intellectual and administrative support and for continued moral encouragement to accomplish the work.

The members of ILCA's Programme Committee under the chairmanship successively of Prof. D.E. Tribe and Dr. A. Provost have provided valuable suggestions and criticisms on earlier drafts. For their particular efforts I must mention Prof. W. Schaefer-Kehnert, Prof. C.R.W. Spedding and Prof. H. Ruthenberg.

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The Institut d'Elevage et de Medecine Veterinaire des Pays Tropicaux (IEMVT) granted me access to their archives; its Director Général Dr. A. Provost and its Assistant Director Dr. G. Tacher took the time for long discussions and provided numerous valuable suggestions.

The final draft of the work benefitted substantially from suggestions and criticisms by my colleagues at the University of Kiel, in particular by Prof. C.-H. Hanf, Prof. W. Scheper, Dr. R. Müller Dr. R. Herrmann and Dr. P.M. Schmitz and by Prof. G. Weinschenk of the University of Hohenheim.

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F. Platte and Mr. H.-P. Schadek compiled statistics, Ms. H. Jürgensen and Mr. F. Küllsen prepared the drawings, Ms. S. Lemke typed earlier drafts and the tables, Ms. E. Fey and Ms. M. Krause prepared the final typescript and Ms. H. Kross undertook the tedious editorial work.

Hans E. Jahnke

March 31, 1982

Kiel, Federal Republic of Germany

CONTENTS

LIST OF TEXT TABLES

LIST OF ANNEX TABLES

LIST OF FIGURES

ACRONYMS OF ORGANIZATIONS

BDPA	Bureau pour le Développement de la Production Agricole, Paris
CEEMAT	Centre d'Etudes et d'Expérimentation du Machinisme Agricole Tropical
CFDT	Compagnie Française pour le Développement des Fibres Textiles, Paris
CRED	Centre for Research on Economic Development, University of Michigan
CRZ	Centre de Recherches Zootechniques, Bouaké
EDI	Economic Development Institute of the World Bank, Washington, D. C.
FAO	Food and Agriculture Organization of the United Nations, Rome
GERDAT	Groupement d'Etudes et de Recherches pour le Développement de l'Agronomie Tropicale, Paris
GTZ	Gesellschaft für Technische Zusammenarbeit, Eschborn
IBAR	Interafrican Bureau for Animal Resources, Nairobi
IBRD	International Bank for Reconstruction and Development, Washington, D. C.
IEMVT	Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, Maisons-Alfort, Paris
IFDC	International Fertilizer Development Centre, Alabama
Ifo	Institut für Wirtschaftsforschung, München
IFPRI	International Food Policy Research Institute, Washington, D. C.
ILCA	International Livestock Centre for Africa, Addis Abeba
KCC	Kenya Cooperative Creameries, Nairobi
LMB	Livestock and Meat Board, Addis Abeba
NAPRI	National Animal Production Research Institute, Kaduna
OAU/STRC	Organization of African Unity/Scientific and Technical Research Commission
OMS	Organisation Mondiale pour la Santé
SATEC	Société d'Aide Technique et de Coopération, Paris
SEDES	Société d'Etudes pour le Développement Economique et Social, Paris
UNCTAD	United Nations Commission for Trade and Development, Geneva
UNDP	United Nations Development Programme, New York
UNECA	United Nations Economic Commission for Africa, Addis Abeba
UNFPA	United Nations Fund for Population Activities
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

UNITS AND ABBREVIATIONS

AT 2000	Agriculture: Towards 2000 (FAO publication)
CDW	Cold dressed weight
CP	Crude protein
DCP	Digestible crude protein
DM	Dry matter
FU	Fodder unit (equivalent to 0.7 of a starch unit after Kellner)
GD	Growing days
GDP	Gross domestic product
GE	Grain equivalent
GP	Growing period
HSC	Human supporting capacity
LW	Liveweight
MDE	Man-day equivalent
ME	Man equivalent
MH	Man-hour
MT	Metric tonne (the symbol "t" is also used)
n. ap.	Not applicable
n. av.	Not available
$	United States (US) dollars
TCU	Tropical cattle unit (a bovine of 175 kg LW)
TLU	Tropical livestock unit (an animal (ruminant) of 250 kg LW)
UBT	Unité de bétail tropical (an animal (ruminant) of 250 kg LW)

1 Introduction

1.1 Background

Tropical Africa is one of the least developed world regions comprising most of the world's poorest countries. Agriculture as the mainstay of the economies hardly keeps pace with population growth. Self-sufficiency ratios for cereals and other staple foods are generally declining; the dependence on food imports is increasing. The performance of livestock as part of agriculture is particularly disturbing. While some modest productivity improvements have taken place in cropping, livestock production increases in the past have been largely due to numeric expansion of herds and flocks rather than to improvement of the productivity. Major livestock areas like the Sahel and parts of Eastern Africa provide an extremely fragile environment in which the constant threat of droughts affects not only the survival of livestock but that of the human population as well. Overgrazing and resource degradation characterize livestock production over much of the region while the apparent potential in other regions is not used at all. The use of animal traction for cropping and the integration of livestock into farming are uncommon. Overall the levels of livestock productivity and of availability of livestock products like meat, milk and eggs for the human population are the lowest of any world region which is all the more serious since, in many areas, livestock products constitute the major source of subsistence. Even at the prevailing low levels of consumption production does not keep pace with demand and the region as a whole moves towards the position of a net importer of livestock products despite its apparent potential for livestock production.

For general agriculture as well as for livestock production the need for development is great and the modest objective of maintaining per caput levels of production constitutes a formidable challenge in the light of a rapidly growing human population. Efforts at agricultural and livestock development will need to be carefully planned and take account of the pronounced diversity of the natural and human environment. The agro-climatic conditions range from extreme aridity in deserts and desert-like areas to extreme humidity in areas whose natural vegetation is dense rainforests; in addition altitude intervenes rendering highlands ecologically different from the low-lying areas. In all ecological zones there are areas of high population density with intensive forms of land use as well as vast stretches of land, hardly used and almost void of man and stock. Diversity is further accentuated by the coexistence of pre-technical forms of agriculture and modern forms introduced into Africa in the last 100 years, sometimes only in the past two decades. Shifting cultivation in the rain forests and pastoral nomadism in the arid zone have existed in their present form from times immemorial; commercial plantations, ranching, large-scale farming and industrial poultry complexes are "children of the industrial revolution" (Grigg 1974) transplanted to Africa in recent times. The distribution pattern of the human and the livestock populations and the penetration of modern forms of agriculture have been influenced in a manifold and often obscure way by the presence of tsetse flies and the diseases they carry, a factor which is unique to Tropical Africa, and which affects 10 million square kilometers or 40% of the land area considered here.

Livestock production is a form of agricultural production with many facets and the manifestation of these facets differs from one situation to another. It is obvious that livestock production by a nomad who keeps camels for milk to secure his subsistence is different from that of a peasant who raises some poultry in his farm yard for sale on the market. The different livestock species - camels, cattle, sheep, goats, equines*, pigs and poultry - vary radically in their management requirements, their production and productivity and also in the products they supply and the functions they fulfill. But one and the same species may also be held for completely different purposes: On some farms cattle are kept to produce beef for sale, on others to supply dung for the fields and to provide tractive force in farm work. In addition the same product and function, say meat for sale, can be provided by radically different management principles; long-range migration as a form of adaptation to ecology in a pre-technical world in one case, and the application of modern technology in an artificially controlled environment in another. And the functions of livestock are by no means restricted to production. The keeping of livestock for prestige and the payment of bride price in the form of cattle are only examples of the role of livestock that pervades the emotional, social and cultural spheres of many African societies.

Livestock production in Tropical Africa is characterized by great complexity not only in environment but also in livestock types, products, functions and management principles and is compounded by often perplexing interactions with the human sphere. This com-

* As a group of species to include asses, mules and horses.

plexity constitutes a formidable challenge for the design of development efforts, further complicated by the generalized and often discouraging lack of data. In this light it is not surprising that efforts at livestock development are beset with problems and have done little to improve overall performance levels. Moreover, and also as a consequence, the reasons for success or failure of such development efforts are little understood.

The complexity of livestock production and development in Tropical Africa is certain to have been rationalized and broken down in many an experienced mind, but a systematic and accessible treatise of the subject does not exist.

1.2 Aim and Scope

This study aims to improve the planning basis for livestock development in Tropical Africa by bringing order into the complexity of livestock production phenomena through the concept of production systems, by assessing the development possibilities of these different production systems and by providing quantitative information on the resource base and production status.

To order the phenomena a concept of livestock production systems is developed with the specific purpose of being useful for the assessment of development opportunities and constraints which, more often than not, are interwoven with the human environment. Existing agricultural typologies, even if they were universally applicable, prove deficient in that respect. The alternative of deriving farm groupings from a theory of their differentiation (e. g. the distance from the market or the factor proportions available) results in a typology that reflects too narrow a spectrum of reality. One is left without an entirely satisfactory solution to the problem. Judgement and pragmatism must still take precendence over principle and rigour. The basis of classification in this study is provided by the systems of tropical farming as developed by Ruthenberg (1980) adapted to the specificities of livestock production. In spite of their shortcomings the resulting systems are useful for describing real livestock production and in providing a framework for further study.

The systems are also useful for considerations of livestock development. Poor performance in actual production and in development shows up in aggregate statistics. But a problem-oriented view needs to descend on the level of individual livestock producers and on that of development projects to determine causes and remedies. It is man's management of livestock that is at the root and that needs to be understood before promising development efforts can be designed. The systems concept used in this study takes explicit account of this since it is based on the individual farm unit as the "building block" (Andreae 1977, Ruthenberg 1980) of a production system. A livestock production system in the simplest sense is then nothing but a group of similar management units. This is also the level at which development efforts normally set in. Projects as the cutting edge of development (Gittinger 1972) are the smallest organizational units within which costs are incurred to obtain benefits and reach development objectives (Ruthenberg 1977). One of the advantages of the systems concept followed here lies precisely in the fact that the unit size and level can be brought in direct correspondence with the unit size and level of development projects. Consequently it can be attempted to bring together experience from development projects for each production system and to draw inferences for development possibilities.

Quantitative information on the resource base and on livestock production and productivity is introduced and considered at the level of countries and also at the level of ecological zones and of production systems. On all these levels such information is useful to delimit the development potential and maybe even necessary for policy and strategy decisions. But this study cannot substitute for the general absence of reliable statistics. In many cases the estimates are to be regarded less as assertions and more as explicit formulations of opinions and biases. They are then meant to challenge students and policy makers rather than to encourage their uncritical use.

The scope of the study is delimited in space and time and further characterized by the specific viewpoint taken.

Tropical Africa has been chosen as the area of investigation. At the edges country boundaries have been found to be more useful than the exact geographical limits of the tropics. In this politico-geographical definition Tropical Africa includes all mainland countries except former Spanish Sahara and the countries bordering on the Mediterranean in the north, and South Africa, Lesotho and Swaziland in the south. Madagascar is included. Subdivisions and country groupings used are given in chapter 2. The area is large (22 million square kilometers), and important local variations are often ignored; for the natural environment this particularly refers to the soil types.

The time dimension essentially covers the past two decades and the same period ahead. This has an important implication for development inferences. What has been tried out, successfully or not within that time period of the past is of concern and what is likely to be possible up to say the year 2000. For many aspects the inclusion of more distant experience from the past would be useful if only to show that seemingly new ideas and approaches are nothing but repetitions of experience long forgotten. By restricting the forward view to technical innovations that are already possible it cannot be excluded that elements are now overlooked that may change livestock development prospects radically in future. A particularly intriguing aspect is that of overcoming the tsetse by the sterile male technique or by the development of a vaccine against trypanosomiasis. But by and large the view that enough is known of technical possibilities and too little has been made applicable and put into practice (Nestel et al 1973) appears a reasonable basis also for this study.

The viewpoint is that of an economist whose concerns are with resource assessment, allocation of production factors, productivity and the contribution of production activities to farmer's objectives, the design of economic development on project and policy level and the outcome of development efforts on the farm and in more aggregate terms. The use of more elaborate economic methodologies is severely limited by data availability and by the size of the task which prohibits in-depth elaboration of any one particular aspect. But the viewpoint is still determined by these economic concerns and is therefore not that of a technical man or a natural scientist who might be appalled by the manner in which sophisticated and detailed aspects of, e. g. precipitation, nutrients, grass growth, animal reproduction, milk yield, growth and husbandry are reduced to gross concepts of carrying capacity and livestock productivity. It is realized that in this process of reduction differentiations are lost that may often constitute important development opportunities and constraints. The need for a technical assessment of the conclusions reached on the more general economic level and of their applicability to specific situations must therefore be emphasized.

The aims, the scope and the restrictions of this study are best summarized by considering it as a framework useful for development planning. Some of the information given on resources and production, production systems and development possibilities may be used directly in concrete planning exercises, but for the most part there is need for refinement and local adaptation. The contribution of this study then lies in the outline of a development-oriented approach and of the concepts required to identify the type of further information needed and to order information in a way useful for development planning and implementation.

1.3 Approach

Chapter 2 gives a quantitative overview of the resources engaged in livestock production in Tropical Africa. The major resource is the livestock; their numbers are given by species as well as the distribution of herds and flocks by country groups. Land as the second major production factor is differentiated by quality and potential. The concept of ecological zones is introduced; the study area is subdivided into arid, semi-arid, sub-humid and humid zones; highland areas are distinguished as a separate zone. A further differentiation is introduced according to tsetse infestation of the land. This permits the assessment of the livestock, land and labour resources together for each ecological zone, a unit which can be more readily translated in production systems than national units.

Livestock production is the topic of chapter 3. The sector contribution by livestock is estimated country by country. Readily available statistics relate to meat, milk and egg production only. An attempt is made to identify all the different livestock products and services and to estimate their value. Beside foods there are materials like hides, skins, pelts, horns and the like, dung as fuel and fertilizer, work as field work in cropping and for transport as well as animals as a result of reproduction of livestock. Quantification of production by ecological zone allows a comparison with the resources engaged and provides various livestock productivity indicators.

Having assessed the resources, livestock production and productivity of Tropical Africa, the issue of livestock development is introduced (chapter 4.1). The performance to-date is examined and the case for livestock development presented. The essential aim of chapter 4 is to link development considerations to the concept of livestock production systems as developed in chapter 4.2. The typology is related to farming systems and ecological zones on the one hand and to the livestock characteristics of the farming systems on the other. These are the livestock type (species essentially) and the livestock product, the function(s) livestock have in the farming systems concerned and the livestock management principles. The systems concept links the view by ecolocial zone to that on the farm level and to that of development projects whose targets normally are groups of similar production units within an ecolocial zone.

Five classes of livestock production systems are distinguished:

- Pastoral Range-livestock Production Systems
- Crop-livestock Production Systems in the Lowlands
- Crop-livestock Production Systems in the Highlands
- Ranching Systems, and
- Landless Livestock Production Systems.

They are dealt with one by one in chapters 5 to 9 under the headings 'general characteristics', 'production and productivity' and 'development possibilities'.

The general characteristics provide for each class of production system definitional aspects and delimitations, types and their geographical distribution and livestock characteristics, from species and product to function and management principles. Within this general framework a flexible approach is taken to emphasize for each production system the particularly relevant aspects: For pastoral systems the social and cultural functions vis-a-vis the subsistence function and the role of communal land tenure; for lowland crop livestock systems the importance of crop-livestock interactions and the phenomenon of contract herding; for highland systems the role of livestock under increasing population pressure and for ranching systems the intricacies of management.

Production and productivity levels are characterized for each production system to the extent possible. Again different facets stand in the foreground for different production systems: The human supporting capacity of pastoral systems, the influence of tsetse flies on livestock productivity in the lowlands and the potential productivity of highland and ranching systems.

The section on development possibilities is the one most specific for each production system: For pastoral systems the scope and limitations of the conventional approaches are emphasized; mixed farming concepts and the role of tsetse control dominate the discussion for the lowland systems; dairy and sheep development are the major themes for the highlands and management issues again receive attention in ranching systems.

The chapter on landless production systems in principle follows a similar outline but is more condensed on account of the reduced importance of these systems as yet and also because much less information is available. Traditional and modern pig and poultry systems are dealt with as well as intensive beef fattening systems. Their development possibilities are largely viewed in connection with price ratios and the availability of feeds.

Chapter 10 draws conclusions for livestock development planning that go beyond the context of specific production systems. Development planning generally takes place at the national level and therefore basic policy decisions on general, agricultural and livestock development have to be applied to a mix of different production systems. The role of planning under these conditions and the size of the task are outlined. Specific strategy choices that result from the view of livestock production and development in the context of systems are discussed. A central theme is that livestock development cannot be viewed as the parallel expansion of all existing systems but requires conscious choices about their relative place and about the approaches to them in the course of development. As a final point some of the limitations of planning in achieving improved livestock performance are outlined as well as the role of monitoring in complementing development planning and in assisting this study in achieving its aim of improving the planning base for livestock development in Tropical Africa.

2 Resources for Livestock Production

2.1 Livestock

The main categories of domestic livestock in Tropical Africa are large ruminants (cattle and camels), small ruminants (sheep and goats), nonruminant grazing animals (asses, mules and horses summarized as equines), pigs and chickens. Other species are not dealt with in this study, which excludes from consideration important animal resources like fish and wildlife.

The essential difference among ruminants and non-ruminants is that the former can be fed on roughage. Thereby plant material that is of no direct use for man can be converted into food for man and into other useful products. Ruminant animals and equines can be grouped together as grazing animals, i. e. animals that depend largely on grazing for their feed. Given the similarity of the feed base, particularly of ruminants, the conversion of animals of different size and of the different species into reference units is useful. The tropical livestock unit (TLU) or "unité de betail tropical" (UBT) is commonly taken to be an animal of 250 kg liveweight. The tropical cattle unit (TCU) is less commonly used, it is here taken to be the equivalent of a bovine of 175 kg liveweight which, on the aggregate level, is assumed to represent the average liveweight of a bovine. A small ruminant unit is put at 25 kg liveweight. Due to considerable differences between zones, breeds, and management systems, these conversion factors should only be used for gross calculations on an aggregate level. More accurate calculations would also have to take into consideration that feed requirements are more directly determined by the metabolic weight rather than the liveweight (LW)*. Table 2.1 shows the livestock population in Tropical Africa. Conversion into TLU is given for all species although this is normally only done for ruminant livestock and possibly for equines.

* The basal metabolic rate (MB) is a function of the surface area of the animal and related to its liveweight (LW) by the following formula

$$MB = a \cdot LW^{0.73} \qquad a = \text{a constant of MB per kg metabolic weight}$$

$LW^{0.73}$ is termed the metabolic weight (see Rivière 1978, p.129).

Table 2.1: Livestock Population in Tropical Africa by Species in Numbers and in Tropical Livestock Units (TLU) 1979

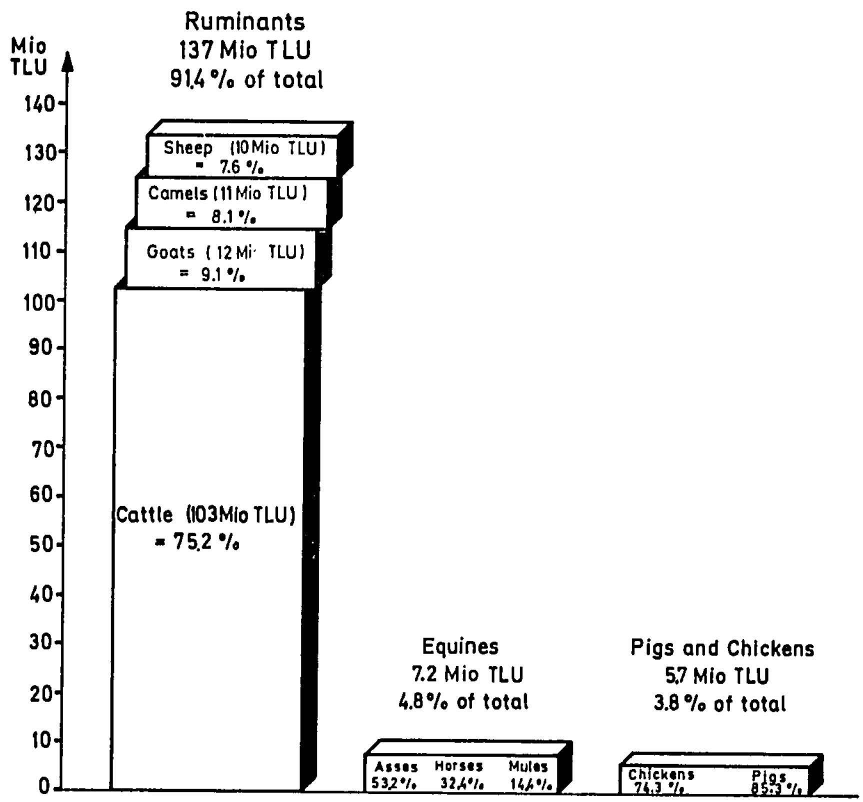
Species	1 000 head	TLU conversion factor	1 000 TLU
Camels	11 135	1,0	11 135
Cattle	147 510	0,7	103 257
Sheep	103 865	0,1	10 387
Goats	125 287	0,1	12 529
a Sub-total ruminants	387 797	n. ap.	137 308
Horses	2 899	0,8	2 319
Mules	1 478	0,7	1 035
Asses	7 618	0,5	3 809
b Sub-total equines	11 995	n. ap.	7 163
c Sub-total grazing animals (a + b)	399 792	n. ap.	144 471
Pigs	7 244	0,2	1 449
Chickens	426 180	0,01	4 262
d Sub-total pigs and chickens	n. ap.	n. ap.	5 711

Source: FAO (Production Yearbook 1979); TLU conversion factors constitute a compromise between different common practices.

Figures on livestock populations in Tropical Africa are only rarely based on censuses. In most cases they constitute estimates of varying statistical reliability. The possibility of comparison in space and time has rendered these estimates more reliable and they are certainly the best available on a continental basis. Nevertheless they are subject to a margin of error the importance of which is not known. It is likely to be greatest in the case of chickens.

Table 2.1 shows for the larger animals the numerical importance of ruminants and within this group of cattle. In terms of livestock units cattle account for three fourths of the total livestock population. The relative numerical importance of the different species is graphically shown in Figure 2.1. Figure 2.2 gives the regional subdivision of Tropical Africa used in this study and Table 2.2 shows the distribution of the ruminant livestock population in that region.

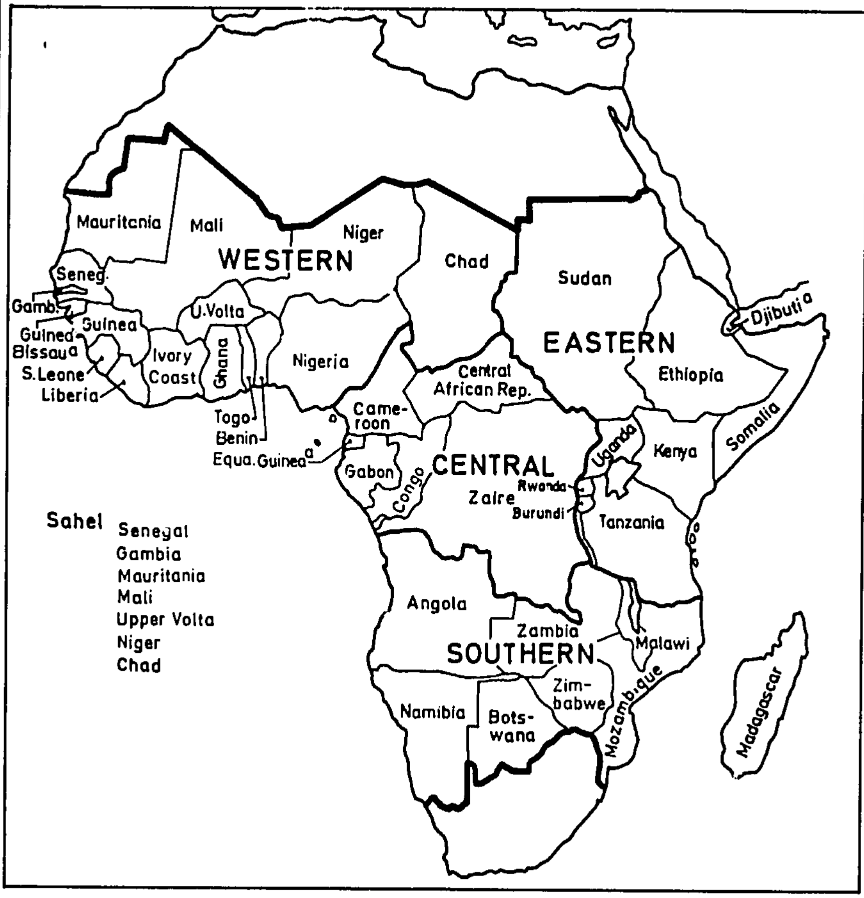
Figure 2.1.
Species Composition of the Livestock Population in Tropical Africa 1979



Source: FAO (Production Yearbook 1979).

Figure 2.2.

Regions of Tropical Africa



[a] Excluded from most statistics for lack of data

Source: Map projection FAO (Higgins et al 1978); regional subdivision by author.

Table 2.2: Distribution of the Ruminant Livestock Population by Species and Regions/Countries in Tropical Africa 1979

Region/ country	Camels 1 000 head	Cattle 1 000 head	Sheep 1 000 head	Goats 1 000 head	Total 1 000 TLU	Share in total TLU %
Western Africa	1 694	35 812	33 662	51 818	35 311	25.7
Sahel	1 677	19 174	19 897	21 660	19 255	14.0
Nigeria	17	12 000	8 500	24 500	11 717	8.5
Rest	-	4 638	5 265	5 658	4 339	3.2
Central Africa	-	4 919	3 270	5 500	4 320	3.1
Zaire	-	1 144	779	2 783	1 157	0.8
Rest	-	3 775	2 491	2 717	3 163	2.3
Eastern Africa	9 441	79 645	59 405	58 556	76 989	56.1
Sudan	2 500	17 300	17 200	12 200	17 550	12.8
Ethiopia	966	25 900	23 234	17 120	23 131	16.9
Rest	5 975	36 445	18 971	29 236	36 308	26.4
Southern Africa	-	27 134	7 528	9 413	20 688	15.1
Mainland	-	18 390	6 870	7 830	14 343	10.5
Madagascar	-	8 744	658	1 583	6 345	4.6
Total	11 135	147 510	103 865	125 287	137 308	100.0

Source: FAO (Production Yearbook 1979).

Figure 2.2 and Table 2.2 indicate that the distribution of ruminant livestock in Tropical Africa is uneven. Eastern Africa has over one half of the total population while the ruminant livestock herd in Central Africa accounts for little more than three percent of the total. A similarly low figure holds for the coastal countries of Western Africa. In terms of the individual countries listed Sudan and particularly Ethiopia stand out for their large ruminant livestock herds, while Zaire, compared to its size, features very low numbers. For further interpretation livestock-land ratios would be required; in turn these are only meaningful if related to the potential of the land.

The distribution of the equine population follows a pattern similar, though not identical, to that of ruminants (Table 2.3).

Table 2.3: Distribution of the Equine Livestock Population by Species and Regions/Countries in Tropical Africa 1979

Region/ country	Horses 1 000 head	Mules 1 000 head	Asses 1 000 head	Total equines 1 000 head	share %
Sahel	947	-	1 809	2 756	23.0
Nigeria	250	-	700	950	7.9
Sudan	20	1	680	701	5.8
Ethiopia	1 530	1 446	3 885	6 861	57.3
All other	152	31	544	727	6.0
Total	2 899	1 478	7 618	11 995	100.0

Source: FAO (Production Yearbook 1979).

There are two important regions of equines in Tropical Africa, the Sahel countries and Ethiopia. The concentration is even more pronounced if one considers that the figures given for Nigeria relate to the northern part bordering the Sahel countries and that large parts of Sudan are ecologically similar to the Sahel countries. Ethiopia claims over 50% of the horses and asses and almost the totality of the mules. A sizeable portion of the ass population also occurs in the Sudan. Natural factors like the presence of the tsetse fly combined with historical and cultural factors play a role in their distribution. Land availability is not a determining factor and a relationship to the distribution of the human population does not appear to exist.

Table 2.4 gives an indication of the distribution of pigs and chickens in Tropical Africa. The pig population of Tropical Africa stands at 7.2 million head. The distribution is influenced by religious (particularly but not exclusively islamic) taboos which explain the low numbers in the Sahel countries, Sudan and Ethiopia. The coastal countries of Western Africa including Nigeria and Central Africa on the other hand have almost two thirds of the total population. The number of chickens is estimated at some 426 million head, a figure which is probably subject to a considerable margin of error. Their distribution follows relatively closely that of the human population. The ratio ranges from one to two birds per person throughout Tropical Africa. The higher figures tend to be found in the more humid countries.

Table 2.4: Distribution of Pigs and Poultry and of the Human Population by Region in Tropical Africa 1979

Region	Pigs 1 000 head	Pigs %	Chickens 1 000 head	Chickens %	Agricultural population %
Western Africa	3 310	45.7	193 577	45.5	37.4
Central Africa	1 750	24.2	26 989	6.3	12.8
Eastern Africa	484	6.7	136 958	32.1	36.4
Southern Africa	1 700	23.4	68 656	16.1	13.4
Total	7 244	100.0	426 180	100.0	100.0

Source: FAO (Production Yearbook 1979).

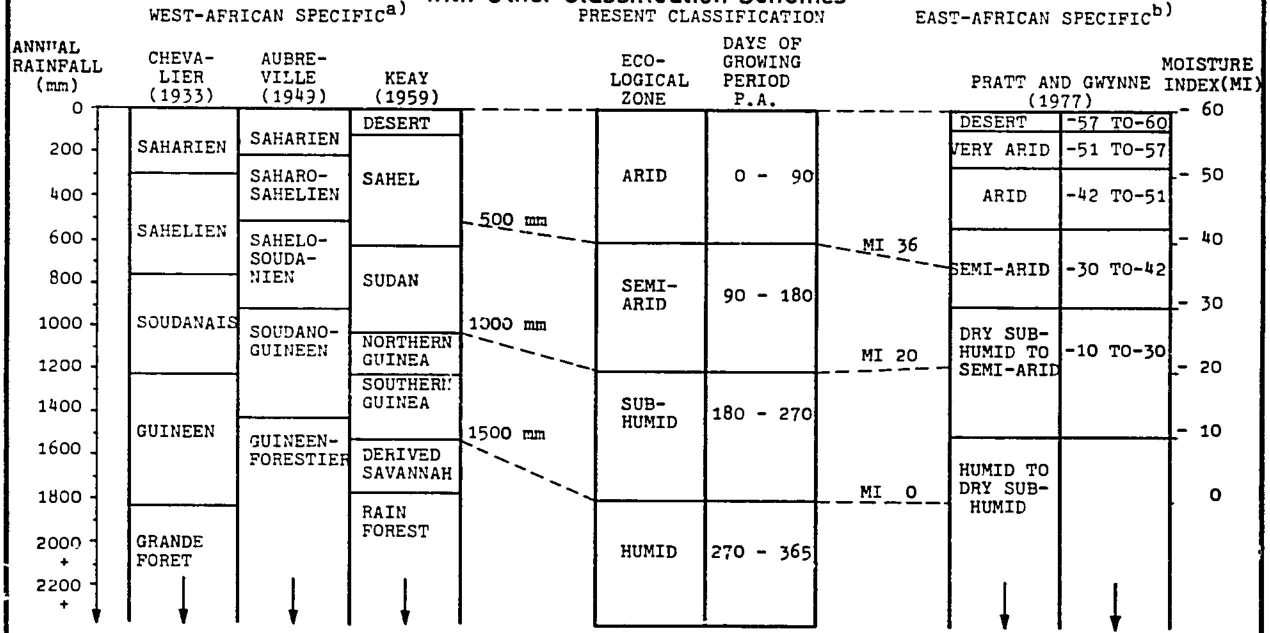
2.2 Land

An important complementary resource to livestock themselves is land. The calculation of land availability and of land livestock ratios is only meaningful if the quality of the land is taken into account. As a first approximation the quality of the land for livestock production as well as for crop production can be characterized by the agro-climatic conditions, in particular by the length of the growing period. In the low-lying tropics the growing period is a function of moisture availability rather than the temperature regime, which is the important determinant in the temperate zones. It is only in the tropical highlands that temperature becomes a factor to be considered for the ecological zonation. The classification used here is based on growing days (GD) as defined by FAO (Higgins et al 1978). By that definition a growing day is a day during which precipitation exceeds potential evapotranspiration. To the total thus calculated are added those days immediately preceding or following the growing period during which precipitation exceeds half the potential evapotranspiration. While this approach is primarily geared toward cropping agriculture the implications for range productivity, fodder production and livestock are direct. It should nevertheless be borne in mind that the growing periods are to be taken as general indicators rather than specific estimates of the length of the growing period e. g. of grass or of livestock.

The grouping into arid (less than 90 GD), semi-arid (90-179 GD), sub-humid (180-269 GD) and humid (over 270 GD) is the author's. The highlands range from semi-arid to humid though they are defined here as land where mean average daily temperature is less than 20° C during the growing period. The terms "arid", "semi-arid", "sub-humid" and "humid" have received definitions by a number of authors (Thornthwaite 1948, Troll 1966). The specific interpretations here are meant to make them into useful categories for the specific purpose at hand, livestock development in Tropical Africa, not to challenge or replace their established climatological meaning in the strict sense. It is believed that the suggested categories are also in line with common conceptions of relative abundance or scarcity of water that are implied by the terms humid and arid. Figure 2.3 shows the grouping of the zones and their relationship to other classification schemes commonly applied to Tropical Africa. Zonations developed for West Africa have a relatively straight-forward relationship with average annual rainfall. Zonations commonly used in East Africa are based on moisture indices which express the relationship between rainfall and evaporation. Various refinements have have been developed over time. Figure 2.3 shows for the example of the indices used by Pratt and Gwynne (1977) that an approximate relationship to the zonation by growing days used in this study can also be established. Figure 2.4 gives a map of the ecological zones of Tropical Africa defined by growing days and Table 2.5 shows their extent by region.

Figure 2.3.

The Ecological Classification Scheme Used and its Approximate Correspondence with Other Classification Schemes



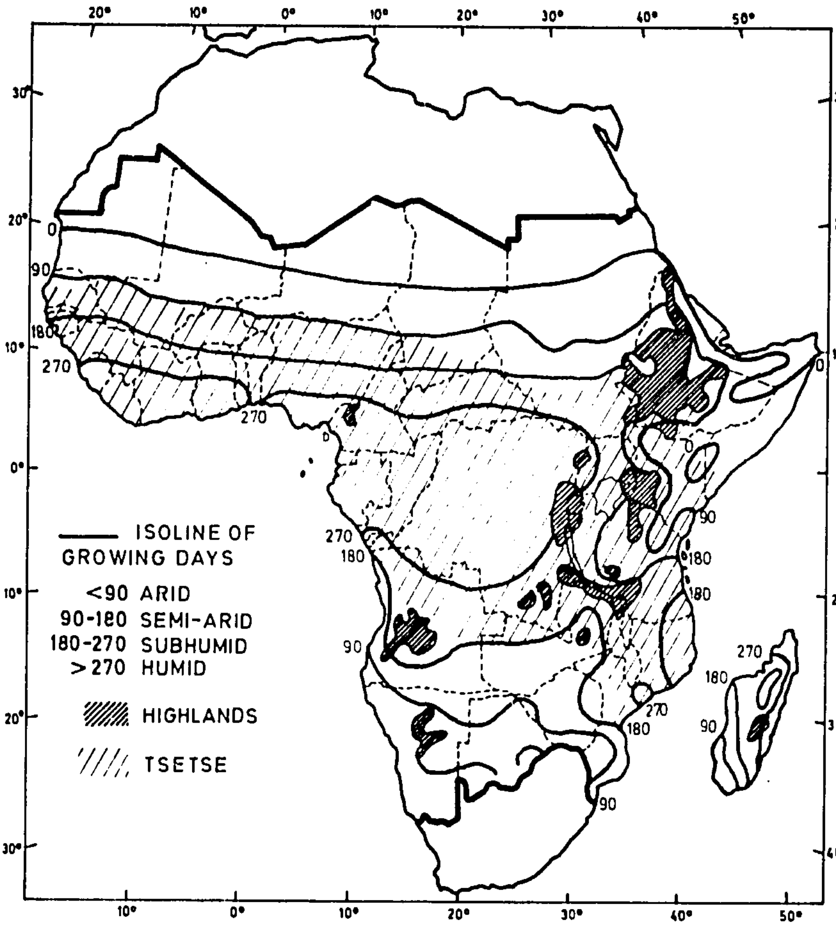
--------Lines of approximate correspondence of definitions.

a) The zones have a more or less direct relationship with annual rainfall.
b) Zonation is based on the relationship between rainfall and evapotranspiration as indicated by the moisture index.

Source: Compiled by the author.

Figure 2.4.

The Ecological Zones of Tropical Africa and the Extent of Tsetse Infestation



Source: FAO (Higgins et al 1978), Ford and Katondo (1973).

Table 2.5: Extent of Ecological Zones by Region in Tropical Africa (1 000 sqkm)

Ecological zone	Western	Central	Eastern	Southern	Total	%
Arid	3 990	-	3 015	1 322	8 327	37.3
Semi-arid	1 442	74	1 047	1 487	4 050	18.1
Sub-humid	1 187	805	959	1 907	4 858	21.7
Humid	707	3 029	94	307	4 137	18.5
Highlands	4	61	718	207	990	4.4
Total	7 330	3 969	5 833	5 230	22 362	100.0

Source: Author's compilation by planimetric estimation of extent of ecological zones in each country using the isolines of FAO (Higgins et al 1978); the results were checked against FAO's more detailed ecological zonation for verification of orders of magnitude.

Table 2.5 points to the importance of arid areas in Western and Eastern Africa, of humid areas in Central Africa, of more intermediate ecological zones in Southern Africa and of the highlands in Eastern Africa. It also shows that these ecological zones cut through regions and -as the base calculations show- through individual countries as well. The need to use ecological zones in addition to countries as reference units is therefore obvious.

Within a given ecological zone tsetse flies and trypanosomiasis must be regarded as the biggest single obstacle to livestock production. This is due to their wide spread and to the absoluteness with which they render livestock production on a permanent basis impossible. Unlike most other diseases the tsetse and trypanosomiasis comlex is tied to the land through the habitat requirement of the tsetse flies. Tsetse infestation is therefore an inherent factor of land quality or productivity for livestock in Tropical Africa. Figure 2.4 shows in addition to the ecological zones the distribution of tsetse flies in Tropical Africa. Table 2.6 gives an estimate of the extent of tsetse infestation by ecological zone.

Almost 50% or 10 million square kilometers of the total land area

Table 2.6: Extent of Tsetse Infestation by Ecological Zone in Tropical Africa

Ecological zone	Tsetse-infested 1 000 sqkm	% [a]	Tsetse-free 1 000 sqkm
Arid	1 038	12.5	7 289
Semi-arid	2 036	50.3	2 014
Sub-humid	3 298	68.2	1 560
Humid	3 741	89.7	396
Highlands	195	19.7	795
Total	10 308	46.1	12 054

a) Of total land area

Source: Compiled by the author after Ford and Katondo (1973) and FAO (Higgins et al 1978); the maps of tsetse infestation by species groups were superimposed over the map of ecological zones and the infested areas were determined by a planimetric method.

is infested with tsetse flies and by implication not usable or only seasonally usable by livestock. These figures are probably on the high side. The maps on which the estimates are based are constructed by connecting points of proven or assumed tsetse infestation, which tends to push the boundaries of infestation outwards, and within large tsetse belts complete infestation is usually assumed. Thus considerable portions of the arid zone and of the highlands are shown as infested when for all practical intents and purposes they are tsetse-free. Areas shown as free of tsetse flies can generally be assumed to carry no risk of trypanosomiasis for livestock. This does not mean that all the tsetse-free area is available for livestock. It contains cultivated area, forests, waste land and land too dry for any use.

2.3 Resources by Ecological Zone

Table 2.7 gives the distribution of the ruminant livestock population by ecological zone. The figures constitute rough estimates and must be taken for their orders of magnitude rather than their precise values. In comparison with the proportion of land area in the different ecological zones (Table 2.5) the distribution is again uneven. The arid zone occupies 37% of the land area and harbours a high 30% of the ruminant livestock population inspite of a grazing potential that must be assumed low. The greatest relative concentrations are found in the semi-arid zone. As humidity increases livestock density decreases. The humid zone accounts for 19% of the land area but for only 5% of the livestock population. The highlands stand out with the highest livestock concentration (17% of the herd on only 4% of the area).

Table 2.7: Ruminant Livestock Population by Species and Ecological Zone in Tropical Africa 1979

Ecological zone	Cattle 1 000 head (%)	Sheep 1 000 head (%)	Goats 1 000 head (%)	Ruminants[a] 1 000 TLU (%)
Arid	31 462	37 063	48 287	41 697
	(21.3)	(35.7)	(38.6)	(30.4)
Semi-arid	45 454	23 071	33 215	37 446
	(30.8)	(22.2)	(26.5)	(27.3)
Sub-humid	32 758	14 153	20 266	26 370
	(22.2)	(13.6)	(16.2)	(19.2)
Humid	8 814	8 177	11 586	8 148
	(6.0)	(7.9)	(9.2)	(5.9)
Highlands	29 022	21 401	11 933	23 646
	(19.7)	(20.6)	(9.5)	(17.2)
Total	147 510	103 865	125 287	137 308
	(100.0)	(100.0)	(100.0)	(100.0)

a) Including camels

Source: Compiled by the author; distributional information from World Atlas of Agriculture (1976), OAU/STRC (1976) and informal sources; totals correspond with country figures by FAO (1980); the whole of the camel population has been put into the arid zone.

The availability of land and labour for livestock production cannot be established with any precision because these resource categories cannot be delimited as production factors specific to livestock. Land in the definition used continues to include arable land. Labour engaged in livestock production cannot be separated out from total agricultural labour on the zonal level. Furthermore information on the distribution of the non-ruminant livestock is too vague to allow their allocation to the different ecological zones. The figures and ratios in Table 2.8 therefore have to be interpreted with caution.

Table 2.8: Livestock, Land and Labour Resources by Ecological Zone in Tropical Africa 1979

Ecological zone	Livestock[a]		Land[b]			Labour[c]		
	1 000 TLU	%	1 000 sqkm	%	ha/ TLU	1 000 ME	%	persons /TLU
Arid	41 697	30.4	7 289	60.5	17.5	11 193	12.2	0.3
Semi-arid	37 446	27.3	2 014	16.7	5.4	30 919	33.7	0.8
Sub-humid	26 370	19.2	1 560	12.9	5.9	20 552	22.4	0.8
Humid	8 149	5.9	396	3.3	4.9	20 277	22.1	2.5
Highlands	23 646	17.2	795	6.6	3.4	8 808	9.6	0.4
Total	137 308	100.0	12 054	100.0	8.8	91 749	100.0	0.7

a) Ruminant livestock only

b) Tsetse-free land only

c) Total population economically active in agriculture, i. e. agricultural population in man-equivalents (ME)

Source: Compiled by the author; for details of the estimation of the livestock and land resources see the previous tables and text; the distribution of the human population is based on censuses and estimates for each country used by FAO as background material for AT 2000; the country totals correspond with the population figures in FAO (Production Yearbook 1979); to derive the economically active proportion in the agricultural population the continent's average share of 38.5 % has been applied to each zone.

The arid zone shows the highest land-livestock ratio and the lowest labour-livestock ratio while possessing the highest proportion of the ruminant livestock population. The figures for this zone support notions of low productivity of the land, of high importance of livestock for employment and subsistence and the precariousness of subsistence if its sole source was to be livestock (3 TLU for an economically active person). The more humid areas have less land available for a livestock unit but to a certain degree this is offset by the higher productivity of the land. Total land area per TLU progressively increases with humidity but tsetse infestation reduces the availability of land to similar levels in all of the more humid lowland zones. Interpretation of the labour livestock ratios is hazardous because of the importance of cropping in these zones. The low livestock population in the humid zone results in the highest labour- livestock ratio here. The highland zone stands out for both a low land-livestock ratio and a low labour-livestock ratio pointing to considerable pressure on the resources.

The non-ruminant grazing animals (equines i. e. horses, mules and asses) account for the equivalent of 7.2 million TLU. From their distribution by country (Table 2.3) and knowing that in Ethiopia equines are distributed over all zones one could guess at an even distribution of the equine population over the arid, semi-arid and highland zones. Thus the equines would add 2.4 million TLU to each of those zones that have already the highest grazing pressure. The distribution of pigs is by tendency the inverse of that of grazing animals. The greatest concentrations are found in the sub-humid and humid zone. They cannot be sensibly expressed in area densities. The same holds for the chicken population the distribution of which is related to the distribution of the human population.

3 Livestock Production and Productivity

3.1 Sector Contribution

The average per caput income in Tropical Africa in 1980 is estimated at $ 285; the average contribution of agriculture to the GDP is 29% and the average contribution of the livestock sub-sector to the agricultural GDP is estimated at 17.4% (Table 3.1). Total livestock production is valued at slightly over five billion dollars*.

The contribution of the livestock sub-sector to the national economies varies a great deal. The country groups that represent the more humid zone (coastal countries in Western Africa, Central Africa) show a low contribution. Countries with a large proportion of arid lands like the Sahel countries and Sudan display relatively high figures as does Ethiopia with a large livestock population both in the lowlands in the highlands. Figure 3.1 gives the share of agriculture and the share of livestock for the individual countries. Variation is considerable. The quadrants established by the lines of the weighted averages for these values lend themselves to a cautious interpretation:

- Quadrant I comprises relatively poor countries in which agriculture still accounts for a high proportion of total GDP; at the same time their ecolocial conditions allow cropping to be the main component of agriculture; extreme examples are Rwanda and Burundi.

- As one moves to Quadrant II the countries are, because of their ecological conditions, more dependent on livestock; example are the Sahel countries of Niger and Chad; extremely high values for the importance of livestock are shown by Mauritania and Somalia.

- Quadrant III shows countries with a relatively more advanced economy as indicated by the lower share of agriculture and a well-established livestock industry accounting for a relatively high proportion of livestock products in agricultural production; Zimbabwe represents that situation well.

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* This refers to the value of meat, milk, eggs, wool, hides and skins only, the only livestock products that normally enter national accounts. If one were to add the estimated value of the other livestock products like work and manure and the stock increases (see the following sections) this figure would easily double.

Table 3.1: Estimated Per-caput Income, Agricultural GDP and Livestock GDP in Tropical Africa by Country Groups 1980
- all values in 1975 prices -

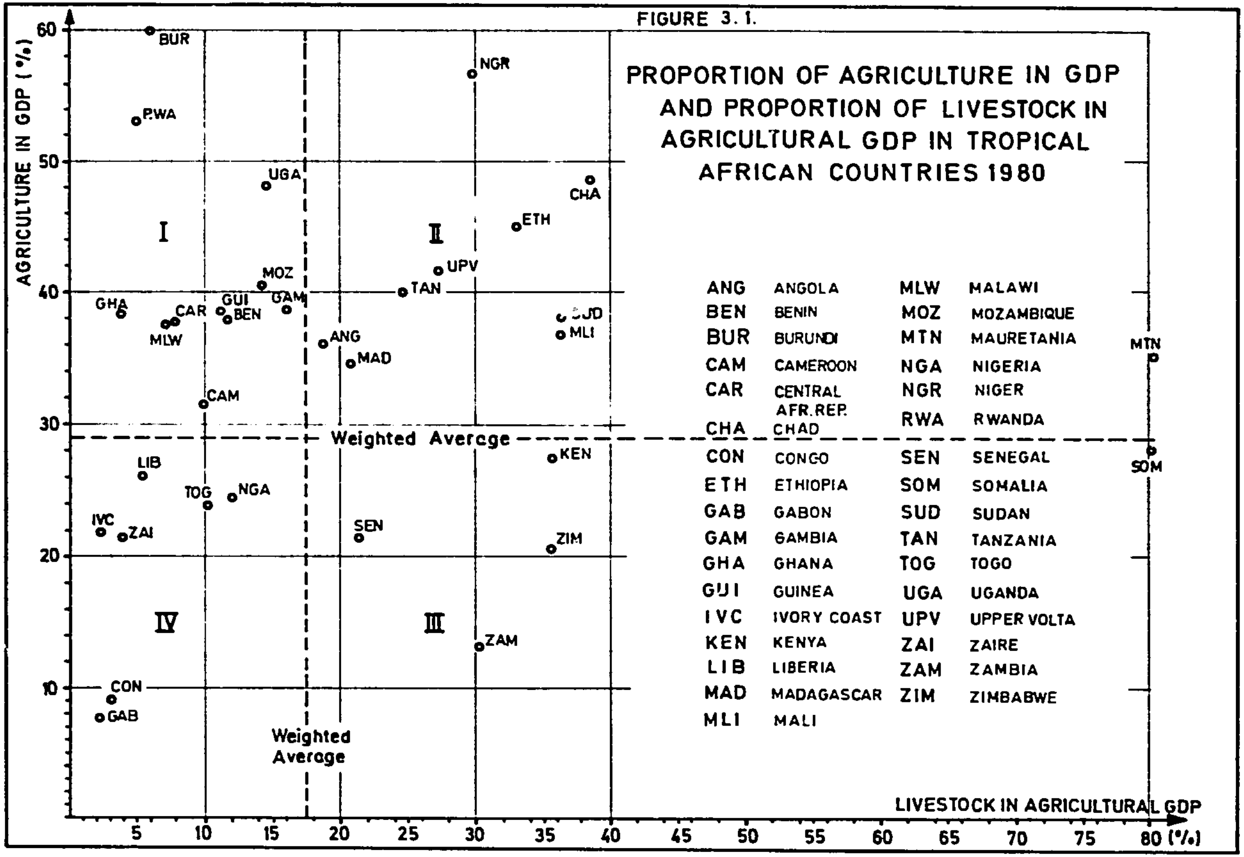
Region /country group /country	GDP per caput	Share of agric.[a]	Share of livestock[b]	Livestock GDP
	$	%	%	million $
Western				
Sahel	186	34.3	32.6	646
Nigeria	466	24.4	11.0	965
Rest	428	30.8	5.0	238
Central				
Zaire	85	21.5	4.0	21
Rest	577	18.1	8.8	103
Eastern				
Sudan	300	38.2	36.3	765
Ethiopia	94	45.1	33.0	458
Rest	184	36.1	24.9	995
Southern[c]				
Mainland	328	29.6	21.0	708
Madagascar	242	34.5	20.7	151
Total/average[c]	283	29.0	17.4	5 050

a) In GDP

b) In agric. GDP

c) Excluding Namibia and Botswana

Source: Compiled by the author from background material to FAO (1979); the GDP figures are derived from national accounts for 1975; the share of agriculture in GDP is based on national valuation procedures; the share of livestock is calculated from the ratio of the gross value of production of that subsector to the total agricultural sector; the figures for 1980 are derived by projection of the trend 1965 to 1974 with correction for anomalies like the drought in the mid-seventies and the recovery of the livestock industry thereafter.



Source: Compiled by the author from sources as in Table 3.1.

- The countries in Quadrant IV are rich in natural resources Gabon, Congo as extremes) and/or are well advanced on the path to general economic development (Ivory Coast); agriculture therefore shows a reduced relative importance in the overall economy. At the same time these countries lie in the humid zone which explains the particularly low share of livestock.

The data base does not allow interpretation to be carried much further. The statistics suffer from problems of consistency among countries in quantity accounting and in valuation, problems in principle of putting market values on the subsistence portion of production and problems of currency conversion.

Furthermore the figures for livestock production only include meat, milk and eggs as food products and hides, skins and wool as non-food products. Livestock products like manure as fertilizer and fuel, agricultural field work, transport work and the like are ignored. It is therefore necessary to look at the value of livestock products more closely.

3.2 Livestock Products

3.2.1 Foods

The main products of livestock are meat, milk and eggs including their derivatives. The use of national prices is only one method of valuing them and of making them comparable to other foods and products. Table 3.2 shows a selection of different valuation approaches. For comparison the resulting value ratio of livestock product to grain is shown for each approach.

Each valuation method has its particular use and its particular constraints. Domestic prices are an expression of a country's aggregate demand and supply situation; given the market imperfections and the importance of subsistence production they often reflect a statisticians hunch more than objective data. The application of a world market price is useful for the valuation of export production and import substitution. The method is used by FAO in its study 'Agriculture: Toward 2000' (AT 2000 1979) as a consistent price basis for long-term projections of self-sufficiency ratios; price differences between countries resulting from their internal supply ands demand structure are neglected. The calorific value of livestock foods is important where they are the main subsistence basis; this often implies a luxury consumption of

Table 3.2: Selected Methods of Valuation of Livestock Food Products

Valuation basis	Meat	Milk	Eggs	Grain
Average domestic prices[a]				
Index	240	100	600	60
Ratio to grain	4.0	1.7	10.0	1.0
World market prices[b]				
$/t	1 200	200	900	160
Ratio to grain	7.5	1.25	5.6	1.0
Calorific value[c]				
Mcal/t	2 400	700	1 500	3 400
Ratio to grain	0.7	0.2	0.4	1.0
Protein value[c]				
kg/t	150	35	110	70
Ratio to grain	2.1	0.5	1.6	1.0

a) As established by Klayman (1960); in principle they reflect the weighted average of the prices used for calculation of sectorial contributions in national accounts; grain refers to maize; wheat equals 100

b) According to FAO (AT 2000); grain refers to wheat; absolute $ values on 1975 basis

c) Calory and protein contents to be regarded as averages useful for rough aggregate estimates only

Source: FAO (AT 2000, 1979), Clark and Haswell (1970), Klayman (1960) and various informal sources.

protein while the diet is deficient in energy. Consideration of the protein value is one way of accounting for the particular nutritional quality of livestock foods. It does not fully account for the effect of upgrading whole diets from a protein-deficient level.

All methods can be used to relate the value of livestock foods to other foods, grain being the most common reference commodity. The value of livestock products can therefore be expressed in grain equivalents (GE) defined according to the different valuation methods. The use of the term grain equivalent will in this study be restricted to grain equivalents as derived from average domestic price ratios. The conversion factors are therefore 4.0 for a weight unit of meat, 1.7 for that of milk and 10.0 for that of eggs. These grain equivalents can also be converted into $ values by using the base price of $ 160/t as an import parity price for wheat and applying the GE ratios. Thus meat would be worth $ 640/t, milk 272 and eggs 1 000 (about 4 cents per piece).

Table 3.3 shows the total production of meat, milk and eggs in Tropical Africa both in physical quantities and in grain equivalents.

The grand total food production from livestock comes to 35 million GE tonnes. Ruminants account for almost 80%, cattle alone for 50%. Milk is the most important commodity; meat follows closely, eggs account for a sizeable 13%. A consistency check can be carried out in relation to the preceding section. There the value of livestock production - essentially food products only - was estimated at $ 5.1 billion. If the above figure of 35 million GE tonnes is converted to a monetary figure at $ 160 per GE tonne the value would be $ 5.6 billion. This discrepancy is well within the 'confidence limits' of the type of calculation carried out here, particulary if one considers that two important livestock countries, Namibia and Botswana, were omitted from the former calculations. A more specific aspect can also be examined: The contribution of livestock to food production in Tropical Africa. If the main food crops are converted to grain equivalents (grains and pulses at the conversion factor of 1.0, roots and tubers at 0.25) food crop production can be estimated at 100 million GE tonnes. Livestock would then account for 25% of total food production in grain equivalents. Of course this implies a valuation of livestock products over and above their calorific value and over and above their protein value since based on average domestic price ratios. Valuation at the suggested level of world market prices on the other hand would lead to a higher figure for the contribution of livestock to food production.

3.2.2 Materials

The term materials is to refer to non-food livestock products that can be regarded as farm outputs. This excludes manure which

Table 3.3: Food Production of Livestock in Tropical Africa 1978

Livestock species/product		Quantity 1 000 t	Grain equivalents 1 000 t	%
Camels	Milk	2 200	3 740	10.8
Cattle	Meat	1 979	7 916	22.9
	Milk	5 627	9 566	27.8
Sheep/goats	Meat	809	3 236	9.4
	Milk	1 507	2 562	7.4
Sub-total ruminants		n. ap.	27 020	78.3
Pigs	Meat	234	27 020	2.7
Chickens	Meat	522	2 088	6.1
	Eggs	446	4 460	12.9
Sub-total non-ruminants		n. ap.	7 484	21.7
Grand total		n. ap.	34 504	100.0
Total meat		3 544	14 176	41.1
Total milk		9 334	15 868	46.0

Source: FAO (Production Yearbooks 1979 and 1978); milk production of camels has been put at 200 kg/head which is conservative in comparison with the figures surveyed by Dahl and Hjort (1976).

normally is used as an input for crop production although in its use as fuel it could be classified as livestock materials. In the restricted sense the major materials from livestock are hides, skins and wool. Pelts of Karakul sheep are of localized importance only. Horns, hooves and even intestines, scrota and the like are also used but valuation on an aggregate level appears impossible. By-products from the processing of food products, e. g. bone meal, can be mentioned but as yet their role is minor in Tropical Africa. Table 3.4 shows the quantities of hides, skins and wool produced and an estimate of their value.

Compared to the value of $ 5.6 billion for food products the non-food products worth $ 420 million constitute 7.5%. The values cannot be readily converted into grain equivalents.

Table 3.4: Quantity and Value of Hides, Skins and Wool Production in Tropical Africa 1979

Product	Quantity	Unit value	Value of production	
	1 000 t	$/t	million $	%
Hides	318	800	254	60.5
Sheep skins (fresh)	63	800	50	11.9
Goat skins (fresh)	82	800	66	15.7
Wool (greasy)	33	1 500	50	11.9
Total	n. ap.	n. ap.	420	100.0

Source: FAO (Production Yearbook 1979); unit values constitute the author's estimates based on informal sources.

3.2.3 Manure

The value of livestock droppings for soil fertility is recognized by most tropical farmers and livestock holders. In addition manure is used for fuel and as a building material. Valuation will here concentrate on the yield-increasing effect as a proxy for the value in all uses although it is realized that manure plays a crucial role as fuel in many areas. If the alternative of manure application to fields exists it must be concluded that the farmers rate the fuel value of dung ever higher than its fertilizer value.

The agronomic value of manure lies in its contents of organic matter and of nutrients. Livestock are not net producers of organic matter or of nutrients; they merely act as a vehicle for the transfer of these components. The two essential aspects of any method to make use of manure are (1) to achieve a degree of concentration of the droppings/nutrients and (2) to have that concentration of nutrients at the most useful place. Strategic herding, night kraaling, folding, stabling etc. serve to achieve the concentration. Cropping on manure sites or transport of manure to the crop fields ensure that the manure is at the desired location.

According to these different methods but also in dependence of the ecological zone, quantity and quality of manure vary tremendously in Tropical Africa (Coulomb et al 1978); thus the N-content was found to be between several percent of the dry matter and zero which makes all the difference between a yield-increasing effect and no effect. The organic matter contained in manure is usually only attributed an effect if accompanied by doses of mineral fertilizer and if proper tillage is practised (Coulomb et al 1978, Charreau 1975). From the very heterogeneous data sources (e. g. Dupont de Dinechin et al 1969, the sources given in Coulomb et al 1978 and in FAO 1975 b) a rule of thumb can be derived according to which the manure from two livestock units would increase crop yields at low levels (say 600 kg) by 50%. One "manure-effective" TLU can therefore be attributed the value of 150 kg of grain equivalents for its manure production alone. This already constitutes a heroic generalization. To calculate the value of manure for all of Tropical Africa one would have to make estimates of the portion of manure collected, of the losses due to degradation, of the portion actually applied to fields, and one would need to take account of differences among the ecological zones.

3.2.4 Work

Work for which livestock are used includes land improvement (e. g. contour ploughing, drainage ploughing), soil preparation (e. g. ploughing, hoeing, harrowing), crop husbandry (e. g. seeding with drills), crop processing (e. g. threshing) and on-farm transport. Off-farm transport is importantly connected to trade and marketing.Particular facets of livestock work are the drawing of water in arid areas both for livestock watering and for human consumption, the transport of homesteads in nomadic livestock husbandry systems and finally the fact that livestock walk themselves to the place of sale and slaughter. The two most important categories of animal work are traction on one side and transport on the other. Traction refers to the employment of the tractive force of animals in crop production, transport to the translocation of loads. The most important species used for work are cattle, the group of equines and camels. The population of draught cattle has recently been estimated by FAO (AT 2000 1979). Of the equine and camel population one half are classified as work animals in Table 3.5.

Table 3.5: Population of Work Animals by Regions in Tropical Africa 1979

Region/country	Cattle[a]	Equines[b]	Camels[b]	Total	
	1 000	1 000	1 000	1 000	%
Western	2 220	1 877	848	4 945	20.1
Sahel	1 086	1 379	839	3 304	13.4
Nigeria	1 019	475	9	1 503	6.1
Rest	115	23	-	138	0.6
Central	63	71	-	134	0.5
Zaire	-	-	-	-	-
Rest	63	71	-	134	0.5
Eastern	9 090	3 897	4 310	17 297	70.4
Sudan	1 086	351	839	2 276	9.2
Ethiopia	5 074	3 431	483	8 988	36.7
Rest	2 930	115	2 988	6 033	24.5
Southern	2 058	156	-	2 214	9.0
Mainland	956	154	-	1 110	4.5
Madagascar	1 102	2	-	1 104	4.5
Total	13 431	6 001	5 158	24 590	100.0

a) FAO (AT 2000) figures for 1975 plus own estimates for Namibia and Botswana (50 000 each) extrapolated to 1979

b) 50 % of total population of that species

Source: FAO (AT 2000 and Production Yearbook 1979) and own estimates.

There is a total of 25 million work animals in Tropical Africa. Ethiopia accounts for about one third. The Sahel countries, Sudan, Nigeria and Eastern Africa also show concentrations. Coastal West Africa and Central Africa are virtually void of any work animals. Thus these areas are not only low in livestock foods but have also remained as the classical areas of the hoe and the head load, part of the bane attributable to the tsetse fly (Nash 1969). As far as traction work is concerned there is no simple method of valuation. In particular it would be misleading to look at traction in terms of only one production activity or only one effect. Thus even if animal traction is exclusively used for cash cropping the economics of subsistence cropping are likely to be affected, the effect on area productivity (yields) is likely to be overlain with effects on labour productivity, the cropping pattern, the cost structure and the risk situation (Munzinger 1981). Finally the value of traction is also influenced by the application of complementary inputs like fertilizers, irrigation or simply better husbandry standards as expressed e. g. in row planting. Cassé et al (1965) therefore see the major value of animal traction in the general increase in the farm capacity which allows to multiply by a factor the beneficial effects any other improvements may have on agricultural production, a factor that can only be quantified for specific situations. The introduction of a pair of draught oxen is generally believed to increase the cultivation capacity of a family engaged in traditional hoe farming by a factor of 2 or 3 (Hrabovszky 1980, Munzinger 1981). But there appears no way of deriving from this a generalizeable value of animal traction.

The valuation of transport is more straight-forward. The different types of transport work by the different animal species can be brought to the common denominator of tonne-kilometers performed per day. The body weight of the animal and the weight of the load determine tractive force, possible speed and duration of transport work per day. Performance per day is estimated at between two to five tonne-kilometers for bovines and equines, up to 17 for camels (Clark and Haswell 1970). Clark and Haswell examined the value of transport for a wide range of situations in terms of prices actually paid and converted this into grain equivalents per tonne-kilometer. The figures vary from 1.7 to 11.8 GE kg per tonne-kilometer. A basis for valuation of specific performances therefore exists. There is, however, hardly a basis from which to attempt an aggregate quantification of transport work performed by livestock in the whole of Tropical Africa.

3.2.5 Animals - Reproduction and Growth

Herds and flocks reproduce themselves. Additions to the existing stock must therefore also be considered as livestock products. Table 3.6 shows the development of livestock populations over the years of the 1970s, the period for which complete and more or less consistent data series are available.

Table 3.6: Growth of Livestock Herds and Flocks in Tropical Africa 1969-71 to 1979

Species	Numbers 1969-71 1 000 head	Numbers 1979 1 000 head	Index 1979 (69-71 =100)	Growth rate 69-71/79 % p.a.	Growth rate 74/79 % p.a.	Growth rate 78/79 %
Camels	10 395	11 135	107.6	0.8	5.4	1.4
Cattle	132 181	147 510	111.6	1.2	2.8	2.1
Sheep	93 860	108 644	115.8	1.6	4.9	1.4
Goats	112 779	125 286	111.1	1.2	4.3	1.6
Equines	11 729	11 993	102.3	0.3	1.5	1.3
Pigs	5 405	7 271	134.5	3.3	4.5	3.5
Chickens	355 772	453 472	127.5	2.7	5.5	4.2

Source: FAO (Production Yearbooks, various years).

All grazing animals suffered from the drought in the years 1972 to 1974 and recovered rapidly thereafter. An analysis of the growth pattern shows for all species a normalization from about 1977 or 1978 on. The production values have been determined for 1978 and it appears reasonable to take the rates of 1978/79 as indicators of 'normal' growth.

The value of growth is a function of the value of the standing stock. Ideally the valuation of the standing stock and of growth have to take into account all the products the particular livestock species provides; the discounted value of this stream of production over time would constitute the value of the standing stock from which the value of growth could be derived. Here a simpler approach has been chosen by which ruminants, pigs and poultry are valued at their meat value. By this principle a TLU (250 kg live-weight, 125 kg dressed weight) is valued at 500 GE kg or $ 80. Pigs and chickens have a higher value per TLU because of a higher dressing-out percentage. Table 3.7 summarizes the valuation.

Table 3.7: Estimate of the Value of the Standing Stock of Meat Animals in Tropical Africa 1979

Species	Standing stock 1 000 TLU	Unit value $/TLU	Total value million $
Cattle	103 257	80	8 261
Sheep	10 387	80	831
Goats	12 529	80	1 002
Pigs	1 449	110	159
Chickens	4 262	110	469
Total	131 882	n. ap.	10 722

Source: FAO (Production Yearbook 1980); valuation by the author (see text).

The meat animals in Tropical Africa (cattle, sheep, goats, pigs and chickens) represent a standing value of over $ 10 billion. This does not include the value of camels and equines. Livestock probably constitute the most valuable asset of the rural population in Tropical Africa apart from land. Growth rates of between 1.2 and 5.5% (Table 3.6) represent an addition of $ 130 to 600 million to the annual production value of livestock.

3.3 Production and Productivity by Ecological Zone

Figures of partial productivity are arrived at by relating production to a production factor or resource employed in production. A common productivity figure for livestock is one that relates production to the livestock resource. Table 3.8 expresses the production of milk and meat - the two most readily quantifiable products - per animal for the different species. The calculation of such average figures does not imply uniformity for the whole of Tropical Africa. The purpose is (1) to allow aggregate comparisons of world regions and (2) to assess any specific situation within the region in terms of deviation from the calculated mean.

Table 3.8: Productivity Indicators of Livestock by Species in Tropical Africa 1975/80[a]

Species	Meat kg/head	Milk kg/head	Meat kg/TLU	Milk kg/TLU	GE kg/TLU
Camels	-[b]	200	-	200	340
Cattle	13	39	18.5	56	169
Sheep/goats	3.5	7	35	70	259
Pigs	33	-	165	-	660
Chickens	1	-	100	-	400 (1 360)[c]

a) All figures relate to production per annum. In order to achieve consistency among different sources and to avoid anomalies informal averages have been used for the years between 1975 and 1980

b) Camel meat is consumed but neglected here to account for milk yield which as an overall average may be slightly high

c) Including 1 kg of eggs per bird and year

Source: FAO (AT 2000 and Production Yearbooks, various years).

By global standards the figures of production per head given in Table 3.8 are extremely low, lower than in any other region of the world (Jasiorowski 1973, FAO Production Yearbooks). The productivity picture improves somewhat when production is related to a livestock unit since this takes account of the generally small size of African livestock. The inter-species comparison of combined (meat and milk) productivity points to the superiority of non-ruminants and to the particularly low productivity of cattle.

From the African livestock producer's point of view the low figures of meat and milk productivity are less disturbing and the calculated differences among species less meaningful. Production is almost costless with the exception of the labour input and even here opportunity costs are low. Livestock, particularly ruminants, give important additional products and serviccs like manure, traction and transport. In many cases livestock provide the only means of survival in a harsh environment not suitable for any other type of land use. In addition livestock constitute an investment unaffected by inflation that pays a significant dividend not only in terms of low cost production but also in terms of growth. The low productivity figures are real enough but they do not imply that livestock have a low value in the eyes of the African husbandry man.

Table 3.9 relates meat and milk production from ruminants to the ecological zones. Milk production is concentrated in the arid zone. In contrast possibly to expectations the arid zone (i. e. the zone with the harshest climate) is the most important dairy zone of Tropical Africa in spite of quite sucessful dairy development in the highlands. The arid and the semi-arid zones together account for 55% of the meat production and 63% of the milk production. The sub-humid and the humid zones an the other hand which in principle have a much higher potential in fodder productivity produce little meat and milk. This situation is clearly reflected in the availability of animal products for the human population*. In the arid zone one person consumes of 24 kg of meat and 137 kg of milk which is high by most standards. But here meat and milk are not additions to the diet but its main component. In the humid zone availability drops to a low level of 3 and 7 kg respectively. The semi-arid zone in spite of a high volume of livestock production shows relatively low figures on a per-caput basis because of the high population densities in this zone. Inclusion of food production from other species (pigs and poultry) would improve the picture for the humid zone somewhat but would not substantially alter the overall pattern.

The figures in Table 3.9 present an incomplete picture because the products play different roles in the different zones and because they are complemented by different additional products. In the arid zone food production for subsistence by all ruminants and the transport performance of camels are important. In the semi-arid and the sub-humid zone food production for the market and the role of cattle for crop agriculture (manure, traction) become im-

* In the following the figures relate to the rural population i. e. to the total agricultural population in FAO terminology.

Table 3.9: Availability of Meat and Milk from Ruminants by Ecological Zone in Tropical Africa 1975/80

Ecological zone	Meat 1 000 t	%	kg/person[a]	Milk 1 000 t	%	kg/person[a]
Arid	708	26.0	24.3	3 969	42.2	136.5
Semi-arid	788	29.0	9.9	2 014	21.4	25.2
Sub-humid	570	20.9	10.7	1 381	14.7	26.0
Humid	167	6.1	3.2	363	3.9	6.9
Highlands	487	18.0	21.3	1 674	17.8	73.4
Total/average	2 720	100.0	11.4	9 402	100.0	39.6

a) Agricultural population

Source: Compiled by the author based on Tables 3.8 and 2.8 incorporating considerations from later chapters on the different production systems suggesting a higher than average cattle milk yield in the highlands (50 kg/head against 35 kg for the other zones) and a lower than average milk yield of sheep and goats in the sub-humid and humid zones (5 kg/head against 7.5 kg in the other zones).

portant. Meat production from goats (and pigs and poultry) gain in relative weight in the humid zone. The highlands are characterized by the predominance of sheep over goats, the advances in milk production and, in particular in Ethiopia, the importance of animal traction and transport by equines.

The derivation of productivity indicators for land and labour is hampered because these production factors cannot be delimited to be specific to livestock production (compare section 2.3). This influences interpretation of the figures in Table 3.10 and makes it inadvisable to attempt the computation of a total productivity measure for all resources combined.

Table 3.10: Productivity Indicators of Livestock Production in Tropical Africa 1975/80
- based on meat and milk production from ruminants converted to kg of grain equivalents[a] -

Ecological zone	Livestock[b] kg/TLU	Land[c] kg/ha	Labour[d] kg/ME
Arid	230	13	856
Semi-arid	176	33	213
Sub-humid	168	30	225
Humid	177	30	63
Highlands	206	60	544
Average	196	22	293

a) Conversion factor for milk 1.7, for meat 4.0; production and productivity figures from Tables 3.8 and 3.9

b) Ruminant livestock only

c) Tsetse-free land

d) Total agricultural work force

Source: Compiled by the author; for details see preceding tables and text.

The highest livestock productivities are found in the arid zone due to the high milk productivity of camels, and in the highlands due to the higher average yield of cattle. Differences among the other zones are too small for interpretation. As a result of the high animal-man ratio in the arid zone labour productivity is also the highest. 850 GE kg per man is equivalent to about 330 GE kg per person. This would meet energy requirements in the form of grain but not if livestock products are consumed. Land productivity is highest in the highlands and lowest in the arid zone which corresponds with the respective ecological potentials. Land productivity in all zones is low when compared to cropping which even at low levels would yield 600 GE kg/ha. However, this comparison is problematic. In the arid zone cropping is not a real possibility over most of the area; for the other zones there are definitional problems since the resource land is not differentiated according to livestock land and cultivated land.

Some of the crucial problems of livestock production in Tropical Africa become apparent from the analysis:

- Livestock is concentrated exactly in the areas with the lowest ecological potential.

- Livestock provide a precarious subsistence if they are the sole means as is the case in much of the arid zone.

- Animal protein is very scarce in the zones that in principle have a high fodder producing capacity.

- Particularly in the non-arid zones the non-food products (manure, traction, transport) play an important role that must not be overlooked.

- The highlands is the only zone where present livestock productivity is on a higher level, where the ecological potential appears considerable and where tsetse flies do not constitute a major constraint.

4 Livestock Development and Production Systems

4.1 Livestock Development

4.1.1 Performance to-date

Livestock development between 1950 and 1970 has been analysed by Jasiorowski (1973). Over that period livestock production in Africa (meat and milk from all species) increased at an annual rate of 2.1 and 2.3% respectively. To determine the significance of such an increase it must be related to the human population. On a per caput basis meat and milk production decreased during that period. The decrease was only slight but the level in 1950 was already significantly below the world average and was even more so in 1970. In 1950 Europe (including USSR) produced 2.1 times as much meat per caput as Africa and 7.1 times as much milk. By 1970 the ratios were 4.5 and 10.5 respectively. This stagnation of per caput production of meat and milk in Africa is associated with low and stagnant animal productivity. Over the 20-year period meat and milk productivity showed minimal increases only, a decrease even for beef. Production increases were therefore mainly the result of growth in animal numbers and that hardly kept pace with the growth rate of the human population which for the period under concern was 2.4% per annum. Industrialized countries showed a substantial increase in per caput production during that period, almost exclusively as a result of increased animal productivity.

The relevance of livestock development experience between 1950 and 1970 is ambiguous. Many African countries underwent commotions preceding and following independence. Concentrated efforts at agricultural development and development aid generally did not take on large dimensions before the mid-sixties. It therefore appears useful to look at livestock development within the framework of general economic and agricultural development during a more recent period. Figures are available for the period 1960/63-1975/77 (UNCTAD 1979, FAO (AT 2000 1979), de Montgolfier-Kouévi and Vlavonou 1981). During that period overall economic growth varied a great deal, but on average the GDP of Tropical African countries rose at a remarkable rate of 4.3% in real terms. There was a positive correlation between the overall growth rate and the GDP per caput. It averaged 3.2% per annum in the least advanced countries, 4.1% for the middle group and 6.1% in the two oilproducing countries. The trend for agricultural production was less favourable. It slowed down appreciably towards the end of the period and progressed by only 1.2% per year on average between 1970 and 1975 against 2.7% between 1963 and 1970. In over half of the countries agricultural production grew more slowly than population leading to a decline in per caput output in several regions including the Sahel, Eastern Africa and Nigeria. The self-sufficiency ratios for agricultural products fell in practically all countries. For the group of cereals the decline was from 96% in 1963 to 92% in 1975. Growth in livestock production also fell behind, particularly after 1970. The importing countries of Central and Western Africa were forced to turn to the international market to complement their meat supplies after their traditional imports from the Sahel were abruptly curtailed, while in Eastern Africa exports of fresh and canned meat collapsed. The countries of the Horn of Africa (Ethiopia and Somalia) as well as Sudan, which export live sheep to the Middle East, found themselves unable to meet the sharp increase in demand from the latter region, which now imports live sheep as well as meat from Australia. Table 4.1 provides estimates of production increase and productivity growth.

Table 4.1: Indicators of Expansion and Productivity Growth in Crop and Livestock Production in Tropical Africa 1963-75

Agricultural	Annual growth rate 1963-75 (%)		
production	Total	Productivity[a]	Expansion[b]
Crops	2.1	0.4	1.7
Beef	1.4	0	1.4
Mutton, goat meat	1.2	0	1.2
Total meat	2.0	0.2	1.8

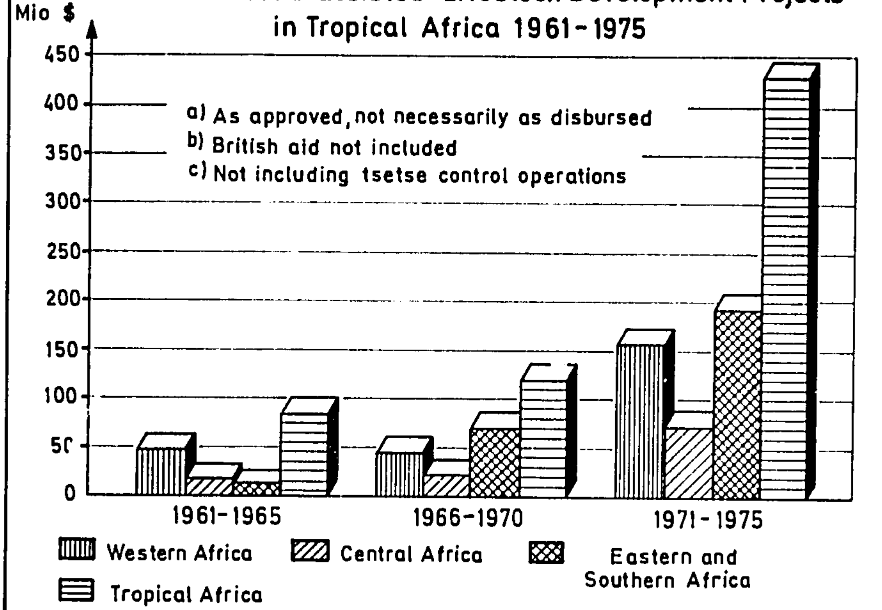
a) Yields per unit area in the case of crops; production per animal in the case of livestock

b) Expansion of cultivated area in the case of crops; expansion of herds and flocks in the case of livestock

Source: de Montgolfier-Kouévi and Vlavonou (1981) after FAO (Production Yearbooks).

The expansion of crop production did not keep pace with the growth of human population. Moreover the production increase was mainly due to area expansion rather than yield increases. Such a development path is limited in its scope and indicates the continued predominance of traditional production techniques. Deviations from this average pattern exist for different crops, regions, countries and sub-periods (de Montgolfier-Kouevi and Vlavonou 1981) but do not change the overall picture of unsatisfactory performance. In the case of beef and mutton/goat meat no increase in productivity is recognizable at all. Numeric growth rates are

Figure 4.1.
Total Costs[a] of Aid-assisted[b] Livestock Development Projects[c] in Tropical Africa 1961-1975



Source: Wissocq (1978).

less than half of that of the human population. Figures for total meat are somewhat more favourable due to relatively high numeric growth rates of the pig and poultry populations and due to some productivity increase in poultry production. Overall production and productivity increase is less than that of crops, significantly less in the case of ruminants. This performance has to be seen against substantial livestock development efforts from the 1960s on (Figure 4.1). Aid-assisted development projects have been taken as an indicator because they are better documented and because they make up the bulk of development efforts.

Table 4.2: Livestock Production and Productivity in Africa 1950, 1970 and 1975/80

Indicator	Total Africa		Tropical Africa
	1950	1970	1975/80
Per caput production[a]			
Meat (kg)	12.0	11.1	8.6
Milk (kg)	32.6	31.5	29.7
Production per animal			
Beef/veal (kg)	13.9	13.6	13.0
Mutton/goat meat (kg)	3.1	3.5	3.5
Pork (kg)	34.1	41.1	33.0
Milk from cattle (kg)	50.9	57.6	39.0
Milk from sheep/ goats (kg)	7.2	6.6	7.0

a) Production related to the total human population

Source: Jasiorowski (1973) for first two columns; third column FAO (Production Yearbooks, various years) and other sources as indicated in section 3.3.

The total costs of livestock development efforts between 1960 and 1975 are estimated at over $ 600 million (Wissocq 1978). The significant increase in development efforts only set in in the 1970s and it can be argued that their effects could not show before an adequate gestation period. But there is general disappointment with the performance of livestock development projects up to the present (see e. g. UN 1977, Goldschmidt 1980, ILCA 1980b, Jahnke 1976 a, Sandford 1980, Ferguson 1979). Major development agencies are contemplating withdrawal from the African livestock sector altogether. Improvement of livestock production as a result of on-going projects does not appear to be imminent.

In summary experience with livestock development to-date is disappointing. Agricultural development as a whole has fallen behind overall economic growth and the shortfall is particularly serious for the livestock sector. The per caput availability of livestock foods in Africa has not improved and whatever increase in production there is mainly due to herd and flock increase rather than productivity increase. Traditional production systems have simply expanded maintaining traditional techniques.

Table 4.2 compares per caput availability and animal productivity in Africa 1950, 1970 and 1975/80.

Jasiorowski (1973) commented the figures for 1950 and 1970: "Twenty Years without Progress". The figures for 1975/80 are not strictly comparable since referring to Tropical Africa only but they are generally lower. Expansion of the comment into "Thirty Years without Progress" appears justified.

4.1.2 The Case for Livestock Development

4.1.2.1 Arguments for Livestock Development

A number of arguments in favour of livestock development are technically based and relate to the protein requirements for human nutrition, to the possibility of converting through livestock roughage and residues that are otherwise unusable, to the need for animal draught in crop production, to the possibility of increasing soil fertility through the application of manure etc. Other arguments relate to the precarious existence of pastoralists in dry areas which painfully comes to the open in drought periods and to the degradation of the natural resource base in these areas.

All these arguments may have their justification but they are all based on needs and possibilities. Needs and possibilities may be real enough but there are just as many needs and possibilities to direct efforts into alternative directions. There are even strong arguments against livestock development like the conversion losses in livestock production or the social injustice in providing few with luxury foods while the poor majority barely subsists. It would indeed be very difficult to argue in favour of livestock development if it were not for one factor: Demand for livestock products, or more precisely, effective demand. People want livestock products and they are prepared to pay for them. Willingness to pay for livestock products which exists on practically all income levels generates income for the livestock producer and this is a pre-requisite for production development and a good starting point for obtaining the cooperation of livestock producers in development efforts. Nutritional, ecological, social, political and humanitarian considerations have their place for specific situations but they cannot carry the argument for or against the development of a whole economic sector for a continent. Demand for livestock products is the strongest single argument for livestock development.

4.1.2.2 Demand for Livestock Foods

Already demand for livestock foods in Tropical Africa has outrun supply, as predicted early-on e. g. by FAO (1970) and SEDES (1969b), leading to shortages, price increases and finally ever-increasing imports of meat and milk which characterize the situation today (ILCA Bulletins 3, 4 and 5, 1979 and 10, 1980). FAO (AT 2000 1979) provides the most consistent and comprehensive projection of demand for livestock foods in Tropical Africa up to the year 2000.

The basic premises are continued growth of the human population estimated at an average annual rate of 2.9% for Tropical Africa between 1975 and 2000 and continued economic growth. Different scenarios are constructed for the latter; only the most conservative one is used here which is close to a trend projection at a growth rate of 5% per annum in real (1975) prices. Considerable variations are assumed among countries so that for the group of the least advanced this scenario implies stagnation or a slight decrease of per caput incomes while the most advanced or resource- richest countries show an annual growth of 3.0 percent and more. Income is translated into demand growth for crop and livestock products via income elasticities of demand (Table 4.3).

Table 4.3: Regional Average[a] Income Elasticities of Demand for Selected Crop and Livestock Foods in Tropical Africa 1975-2000

Region/	Crop foods		Livestock foods		
country	Cereals	Roots	Meat[b]	Milk	Eggs
Western					
Sahel	0.24	0.22	1.04	0.53	0.90
Nigeria	0.16	- 0.09	1.08	1.20	1.20
Rest	0.33	- 0.16	1.08	1.23	1.10
Central	0.51	- 0.03	0.97	1.09	0.90
Eastern					
Sudan	0.22	- 0.18	0.81	0.90	2.00
Rest	0.24	- 0.05	1.01	0.77	1.10
Southern	0.14	0.17	0.84	0.95	1.00
Tropical Africa	0.22	- 0.07	0.98	0.82	1.10

a) Weighted according to share in overall consumption of food products; average over analysis period

b) Excluding edible offals; including game

Source: de Montgolfier-Kouévi and Vlavonou (1981) after FAO (1979d).

The income elasticities show substantial variations among different foods and, for a single commodity, among different countries and regions. Generally the coefficients for livestock foods are substantially higher than those for the staple foods, i. e. roots and cereals. Income elasticities of demand for oil crops, pulses, bananas, fruits and vegetables take an intermediate position. Those for sugar approach the level of livestock foods. The coefficients implicitly express the effect of income levels, share of subsistence in production, availability (and price levels) of alternative foods, cultural factors and the like which differ among the countries. An open question is the extent to which the income elasticities are overlain by price effects. Particularly in the case of livestock products the shortfall in supply has led to rapid price increases and curbed demand accordingly. There is reason to assume that the income elasticities of demand thoroughly corrected for that effect would be higher, possibly substantially higher, than indicated. Demand projections based on the elasticities given (Table 4.4) would then constitute an underestimation. Due to the relatively uniform growth rate of the human population the growth rate of potential demand to the year 2000 is more uniform in regional terms. Only the average figures for Tropical Africa are therefore presented in Table 4.4 for the different commodities.

Table 4.4: Projection of Domestic Demand[a] for Selected Crop and Livestock Foods in Tropical Africa 1975-2000

Food item	Annual growth rate (%) per caput	total	Increase 2000/1975 by factor
Crop foods			
Cereals	0.4	3.4	2.3
Roots	- 0.1	2.9	2.0
Livestock foods			
Meat	1.2	4.2	2.8
Milk	0.8	3.8	2.5
Eggs	2.2	5.2	3.6

a) At constant (1975) prices

Source: de Montgolfier-Kouévi and Vlavonou (1981) based on FAO (1979d).

Table 4.4 shows that even for a commodity with a low income elasticity of demand like root crops total demand will double over the analysis period. For livestock products demand is projected to increase by factors between 2.5 and 3.6. These are the factors by which domestic supply would need to increase if self-sufficiency ratios, presently already below 100%, were to be maintained. This is generally regarded as a minimum goal of any development plan. Higher economic growth rates as implied by alternative scenarios and/or higher income elasticities would lead to an accelerated growth in demand. All indications are therefore for a growth rate of demand for livestock foods that is much higher than the growth rates in production achieved in the past.

4.1.2.3 Demand for Other Livestock Products

Population growth and economic growth translate into a growing demand for other livestock products as well. This may be shown for two examples, fertilizers and power as farm inputs, which can, at least in part, be provided by animal manure and traction. The demand for fertilizers and power is derived from the demand for crops on one side, the production possibilities and costs on the other. The necessary computations are complex and require assumptions, country by country and for each crop, about possibilities of area expansion, likelihood of intensification, level of complementary inputs and the like. They have been carried out at a considerable level of detail and sophistication by FAO (AT 2000 1979) but can still only be considered orders of magnitude. At the same time the figures no longer constitute projections but an assessment of the agricultural development path that is desirable and possible given that the necessary resources are found and that certain policies are implemented (FAO AT 2000 1979).

Fertilizer requirements are estimated to increase almost ten-fold by the year 2000 to meet production goals which are still essentially only the maintenance of present self-sufficiency ratios. The foreign exchange burden of meeting these requirements by import of mineral fertilizers is enormous even without allowance for further price increases and the logistical difficulties of distribution which may be just as serious. At the farm level they may translate into problems of cost and availability that make the substitution by animal manure at least in part an important alternative. Power requirements are estimated to increase at a rate that could theoretically be met by the population increase. However, continued urbanization, increased income level and the specificities of certain natural environments make a trend toward mechanization more likely. Accordingly it is estimated that the mechanization factor in Tropical Africa (i. e. the proportion of total power inputs into crop production expressed in man-day equivalents that is met by animal traction or by tractors) increases from 14% in 1975 to 16% in 2000 (Jahnke and Sievers 1981). The absolute increase in power inputs and the growth in mechanization requirements again provide for substantial scope for the use of livestock for work. Past experience with tractorization programmes in Tropical Africa

Table 4.5: Indicators of Input Requirements of Agricultural Development in Tropical Africa 1975-2000

Input	Level 1975	Level 2000	Increase 1975/2000 p. a.	by factor
Fertilizers (1 000 t)	612	5 799	9.4 %	9.5
Power inputs (million ME)	14 123	27 357	2.7 %	1.9

Source: de Montgolfier-Kouévi and Vlavonou (1981) after FAO (AT 2000, 1979).

is not encouraging, and the prospects for the future are further clouded by rising energy costs. There is therefore reason to believe that the demand for draught animals will increase, at least in those areas that are ecologically suitable for livestock husbandry.

4.1.3 Development Considerations and Farm Systems

Livestock production takes place on the farm level, within rural decision-making or management units. The sector statistics of livestock production and productivity are the aggregate outcome of decisions made by farmers. These decisions reflect the specific aspirations of the farmers as well as the specific constraints under which they operate. Similarly development intentions have to be translated into policies and projects ultimately influencing decisions at the producer level in order to become effective and so raise, as the aggregate outcome, sector performance. To link to sector considerations the analysis of farms* is therefore important

* The conventional notion of the term 'farm' does not readily apply to some forms of livestock enterprises (e.g. feed-lots, ranches, pastoral herding units). For convenience it is used here as synonymous with the more general term 'agricultural management unit'.

because farms are major decision points in agricultural development (Ruthenberg 1980).

Farms can be viewed as systems i.e. entities of interrelated elements. Several activities are closely related to each other by the common use of the farm's labour, land and capital, by risk distribution and by the joint use of the farmer's management capacity. System theory can then be usefully employed as the guideline for description and analysis of these entities.* In particular this allows the introduction of the concept of hierarchy. Any farm is part of a hierarchy of systems, belonging first to the larger system of the rural area (or ecological zone or sector) and, secondly, consisting of various activitities and elements which themselves can be looked upon as systems or sub-systems. Micro-organisms in the soil are a sub-system of the soil system; the soil system is a sub-system of the crop-producing system and that in turn is a sub-system of the farm system. The livestock system is also a sub-system of the farm system. In some cases the livestock (or cropping) system encompasses the whole of the farm system because livestock production (or cropping) constitutes the sole activity of the farm.

The farming systems' approach provides a scheme that is useful for the description and analysis of farms for the purpose of general agricultural development (Ruthenberg 1980). Such a scheme has to be developed for the more specific purpose of livestock development. The 'systematics' of African livestock production is to provide a guideline for the orderly approach to farm systems in Tropical Africa, for description and analysis that is useful for livestock development.

4.2 The Systematics of African Livestock Production

4.2.1 Farming Systems and Ecological Zones

To look at individual management units becomes cumbersome and often impossible when the interest is in the outcome for larger aggregates or even a continent. It is then useful to group management units which are similar in their structure and in their production functions. Such a grouping is also called for when there

* The wording follows Ruthenberg 1980. For the basic reasoning see Bertalanffy 1973; Dent and Anderson 1971; Emery and Frist 1971; Forrester 1972; Fuchs 1973; Kirsch 1974; Laszlo 1972; Walter 1973; and Woermann 1959.

are important interactions among the management units. This is the case with farms sharing a water resource in an irrigation perimeter or with pastoral management units sharing a communal grazing resource and cooperating in the herding task. Such groups are commonly referred to as farming systems (Ruthenberg 1980). In this definition the management units are the building blocks (Andreae 1977) of a farming system. A distinction is therefore made between any given farm unit which, as it stands, is a system, and classes of similarly structured farms which are classified as belonging to a certain farming system. In both cases the term system is appropriate because the variance of the whole is less than the sum of the variance of the parts (Laszlo 1972, p. 41).

The grouping and delimitation of farming systems can be effected in different ways (e. g. Duckham and Masefield 1970, Grigg 1974, Andreae 1977, Ruthenberg 1980), but the way in which the land is used is a central consideration. The large groups normally distinguished are grazing systems, tillage (or annual crop) systems and perennial crop systems. Since the interest here is in livestock the former are referred to as range-livestock systems and the latter two - if livestock are present at all - as crop-livestock systems. The term livestock production systems is used in this study to denote farming systems of interest for the study of livestock and livestock development. The livestock production system may refer to a sub-system of farm systems grouped together into a farming system or it may represent the total farm system. It may also relate to particular groups of farms engaged in livestock production within a broader farming system.

A useful additional grouping of farming systems, particularly of livestock production systems, is by ecological zones as defined in section 2.2. Placing farming systems in the context of ecological zones has the particular advantage of providing information of the basic resource endowment (livestock-land, land-man ratios, extent of tsetse infestation, productivity of the land) since the aggregate resources have already been broken down to the level of ecological zones. The large classes production systems distinguished in this study are

- range-livestock production systems, of which one sub-class, pastoral systems, are concentrated in the arid zone, while another, ranching systems, are found in all or most ecological zones;

- crop-livestock production systems in the more humid areas (with special consideration given to systems in the highland areas); and

- landless production systems or production systems that are largely independent of the specific ecological conditions prevailing.

These large classes can be further sub-divided into so called "types" of farming or livestock production. A feature of these classes and types is that their characteristics can be readily brought down to the farm level or level of the decision-maker which is considered particularly relevant for development. A systematic treatment of these characteristics, of their developmental implications and of their use for further systems' classification has been given by Ruthenberg (1980) for tropical farming systems in general and is adhered to in this study. Elaboration is therefore only required for the livestock aspects of farming systems.

4.2.2 Livestock Type and Product

Livestock production is characterized by the livestock type and by the livestock products. The livestock type may be designated by the species (camels, cattle, goats, sheep, horses, asses, pigs, chickens) or species groups like equines or ruminants. Breed groups like the trypanotolerant animals also sometimes constitute useful units. The livestock products essentially are meat, milk, eggs, hides, skins and wool as farm outputs, and manure and work as farm inputs. Animals, as the constituents of reproduction and growth, have also been considered as products. The different livestock products have been dealt with at some length in chapter 3.2. No further elaboration appears needed here.

4.2.3 Livestock Functions

General: The functions of livestock refer to the mode of action or activity by which livestock fulfill their purpose. Partially the functions of livestock are tied to the livestock products. In the case of meat and milk, the related function of livestock is to provide income and subsistence through their sale or consumption while with manure, the function of livestock is to provide an input to crop agriculture thereby increasing production and income. The differentiation of products and functions allows the differentiation of livestock production systems even if they are based on the same product, e.g. herd growth for security, for social reasons (prestige) or for a pure income objective. It is also a prerequisite for the realistic valuation of livestock products because the value of meat for export can be judged differently from its value as a source of subsistence. The following functions can be fulfilled by livestock

- the output function (subsistence, income and nutrition)
- the input function (crop inputs and farm integration)
- the asset and security function
- the social and cultural functions.

The output function: The production of food and non-food products for home consumption provides subsistence. If the products are partially or wholly sold they generate cash income. For a management unit that trades a farm input like manure livestock fulfill an income function although the farm that uses that manure in crop agriculture may look at it as a crop input. If livestock constitute the only source of subsistence one can hardly talk of a nutritional role of livestock that goes beyond that implied by subsistence. If the livestock products, possibly after trading, serve to upgrade an otherwise deficient diet of say root crops a particular nutritional role can be attributed to the livestock products. The nutritional role of livestock products also assumes importance from a more aggregate view. For the production unit that sells livestock products the income function of livestock stands in the foreground. From the national point of view, however, the livestock products may be valued for their nutritional importance to certain vulnerable groups of the population for which they become available or if the livestock products are destined for export the income function, from the national point of view, is enlarged to include the foreign exchange effect of these exports.

The input function: If livestock are used for their manure or for their work capacity they fulfill a farm input function. The interactions of a livestock sub-system with a cropping sub-system (or between a pure grazing system with a pure cultivation system as distinct but interrelated management units) may be very complex going beyond the simple provision of a farm input. This function is then better described as farm integration (e. g. Brinkmann 1922). The farm integrative function refers to all the different effects livestock may have on the productivity of the resources engaged in agriculture thereby rendering the farm more productive than it would be without the livestock enterprise. Examples are:

- The productive use of non-arable land within the farm;
- the productive use of otherwise (seasonally) unemployed labour;

- the conversion of low-value crops and crop residues to high value animal products by feeding them to livestock;

- the yield increasing effect of including fodder crops in crop rotations;

- the balancing of production and market risks of cropping by the livestock enterprise (see security function).

The input functions of livestock in mixed farming systems can therefore take on many different forms. It covers very different degrees of integration of the livestock sub-system into the overall farming system.

The asset and security function: One aspect of the risk balancing effect of livestock is simply that it is a non-cropping activity. There is the likelihood that not both, crop production and "non-crop" production, are affected by a negative deviation from the expectation at the same time. Other aspects are that some lines of livestock production (milk, eggs) provide a regular income as opposed to cropping and that livestock can be readily sold to solve a liquidity problem of the farm. All this adds to the farm's economic security. But livestock have an additional security function by being an asset. This becomes obvious when seen in the context of traditional agriculture, where any combination of the following characteristics may apply (Barth 1973, Mc Cown et al 1979):

- Arable land is communally owned or 'on loan' from the clan or group; it is not a disposable asset;

- cropping is principally undertaken for subsistence but periodically yields a saleable surplus;

- cropping is carried out on a low technological level; capital inputs are limited to seed and simple equipment;

- commercial banking institutions are not present or are not trusted.

Under these conditions surplus from cropping cannot be invested in land or in other factors of agricultural production. It is likely that a balance is struck between the drudgery of labour in agricultural production and the satisfaction of returns to labour essentially in the form of subsistence. The situation is different if livestock are present in the economy. Agricultural surplus can be converted into livestock through sale, exchange or even direct feeding of crops. Livestock have a savings account function by being recognized as private property, by being a relatively safe and durable form of storing wealth, by earning interest in the form of offspring, and by being readily disposable and convertible into cash or other valued things (liquidity). Livestock are better than a savings account because they are unaffected by inflation and remain under complete control of the investor or those he trusts.

The asset and security function is not limited to the rural population. Even town-dwellers may prefer investment into livestock over other investment venues. In many cases the asset or security function of livestock contributes more to the understanding of a livestock production system than the production of meat and milk or the provision of farm inputs like manure and traction*. The function should conceptually be seen in sharp contrast to the keeping of cattle for social and cultural reasons like prestige and social cohesion. Of course the ownership of livestock adds to prestige and makes it easier to obtain assistance from other people. But this is the case with any form of savings account or monetary wealth and is a derived phenomenon limited neither to livestock nor the developing world. At the basis is the asset role of livestock.

<u>Social and cultural functions</u>: The functions of livestock so far described essentially relate to agricultural production, subsistence, income, and wealth and may be summarized as the economic functions of livestock. If livestock are important for production, subsistence and wealth it is to be expected that man takes an interest in livestock and places a value on them. The more important the economic functions of livestock, the greater that value will be. The social and cultural role of livestock (for an individual one might include the emotional role) is here viewed in the restricted sense of a role that cannot be explained from the economic functions alone. In other words the question is whether livestock in Tropical Africa have a value that goes beyond their economic val-

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* Doran, Low and Kemp (1979) argue that if cattle are held as a store of wealth the overall supply response is likely to be negative and that this is one of the reasons for the phenomenon of overgrazing. Their observations are based on cattle holders in Swaziland, but are proposed to be valid for Tropical Africa as well.

ue. Such a role could be attributed to livestock if they influenced social relationships in a way that cannot be deduced from the economic value of livestock or if the value placed on livestock and the social sanctions governing dealings with livestock were disproportionate with the economic value of livestock. Enough examples are known from Tropical Africa to confirm such a social and cultural role. Thus there are societies in which brideprice has to be paid in cattle and no other carrier of value is accepted; only through the transfer of cattle can marriage be legitimized (Dyson-Hudson 1972). There are also societies in which cattle are valued for their long horns, camels for their racing capabilities; both traits appear quite unrelated to any economic function of livestock. At this stage, without reference to a specific production system the social and cultural function of livestock needs no further elaboration. The function exists but is often overlain by other functions and often disguises management principles that can be related to straightforward economic motives. In general terms two conclusions can be drawn:

- The more diversified and the more important the economic functions of livestock are in a traditional society the more likely it is that also social and cultural values are attached to them.

- While one has to guard against overemphazising the non-economic motives in livestock keeping in Tropical Afria it might be a serious mistake to ignore social and cultural functions of livestock, particularly as they are likely to affect development efforts.

<u>Other functions and conclusions</u>: Some other functions of livestock deserve mention. Thus transport has only been viewed so far in its importance for agricultural production. Transport by livestock, however, can also be a specialized commercial undertaking. The Sahara caravans are possibly the most striking example. Livestock have also been instrumental in providing military strength through the mobility and the thrust they make possible. These functions have lost in importance which is partly the reason for what Grigg (1974) terms the secular decline of pastoralism.

By and large, however, the output function, the input function, the asset and security function and the social and cultural function represent the functions of livestock in Tropical Africa. The most puzzling may be the social and cultural function but it is believed that the distinction of the asset function from what is otherwise often mixed together in the terms "prestige" or "irrational" helps to render this aspect more tractable. In industrial societies development has implied a narrowing of livestock functions and specialization towards one product. One aspect of that specialization is that species for production (essentially cattle, pigs, poultry) are different from those for affection, recreation and cultural events like horses and dogs, that banking institutions have replaced livestock as savings accounts and that motor power and mineral fertilizer have largely replaced animal traction and manure. To see the multitude of actual and potential functions of livestock in Tropical Africa is not only important for an understanding of the livestock production systems but also for the achievement of livestock development.

4.2.4 Livestock Management

General: Livestock production tends to be more complex and more demanding on management than crop production. Figure 4.2 illustrates the differences:

- Firstly livestock production implies the management of two "crops", fodder and livestock. In the case of extensive grazing there might be little work directly associated with the growing of fodder but the management complexity of matching fodder supplies with feed requirements throughout the year remains.

- Secondly the management of livestock and grazing affects subsequent fodder productivity (e. g. overgrazing that results in poor plant recovery). It also affects the productivity of the basic production factor land in the long run (e. g. overgrazing that leads to irreversible degradation of the land).

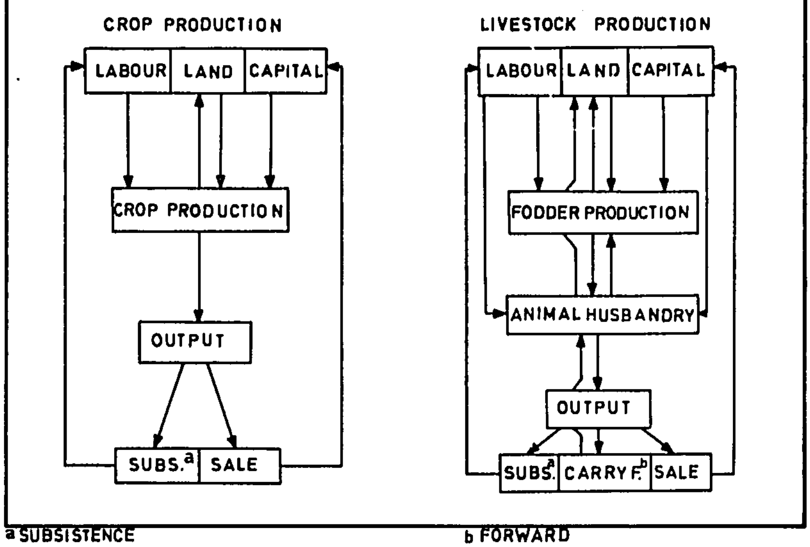
- Thirdly the output from livestock is not just the products for sale and subsistence but also the herd to carry forward to the next production cycle. Production decisions in one year have, in a much more pronounced way than is the case with cropping, an effect on production in the following years.

This comparative complexity of livestock production remains, no matter how simple the livestock production enterprise and how specialized the function of livestock.

The complexity of farming systems increases considerably if both crop and livestock production are carried out and if these sub-systems interact. A multitude of competitive, supplementary and

Figure 4.2.

Diagrammatic Representation of Crop Production and Livestock Production



Source: Compiled by the author.

complementary relationships with respect to the production factors and to the total output have to be taken into account.

Apart from these general considerations livestock management can be characterized by three aspects:

- The feeding regime,
- the grazing land tenure, and
- the herding arrangements.

The feeding regime: The feeding regime refers to the way in which the feed (and water) requirements of livestock are matched with supply. A first distinction can be drawn according to the intensity (in terms of labour and capital input or in terms of the land input) of the feeding regime. The most extensive form is that in which the livestock are largely left to themselves in collecting their feed. Large-scale ranching with a peripheral fence approaches this situation in arid areas. Small ruminants scavenging in villages in the humid zone is another example. More normally a degree of control is exercised over the grazing requiring essentially the input of labour (herding) or the input of labour and capital (fences for sub-division, rotational grazing). A higher intensity level is reached when fodder is grown. This may be harvested by the animals themselves or cut and brought to the animals (stall feeding), which is yet another step in intensification. The feeding of concentrates to the animals may be regarded as the most intensive feeding regime, particularly if this constitutes the main part of the ration.

The second important characteristic of the feeding regime is the way in which the feed and water requirements of livestock (which for physiological reasons are of a continual nature) are adapted to the fluctuations in supply. In the temperate zones the fluctuations are essentially due to the cold season that arrests plant growth. In the tropics the role of the cold season is played by the dry season with moisture as the limiting factor. An essential difference is that the water constraint is more amenable to correction through the application of capital and labour (e. g. irrigation) than is a temperature constraint. The two essential ways of adaptation are herd management on the one hand and pasture management on the other. In herd management the variables determining seasonal variation are the calving pattern and the product and sales strategy. Thus seasonal calving and the sale of say 3-month-old feeder stock result in a peak biomass (and thus feed requirements) just before selling and a small herd between then and next year's calf crop. Through the distribution of calvings on two peaks and the adoption of steer fattening activities feed requirements can be evened out more. Staggering calvings evenly throughout the year and switching to milk as the main product results in an almost constant pattern of feed requirement throughout the year. Pasture management, on the other hand, can be used to influence the carrying capacity or feed availability throughout the year. From a situation of stationary grazing with no fodder conservation, fluctuations can be reduced variously by rotational grazing, fodder conservation and the introduction of irrigated fodder production or even complete stall feeding (zero grazing).

The essential task is neither to even out feed requirements nor feed availability per se but to adapt the two to each other. For both pasture management and herd management a reduction in the fluctuation pattern calls for higher labour and capital inputs and for higher managerial skills, and is therefore linked to the intensity level of the production enterprise.

The grazing land tenure: Most of the African grazing lands are communal property. Maintaining an appropriate level of livestock numbers is the crucial element in good management of the rangelands. However, when livestock are owned by individuals and when land is common property, no individual has adequate incentive to contain the number of his stock so that together with his neighbours' stock, the aggregate numbers on the common land would be optimal*. For if this individual adds additional animals to his herd he will secure for himself all the benefits that arise from the additional production; but the costs imposed by these additional animals, in terms of the lower amounts of grazing available on average per head for all the animals and of the increased environmental degradation caused by overgrazing, will not fall on this individual alone but will be shared by everyone else whose livestock use the common land. For this reason this individual, and every other one similarly, will be inclined to go on adding extra livestock beyond the point at which the aggregate extra costs which these livestock impose (and which are shared) exceed the aggregate benefits (which are not shared). Moreover, even if the individual is not particularly inspired by greed (or need), he will be disinclined to take any action that might improve the grazing, e. g. by investment or by reducing the size of his own herd, because some other individual is likely to appropriate the benefits from this improvement by increasing the size of his herd. The inevitable consequence, therefore, of private ownership of livestock and common ownership of land is an excessive increase in livestock numbers, having already reached the point where saturation leeds to overgrazing as well as low fertility and high mortality rates. The general argument has come to be known as "The Tragedy of the Commons"**. This general argument will be the subject of

* For a formal presentation of the discrepancy between the social optimum and the private optimum in communal grazing see Crotty (1980).

** Following an article of that title by Garrett Hardin which appeared in Science in 1968. The wording of the argument used here is largely taken from Sandford (1980).

more detailed scrutiny in the context of specific production systems, particularly of the pastoral production system in the arid zone.

The herding arrangements: On large-scale livestock production enterprises the hiring of labour for herding and other livestock related work is a normal practice. It is a central task of management then to ensure that the herding practices are in line with the objectives of ownership. This is ensured by supervision and arrangements of punishments and incentives. The dichotomy between herding (or livestock management) and ownership is often most pronounced in smallholder situations, particularly in the so-called contract herding arrangements, common in West Africa. For part of or all over the year livestock are entrusted by the owner to herdsmen often of a distinct ethnic group that are renowned for their expertise in livestock husbandry. In West Africa this typically involves cultivators as the livestock owners and Fulani as herders. These livestock are taken on migrations of varying extent. The remuneration for the herders is normally in kind (milk and share of the offspring). The advantage for the owner is that he can devote all his attention to his crops with all his labour resource available for the peak requirements in cropping, and that damage to the crops by livestock is avoided. The disadvantage for the owner/cultivator is that he foregoes much of the output, that his herd is managed to maximize the herdmen's benefits (e. g. milk) rather than his own and that he loses manure and work as potential inputs to his cropping activities. The arrangement works fine if the owner's main interest is in the asset and security function of livestock. Problems arise, however, when such systems, normally low in livestock productivity, are to be improved. Development efforts would have to be directed at both herder and owner, or would have to venture into the complexity of breaking up traditional social arrangements and of introding livestock into the owner's farming system with all the management consequences. Again this aspect requires further scrutiny in the context of specific production systems.

4.3 Livestock Production Systems and their Development

Comprehensive classification schemes of production systems tend to produce a large number of boxes for all possible combinations of phenomena. When applied to reality a high proportion of boxes remain empty because they are not applicable or because time and space do not permit to investigate the real systems comprehensively. The aim here is not to provide a rigid and comprehensive classification scheme. It is merely suggested that an orderly procedure be followed when approaching livestock production in an area as huge and heterogeneous as Tropical Africa, incorporating a few key features for the differentiation of production systems.

As a first step livestock production is put in the context of the large classes of farming systems and in the context of the principal ecological zones. This ensures that livestock production as a form of land use is seen in relationship to other forms of land use, in particular cropping. It also gives an indication of the basic resource endowment, of the potential of the land, of the existence of a tsetse constraint, and of livestock-man and livestock-land ratios. The characteristics of livestock production are then assessed by the type of livestock and the livestock products, by the function livestock have and by the management principles of production.

In the arid zone pastoral range-livestock systems predominate. Ruminants are by far the largest species group and milk is the main product. The subsistence function and the social and cultural function of livestick play important roles. Management is characterized by an extensive adaptive form of migration and by the overgrazing syndrome.

As the zones become more humid the cropping potential grows, the crop-livestock systems are increasingly subject to tsetse challenge. The input function and the asset and security function of livestock gain in weight. More intensive feeding regimes become possible. Although grazing is normally communal the overgrazing syndrome is often less pronounced because of low livestock densities. Contract herding is common for cattle. Pig and poultry production systems assume importance in the humid zone.

The crop-livestock production systems of the highlands are characterized by particularly high densities of human and livestock population. Tsetse flies are largely absent. Milk and sheep production are important. The output function of livestock tends to stand in the foreground. A particular facet is the existence of intensive feeding systems which is connected with the individual land tenure that prevails in many parts.

These essentially indigenous livestock production systems contrast with introduced systems like ranching and modern intensive dairy, beef, pig and poultry units. For these the commercial output function of livestock prevails and management is similar to that in any other part of the world.

The justification for applying a concept of livestock production systems lies in its usefulness for livestock development. Livestock development, like general development, does not imply the parallel expansion of all production activities. Within one system it implies changes in factor combinations, technologies, intensities, and product mixes; the species of livestock may alter, their functions may change and existing management principles be replaced. The potential for change and improvement is likely to be different in different production systems due to constraints imposed by factor endowment, livestock functions and management standards. Different development efforts are required to reduce the constraints and to make best use of the opportunities. Development may also call for the concentration of efforts on one system at the expense of another or for the transformation of one system into another. The concept of livestock production systems allows the discussion of livestock development in terms of concrete policies, strategies and projects as they ultimately affect the individual livestock producer.

5 Pastoral Range-livestock Production Systems

5.1 General Characteristics

5.1.1 Definition and Delimitation

Rangeland is defined as "land carrying natural or semi-natural vegetation which provides a habitat suitable for herds of wild or domestic ungulates" (Pratt and Gwynne 1977, p. 1). Range-livestock production systems are production systems based on the use of the natural or semi-natural vegetation via domestic animals, in particular ruminants. Range-livestock production systems take the form of ranching systems, which are dealt with in another section, and of pastoral systems. In pastoral systems the main product is milk and the main function of livestock is subsistence, although social and cultural functions are also important. Management is characterized by the adaptation of the feed requirements of the animals to the environment through migration; land tenure is communal. The term pastoral system will be used in the following as a short form for pastoral range-livestock production systems.

5.1.2 Types and Geographical Distribution

Pastoral systems are associated with the arid zone i. e. the zone that is too dry for cropping to serve as the base for subsistence. However, migrations do take pastoralists into wetter areas and there are several higher rainfall areas with a tradition of pastoral land use although the land has arable potential (e. g. the areas of the Bahima in south-western Uganda, the highland areas of Narok District in Kenya and the areas used by the Tutsi herders in Rwanda and Burundi). Pastoralists in West Africa have had a traditional presence in the higher rainfall areas south of the Sahel and this has been accentuated by the drought of the early seventies. Nonetheless pastoral systems can be considered systems of the arid zone. Here they constitute the major production system in terms of area used and in terms of food production.

Notwithstanding the common basic characteristics of the pastoral production system as a whole different types can be distinguished. Partly these are the result of differences in the specific natural environment. The factor of overriding importance is annual rainfall. The magnitude of average annual rainfall is negatively correlated with variability of rainfall (Le Houérou and Hoste 1977); a lower rainfall also indictes a low reliability thereby increasing the impact of aridity. Table 5.1 gives some of the features of pastoral systems that by tendency vary with the degree of aridity.

Table 5.1: Types and Characteristics of Pastoral Production Systems in Tropical Africa in Dependence of the Degree of Aridity

Indicators	Degree of aridity very high	 high	 medium
Annual rainfall (mm)	0-200	200-400	400-600
Growing period (days p. a.)	0-50	50-75	75-90
Type of pastoralism	nomadic pastoralism[a]	transhumant pastoralism[a]	agro-pastoralism
Supplement to live-stock products	oasis products	wildlife	grain
Migration	erratic and long-range	medium to long-range	short-range
Lead species	camel, goat	mixed	cattle, sheep

a) Transhumant pastoralism is based on more or less regular seasonal migrations from a permanent homestead which is lacking in pure nomadism

Source: Compiled by the author.

The rainfall brackets in Table 5.1 are not to be taken in a rigid way, neither is the correspondence between rainfall and growing days. Toward the more arid parts of the zone it becomes precarious to subsist on livestock alone. Thus the desert pastoralists of the Sahara depend increasingly on an oasis base for watering of the livestock and to supplement their own diet. In the more favourable areas fodder productivity and cropping potential are higher but this advantage tends to be offset by the competition for land by sedentary cultivators. Migrations by necessity become longer as the degree of aridity increases. The hardier species (camels and goats) gain predominance over cattle and sheep. Particularly the camel then stands out as the source of milk and in its function of transporting the homestead.

Land use systems are partly the result of the natural environment but few if any human communities can by said to utilize their environment in the only possible way (Dyson-Hudson 1972, p. 22). The threefold classification more or less by rainfall gradient is sufficient for the purposes here but certainly very crude when the different pastoral societies are looked at in more detail. In each one the livestock production system has its own characteristic and in each one the all-pervading role of livestock in the society takes on different forms. Some 120 different ethnic groups can be distinguished, some numbering only a few thousand, some millions, and this differentiation is still crude. Their geograhical distribution has been mapped in Figure 5.1. Helland (1980) has also compiled the -rather unreliable- estimates of the size of the different populations. From this the total number of pastoral people in Tropical Africa can be assumed to be in the order of 20 million. About 9 million of these are classified by Helland as agro-pastoralists.

5.1.3 Livestock Functions

The output function: The subsistence function of livestock is by definition a principal characteristic of pastoral systems. By and large the areas are too dry for cropping to be the sole basis of subsistence. Ruminant livestock are the prime vehicle of land use. The human physiology requires a continual supply of food. The main product for subsistence is therefore milk; the use of the animals is of usufructuary nature. Only rarely are large animals slaughtered for their meat, but emergency slaughters occur. Small ruminants constitute a more convenient quantity and their meat finds their way into the diet more often. The degree to which livestock products are supplemented by plant products varies. Even in the driest areas there are cases and patches with a sufficient run-on of water to permit cropping. On the other end of the rainfall scale cropping becomes a more regular possibility. Some pastoralists practise cropping regularly e. g. the Karimojong in Uganda in a zone that approaches the semi-arid. Others do not crop themselves but obtain crops by barter (many of the Fulani). Other pastoralists only rarely consume vegetable products, although this is changing rapidly in some cases (e. g. the Maasai in East

Africa. The composition of the diet and the degree to which there is supplementation by non-livestock foodstuffs is shown for selected pastoral groups in West Africa in Table 5.2. The table also sets the different categories of pastoralists in a tentative way against the different dietary patterns.

Table 5.2: Household Budget and Diet Composition of Different Pastoral Households in West Africa (Chad, Niger and Mali)

Year of study	1950s	1940s	1963	1963	1963	1963	1958
Ethnic group	Tubu	Moors	Touareg	Fulani	Touareg	Fulani	Fulani
Pastoralism in household income[a]	38 %	84 %	80 %	96 %	80 %	96 %	57 %
Composition of diet[b]							
Milk	22-48 %	76 %	51 %	39 %	33 %	24 %	25 %
Meat	-	4 %	2 %	2 %	2 %	2 %	-
Millet	22-35 %	20 %	47 %	58 %	65 %	74 %	75 %
Dates	28-43 %	-	-	-	-	-	-
Nomadic	———	———					
Transhumant		———	———	———			
Agropastoralist				———	———	———	———

a) Including crops cultivated by the pastoralists

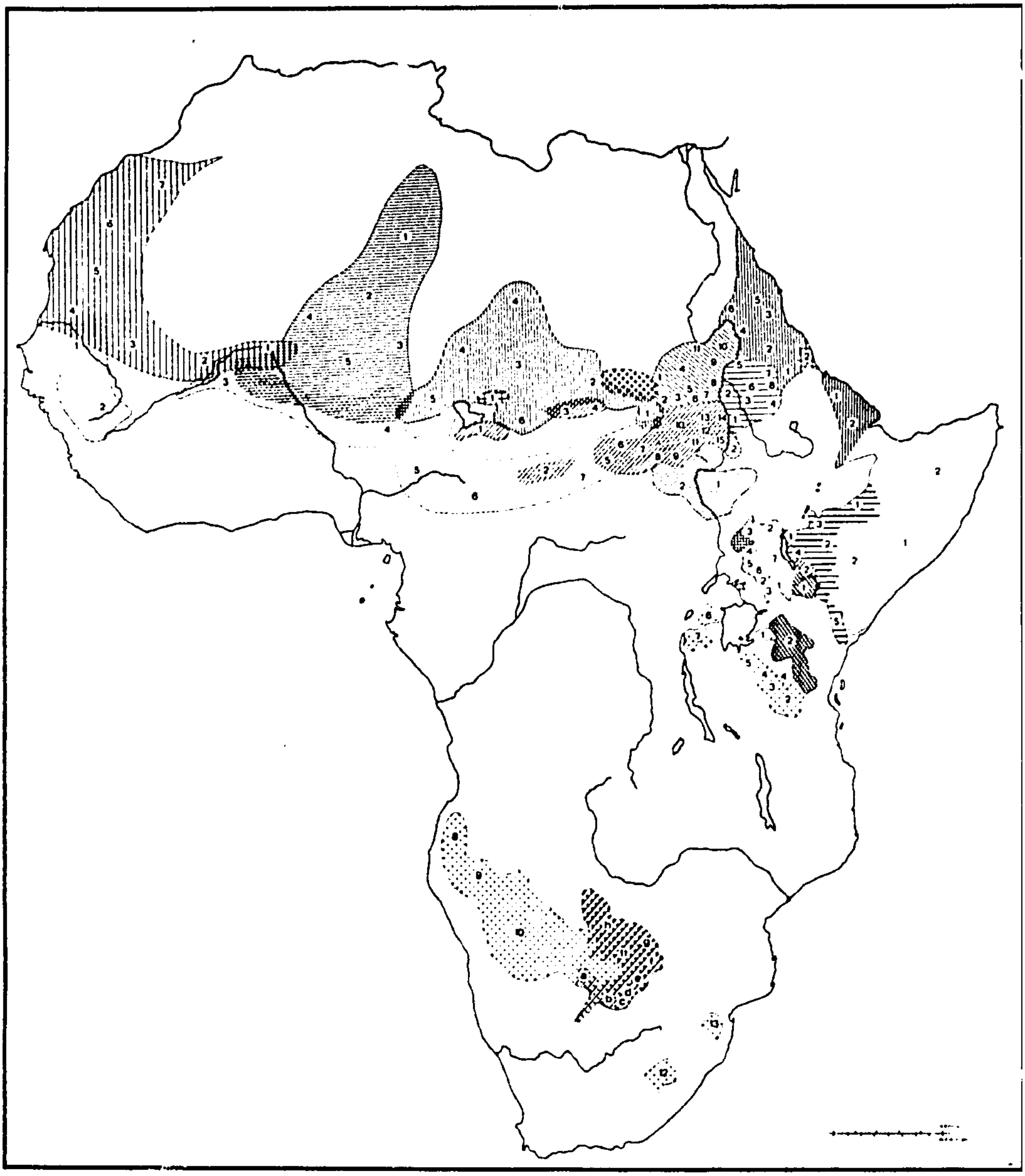
b) In terms of calorie equivalents

Source: Swift (1979) on the basis of various primary sources.

The statistical base of the data in Table 5.2 does not allow interpretation to be carried very far. Nevertheless, the following features stand out:

a) On both sides of the scale, i. e. nomadic pastoralism under

Figure 5.1: Pastoral Peoples of Tropical Africa



PASTORAL PEOPLES OF TROPICAL AFRICA

AFROASIATIC GROUP

SEMITIC

Maurs

1- Kounta
2- Berabish
3- Brakna
4 Trarza

5- Ouled Delim
6- Rgibat
7- Tajakant

Baggara

1- Shuwa
2- Hemat
3- Mahamir
4- Beni Hussein
5- Ta'aisha
6- Beni Halba
7- Habbaniya
8- Rizeigat

9- Messeriya al Humr
10- Messeriya al Zuruq
11- Hawazma
12- Awlad Himeid
13- Gima
14- Ahamda
15- Selim

Jamaala

1- Zeyidiya
2 Hamar
3- Kahwahla
4- Kababish
5- Magunin
6- Ma'aliya

7- Ma'aqla
8- Shenabla
9- Hawawir
10- Hassaniya
11- Shaiqiya

Sudanese 'Arabs'

1- Rufa'a al Hoi
2- Kenana
3- Rufa'a al Sheriq
4- Dar Bakr

5- Batahin
6- Shukriya
7- Rashaida
8- Lahawin

Other Semitic

1- Ouled Sliman

2- Tigre

BERBER

Tuareg (Tamacheq)

1- Kel Ajjer
2- Kel Ahaggar
3- Kel Ayr

4- Kel Adrar
5- Kel Azawak

NORTH CUSHITIC

Beja

1- Beni Amer
2- Hadendowa
3- Amarar

4- Bisharin umm Nagi
5- Bisharin umm Ali
6- Ahabda

EAST CUSHITIC

'Afar & Saho

1- Saho

2- 'Afar

Oromo

1- Arsi
2- Borana
3- Gudji

4- Gabra
5- Orma

Somali

1- Sab

2- Somali

Other East Cushitic

1- Dassenetch

2- Rendille

NILO-SAHARAN GROUP

SAHARAN

1- Zaghawa
2- Bideiyat
3- Bulgeda

4- Teda
5- Daza
6- Kreda

NUBIAN

Midob

BEIR

Didinga

WEST NILOTIC

1- Nuer

2- Dinka

EAST NILOTIC

Karimojong Cluster

1- Jiye
2- Nyangatom
3- Toposa
4- Dodoth

5- Jie
6- Karimojong
7- Turkana

Maasai Cluster

1- Samburu

2- Maasai

SOUTH NILOTIC

1- Pokot
2- Sebei

3- Nandi
4- Barabaig

CONGO-KORDOFANIAN GROUP

WEST ATLANTIC

Fulani

1- Toucouleur
2- Fouta Djalon
3- Macina
4- Bororo

5- Bauchi
6- Adamawa
7- Fellata umm Bororo

BENUE-CONGO (BANTU)

1- Kuria
2- Gogo
3- Turu
4- Iramba
5- Sukuma
6- Hima
7- Tutsi

8- Nyaneka
9- Ovambo
10- Herero
11- Tswana
12- Sotho
13- Swazi

11 Tswana
a- Kgalagadi
b- Ngwatse
c- Rolong
d- Malete

e- Thlokwa
f- Ngwato
g- Sarwa
h- Tawana

lowest rainfall and agropastoralism under higher rainfall, gainful employment and income sources outside pastoralism (including cultivation practised by pastoralists) are found.

b) Meat contributes a small amount to the diet in all systems.

c) Millet is an important part of the diet even in pure pastoral systems, where it is largely obtained through bartering.

d) The type of pastoral system practised is not strictly linked to the ethnic group; even in one area and within the same ethnic group management units differ in their pastoral production pattern.

It is a contention that grains play a larger role in the diet of West African pastoralists than is the case in East Africa. Irrespective of the importance of grain in the diet the universal fact is that livestock constitute the backbone of the subsistence economy. The "luxury" of engaging in risky crop activities can only be under-taken because there is livestock to provide a fall-back. However, crops can constitute an important supplement to the diet in a normal season and help to offset the impact of adverse environmental effects due not only to rainfall but also to disease of man and stock.

The output function of livestock in pastoral systems also includes monetary income. The degree of commercialization varies but there is no pastoral group that will not a least occasionally sell small-stock, old steers and barren cows. During drought even younger female cattle and camels may be marketed. The cash requirements of pastoralists are normally small but for many there are tax obligations, school fees and medical bills; modern consumer goods and gadgets have their attraction and sometimes cash is required to buy food to supplement the diet. Some pastoral groups like the Somali are known to be very commercial-minded and the monetary return from livestock plays a considerable role in the household economy.

Economic versus non-economic functions: The economic functions of livestock are multiple in pastoral systems and the livestock products are put to many uses. The Karimojong society serves as an example (Dyson-Hudson, 1972, p. 83):

> "The milk and blood of cattle are drunk; their meat is eaten, their fat used as food and cosmetic; their urine as cleanser;

their hides make sleeping-skins, shoulder capes, shirts, bell collars, sandals, armlets, and anklets; their hornes and hooves provide snuff-holders, feather boxes, and food containers; bags are made from their scrota; their intestines are used for prophecy, and their chyme for anointing; their droppings provide fertilizer".

Thus even the value of droppings is fully realized and agro-pastoralists concentrate their herds for as much time as possible on areas that are to be used for cultivation. If the pastoralists do not cultivate themselves it is common for them, particularly in West Africa, to enter into arrangements with cultivators whereby herds are kept on fields destined for cultivation. Animal droppings are also important for their fuel value. The often scanty production of dry wood is needed for the building of temporary huts and of night enclosures for the animals, while green woody vegetation is left as dry season fodder reserve. In this situation the droppings may constitute the only available source of fuel. Also work by animals can be important in pastoral production systems. Bringing ground water to the surface is a task that often necessitates the employment of animal power. For the Sahel countries this performance by livestock is of considerable importance (Coulomb et al 1978). The value of livestock for animal traction in crop agriculture is also transmitted to pastoralists through the demand of cultivators in more favourable areas for live animals from the dry areas.

The functions so far mentioned are all associated with products. But it is particularly in pastoral societies that livestock are assigned additional functions. Again for the Karimojong society Dyson-Hudson reports that cattle

- are exchanged for other forms of property,
- are used for the acquisition of desired rights,
- are used for the compensation of wrongs,
- form nuclei of common interests that hold kin groups together,
- provide a way to express aspirations,
- mark and reinforce interpersonal ties through their exchange,
- determine to a great degree social status,
- are a source of rich elaboration of speech and song, and
- provide the symbol and path of man's approach to deity.

Partly these functions relate to the asset role of livestock. Given the multitude of useful products from livestock and given their longevity and reproductive capacity it is normal for livestock to represent wealth and to be used in social transactions as carrier of value. But many of the functions cited clearly go beyond the asset role of livestock. Livestock appear to dominate all walks of life including the spiritual sphere. These "non-economic" functions have led to the explanation of livestock in pastoral societies as a psychological phenomenon ("the cattle complex", Herskovitz 1926). But this does not do justice to the multitude of the products and economic functions of livestock combined with the fact that livestock also act as a store of all these products and functions. If livestock are the single most important item of value in pastoral societies, it is not surprising that livestock play a dominating role also in the socalled non-economic sphere of life but it would be misleading to see that as the exclusive role. A problem is that the different spheres cannot be neatly separated. The social institution of bride price has the economic function of a redistribution of wealth with all the consequences for production and subsistence. Camels that are treasured for their racing capabilities also give advantage in scouting and allow the owner to be the first on a distant piece of land with good grazing. The slaughter of an animal may be ceremonial but the feast still has nutritional value. For the purpose here the relevant question is not whether livestock play a social and cultural role but whether this social and cultural role prevents pastoralists to make best economic use of livestock. Of this there is little evidence indeed. In development, however, the interdependence of economic and non-economic functions of livestock may create particularly vexing problems.

5.1.4 Management Aspects

Livestock management is characterized by three principles:

- Adaptation to the environment in the attempt to ensure subsistence,
- averting risks by the adoption of special management strategies, and
- adaptation to the institutional environment characterized by communal tenure of the grazing land.

These principles are interwoven and interdependent with the different functions of livestock.

Adaptation to the natural environment: From the point of view of agricultural evolution pastoralism belongs to the same pre-machine category of land use as shifting cultivation, but this by no means prevents the type of adaptation being extremely complex and carefully calculated (Ruthenberg 1980, Schinkel 1970, Grigg 1974). The central task is to match the erratic and seasonal patterns of primary productivity with the more or less continual feed requirements of livestock to achieve a regular daily supply of food. The elements of the management strategy have been described by Dyson-Hudson (1972, pp. 43, 44) for the Karimojong:

"1. Since cows yield only as they drop and suckle calves, a continuous milk supply is related both to large herds and a high degree of fertility. Sufficient cows are needed to offset the calving interval of each beast; enough bulls for adequate service are needed; and fertility of both bulls and cows should be such as to keep the calving interval as short as possible. A herd that is deficient in any of these respects will yield only a spasmodic milk supply (however favourable the environmental conditions).

2. Individual yield depends on the general condition of a beast, which in turn depends on regular access to adequate grass and water. In Karimojong country, water and grass are generally sufficient in the rainy season; at that time the condition of the animals is therefore good, and their yields are high. In the dry season, water supplies decrease and grasses wither, cattle rapidly lose condition, and yields fall off sharply. In the rainy season a cow may give four to five pints of milk a day and still rear a healthy calf; in the dry season it is often possible to take only a quarter of a pint or so a day without risk of losing the calf. Again, the large ox will yield seven pints of blood at a single bleeding in the rains, and five months later be fit for bleeding again. To take a similar amount in the dry season would be to risk losing the animal altogether. In sum, a herd large enough to feed a family in the rains would not necessarily be adequate for the dry season; and it is in terms of reduced dry-season yields that Karimojong must calculate minimum necessary herd size.

3. Karimojong say that calves are dropped in every month of the year, but it is likely that a severe dry season impairs fertility through a drastic reduction of the animals' general condition. Both bulls and cows would seem to need some time in the improved conditions of the rains before successful impregnation is accomplished. To this extent harsh conditions mean not only a present decrease or interruption of herd yield, they also involve possible decreases or interruption of yield in the future.

4. In Karimojong conditions it is necessary to distinguish between total yield and effective yield, the one an expression of animal production, the other an expression of the food supply available to humans. Total yield is affected by factors already mentioned. Effective yield is influenced by an additional factor, viz.: the location (rather than amount) of grazing and water throughout the year, for this determines the disposition of the herd and hence its accessibility to the human group which is dependent on it. Thus, grazing and water may be sufficient to keep the herd in condition and promote good yields; but where favourable grazing exists only far from the centers of permanent settlement, then only a part of the human population (that following and tending the herds) will benefit".

The resulting grazing pattern is seasonal and involves migrations of varying lengths at varying times of the year with the whole herd or with parts thereof. A mix of species is usually held to make best use of the total vegetation and to account for their varying comparative advantages in walking ability, hardiness, milking ability etc. Herd size is larger than that required in the good season to account for the lowered productivity and availability of the animals during the dry season. The proportion of females is high because the females are the milkers and therefore the most useful constituents of the herd.

Risk-averting strategies: In addition to these "normal" exigencies of livestock husbandry there is the overwhelming risk of the catastrophe which either takes the form of prolonged drought reducing carrying capacity and production dramatically or of sweeping disease decimating the herds. Given the fact that pastures are communal and access is not normally limited to a specific number of animals or to a specific individual the risk - averting strategy by the pastoralist bears the following key features:

- Herd size is maximized the limiting factor being labour for herding, water drawing and the like. This ensures the highest chance of being left with a viable core herd after disaster has struck.

- Different animal species are kept. The mixes are determined, beside considerations of walking ability, milk production capacity and complementary utilization of the vegetation, by the drought resistence of the different species and their response to favourable conditions, in particular the recovery rate after a disaster.

Herds are split into different management units ro spread the risk and to accomodate the need to exploit distant pasture while providing a regular supply of food for the household.

- Emphasis is put on a high proportion of females among all species not only because of the milk yield but also because of the reproductive potential of the herd to recover after a decline.

- Crops are grown as a sideline of the enterprise; barter and exchange arrangements are entered with cultivators.

A particularly important feature of pastoral systems is the establishment of a network of social bonds to guard against risk (Ruthenberg 1980, p. 337).

- Some of the animals of relatives and acquaintances are kept in a family's herd and they give some of their animals to other people, so that in case of disease the losses for any family are not total.

- Herdsmen lend animals to a neighbour or relative who has lost his animals through disease or theft, and thus ensure his help in their own times of need. The tendency to dispose of animals by lending is encouraged by the fact that large herds entail a rapid consumption of grass and necessitate long treks.

- The owners of large herds, who in any case do not want to keep them in one place, lend some animals to poorer members of the tribe, and in this way guarantee their allegiance.

- If a man wants to marry, he has to give cattle to the bride's father. In poor families this amounts to one or two, and in rich families to ten cows and more. If the woman is treated badly by her husband, she can return to her father without him being obliged to return the cattle. Conversely, the husband can send his wife back to her father and demand back his cattle if she behaves badly or if she is infertile. Consequently, both parties have a material interest in the success of the marriage, but both are equally obliged to hoard animals for some part of their lives in order to meet their obligations if the case arises.

These practices again show that social and cultural functions of livestock are also meaningful in material and economic terms. They also protect against the risk of being assessed by a tax collector who will not be able to establish who owns what in this complex network of allegiances, claims and usufructuary rights that replaces straightforward ownership.

Communal land tenure: Grazing is the basis for production in pastoral systems. Grazing is communal and what has been called the overgrazing syndrome or the tragedy of the commons (section 4.2.2) has an all-pervading effect on this production system. It is reinforced further by special characteristics of this system (Jahnke et al 1974):

- Given the harsh environment and the exigencies on the livestock (long walks, seasonal undernourishment or malnourishment, long watering intervals, heat stress, little or no protection against disease) there is no practical possibility for the pastoralists to increase animal productivity, milk yield in particular.

- In the absence of alternative sources of livelihood production increase necessitated by population increase is in linear and direct relationship with herd numbers.

- The high risk element in this zone necessitates herd numbers over and above those immediately necessary for subsistence.

The overgrazing syndrome is sometimes related to the motive of "greed" on the part of the individual (Sandford 1980), but the motive of "need" may be the driving one. Such a need would imply that pastoralists are short of grazing. Relating the overgrazing syndrome to the fact of communal land tenure is a piece of deductive reasoning that is only relevant if in fact grazing is scarce. It is particularly relevant if grazing is scarce for meeting the subsistence needs of the people concerned. This leads to the basic distinction between pastoral systems that are under pressure and those that are not (Pratt and Gwynne 1977). In both cases there may be overstocking. In the first case it is accumulation of livestock above subsistence requirements that is favoured by the existence of communal tenure. In the second case communal tenure favours, over time, the accumulation of humans above the human supporting capacity of the land in aggregate. Overgrazing in the first case is a nuisance and a detriment to the natural resource endowment of an area. In the second case overgrazing - whatever the underlying cause may be- is an expression of human misery carrying at all times the danger of a catastrophe to human survival. Empirical evidence points to the existence of both cases, even in close proximity to each other and within one country. Thus in Ethiopia the Afars in the North are pastoral people under extreme subsistence pressure while the Borana in the South are considered to operate under conditions of ample resources (Cossins, ILCA, personal communication). The recurrence of large-scale human misery connected to droughts, which after all are not a new or unexpected phenomenon in dry areas anywhere in the world, leads one to suspect that on the whole pastoralists in Tropical Africa overgraze by need rather than greed. A more detailed look is therefore taken in the following section at the human supporting capacity of the rangelands.

5.2 Production and Productivity

5.2.1 Range Production and Carrying Capacity

As rainfall decreases it becomes more important as a determinant of range productivity. The best correlations between rainfall and herbaceous primary production have been obtained for regions where the rainfall is below 700 mm. (Blair Rains and Kassam 1980). The empirical relationship established for the low rainfall region south of the Sahara yields the rule of thumb that one millimetre of rain produces 2.5 kg of dry matter per hectare (Le Houérou and Hoste 1977). In regions of low rainfall woody vegetation is also important in the nutrition of game and domestic stock. Digestibility varies considerably but in general the protein content of the leaves and fruits is high. Under low rainfall conditions of say 250 mm woody vegetation at a density of 130 plants/ha may still yield about 120 kg of DM (Bille 1979). Given that this fodder can be made available during the dry season and that it is of high quality the practice of herdsmen to cut down branches and trees to make them accessible for the stock can be readily understood. On the other hand there is competition between woody vegetation and grass growth so that for the purpose of calculating carrying capacity the contribution by woody plants is usually neglected (Blair Rains and Kassam 1980).

For a variety of reasons only a proportion of the potential yield of fodder plants will be eaten by the animals. Fodder is avoided because of low palatability; fodder is also destroyed through trampling, wind and fire and consumed by wild vertebrates and invertebrate animals. It is often assumed that between a third and a half of the potential ungrazed yield of an area will be used in the growing season and that during the dry season half of the potential yield may be consumed (Blair Rains and Kassam 1980). Since the bulk of the yield is produced during the wet season the overall utilization rate must be assumed to be well below 50%. Bille (1978) suggests 30% as a more realistic estimate.

The feed intake in dry matter of cattle as the major reference species is often put at 2.5% of the body weight (Ministére: "Mémento"). For the standard TLU of 250 kg this is equivalent to 6.25 kg per day or 2 280 kg per year. Whether this is sufficient for maintenance and production depends on the energy content, the digestibility, the content of digestible protein, the level of other essential nutrients and elements and the availability of water. Other factors that intervene are disease, stress (climate, walking long distances), husbandry methods etc. Table 5.3 gives estimates of carrying capacity in dependence of the annual rainfall.

Table 5.3: Utilizable Primary Production and Carrying Capacity in Dry Rangelands[a] in Tropical Africa

Annual rainfall mm	Consumable fodder[b] (dry matter) kg/ha	Carrying capacity ha/TLU
100	-	-
200	150	15.2
300	225	10.1
400	300	7.6
500	375	6.1
600	450	5.1

a) Excluding flood plains which may produce 3 600- 8 000 kg/ha

b) 30 % of total above ground herbacious growth

Source: Blair Rains and Kassam (1980), Le Houérou and Hoste (1977).

The carrying capacities given by Pratt and Gwynne (1977) for East Africa are not directly comparable but there appears to be a correspondence. For very arid conditions (rainfall at 200 mm or below) the carrying capacity is put at 42 ha/TLU the next better zone which can be approximated to rainfall between 200 and 400 mm is estimated at 12 ha/TLU.

5.2.2 Livestock Productivity

Livestock productivity can also be assumed to vary with the aridity but no quantitative estimate is available and the relationship is less clear because the animals migrate between the zones. Table 5.4 shows animal productivity figures derived from a survey of available literature on pastoral livestock. Blood from cattle and camels as a source of food is neglected. In some pastoral groups fallen animals are eaten and this could double the consumption of meat but has not been taken into account. The conversion of production into grain equivalents and calories makes inter-species comparisons possible and allows to estimate the supporting capacity of livestock for people if the diet is exclusively based on meat and milk.

The figures in Table 5.4 show camels and small ruminants to be twice as productive as cattle. This is due to the high milk yielding capacity of camels on the one hand and the high meat producing capacity of sheep and goats (and their good milk production capacity) on the other. While 100 TLU of cattle meet the subsistence requirements of 12 persons, an equivalent herd of camels would support 23, of sheep or goats 28. The comparative advantages of the different species and the usefulness of a species mix preclude concentration on one species according to productivity indicators only. However, the differences in productivity are remarkable. Camels stand out further for their provision of transport, sheep and goats are notable for their reproductive capacity which allows high rates of growth to be achieved. Particularly the latter characteristic is important for recovery after drought or disease incidence. Maximum herd growth rates have been estimated for camels at 8%, cattle 11% and sheep and goats at over 40% (Dahl and Hjort 1976). Table 5.4 also allows an inference as to the importance of trade between pastoralists and cultivators. If the prevailing terms of trade are indeed 1.7 kg of grain for 1 kg of milk and 4 kg of grain for 1 kg of meat as implied by the price ratios underlying the grain-equivalent-concept the pastoralists improves his subsistence basis significantly by trading. From the average TLU he obtains 152 Mcal by consuming the livestock products directly. If traded for grain he receives 340 kg grain contributing 1 150 Mcal to his diet. Measured in calories his subsistence has improved by the factor 7.5.

Table 5.4: Productivity of Camels, Cattle, Sheep and Goats in Pastoral Systems in Tropical Africa

Production		Cattle	Camels	Sheep/ goats	Mixed herd[a]
Milk	kg/head	66.2	248.2	22.0	n. ap.
	kg/TLU	94.5	248.2	220.0	161.3
Meat	kg/head	9.6	7.4	3.5	n. ap.
	kg/TLU	13.7	7.4	34.5	16.3
Total	GE kg/TLU[b]	215.5	451.3	512.0	339.2
	Mcal/TLU[c]	99.0	191.4	236.8	151.9
Supporting capacity[d]					
	persons/100 TLU	11.8	22.8	28.2	18.1

a) According to the share of the different species in TLU in the arid zone

b) 1.7 GE kg/kg of milk, 4.0 GE kg/kg of meat

c) 700 kcal/kg of milk, 2 400 kcal/kg of meat

d) According to calorie requirements at 2 300 kcal per person per day or 840 Mcal per year

Source: Production per head by species from Dahl and Hjort (1976); TLU conversion according to rates used in this study.

Livestock productivity as indicated in Table 5.4 is higher than that underlying estimates of zonal production and productivity in section 3.3. The latter distribute estimated total production in Tropical Africa over the different zones including the arid zone considered here. The figures in Table 5.4 essentially are derived from observed production and yields in pastoral situations on one side and from a herd modelling exercise to extrapolate from individual yield to total herd yield on the other. They are probably overestimates because they neglect the proportion of the herds and flocks that is not (and possibly cannot be) exploited to the same degree throughout the year and over the years given the variable environment and the migratory mode of life of pastoralists. But all aggregate estimates of livestock productivity in Tropical Africa are based on guesswork in one way or another; all that can be said is that the figures in Table 5.4 are probably on the high side.

5.2.3 Land Productivity

Inspite of productivity differences among species pastoralists keep mixed herds, because the different species are complementary in products, growth rates, functions, feed requirements, ecological adaptability, management requirements and sensitivity to drought and disease risks. Animal productivity for any one species can be expected to be dependent on aridity but not necessarily in a linear fashion. Toward the upper end of the rainfall scale (500 mm and above) response to increasing rainfall diminishes; toward the lower end it increases. Milk production is probably more sensitive than meat production. To a degree these effects are offset by herd composition and other management principles (camels predominate

Table 5.5: Indicators of Land Productivity in Pastoral Systems in Tropical Africa

Annual rainfall mm	Milk kg/ha	Meat kg/ha	Total food GE kg/ha	Total food Mcal/ha	HSC[a] persons/ sqkm
200	10.5	1.1	22.1	9.9	1.2
300	15.8	1.6	33.2	14.9	1.8
400	21.1	2.1	44.2	19.8	2.4
500	26.2	2.6	55.1	24.7	2.9
600	31.4	3.1	65.9	29.5	3.5

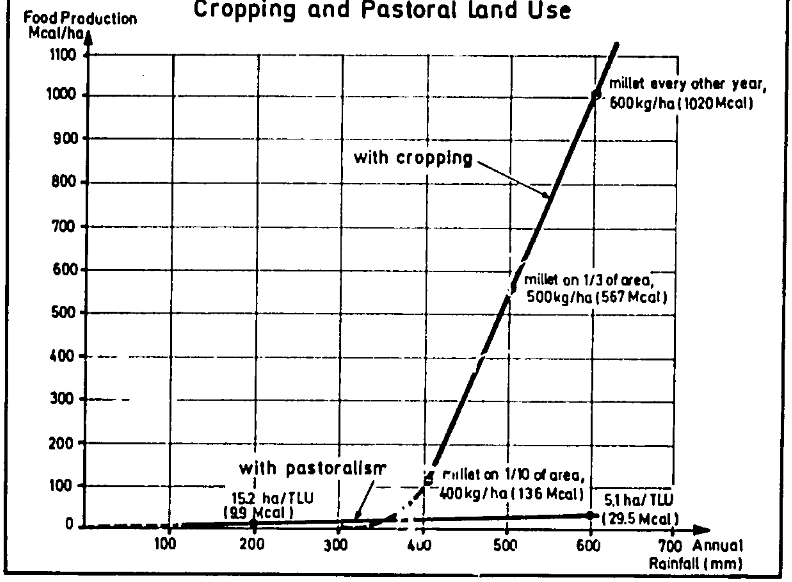
a) Human supporting capacity according to calorie requirements and if met exclusively by meat and milk

Source: Tables 5.3, 5.4.

in the more arid parts, milk cows are not taken on long migrations but left with the families in more favourable areas etc.). The assumption of a linear relationship between livestock production and annual rainfall is therefore not as unrealistic as it appears at first sight, and may serve as an approximation. Table 5.5 is based on the productivity estimates of the average pastoral TLU given in Table 5.4 and on the carrying capacities in Table 5.3.

The figures in the last column of Table 5.5 may be regarded as the critical population densities for the different rainfall zones. At the lower end of the scale they are reached at one person per square kilometre, at the higher end at 3 to 4. Population densities that appear extremely low in absolute terms already represent critical values if subsistence is to be met from livestock alone. The productivity of the land is extremely low if used via livestock to support a human population, but of course that is the only way to support any human life at all in much of this zone. The low productivity also shows if compared to crop production (Figure 5.2).

Figure 5.2.
Hypothetical Scheme of Food Productivity of the Land in Cropping and Pastoral Land Use



Source: Compiled by the author; for details see Table 5.5 and text.

At 600 mm a millet crop may be grown every other year yielding 600 kg/ha or 2 040 Mcal which corresponds with an average land productivity of 1 020 Mcal/ha. As rainfall decreases both yields and cultivation intensity (proportion of arable land) decrease and at 300 mm regular cropping is almost impossible. But at 400 mm if only one tenth of the area is cultivated and if only 400 kg are harvested the area productivity is seven times higher than if food has to be produced via livestock. This explains two phenomena to be observed throughout the arid zone of Tropical Africa. Firstly, cropping encroaches onto rangelands. Cultivators achieve much higher levels of land productivity than pastoralists do even if regular crop failures are included in the reckoning. Two years of complete failure and two years with miserable yields may be offset by one bumper crop (meaning 800 kg or so) and production from the land is still much higher than through any other form of use. In the longer term, however, cultivation may well lead to land degradation in this zone (FAO, Higgins et al 1978). Secondly chancy cropping is practised by many pastoralists in extremely dry areas with extremely low yield expectations. Tuaregs are known to grow millet in areas with less than 200 mm achieving not more than 80 kg of grain per hectare if things go well. But with 80 kg of grain one man meets one third of his subsistence needs and is all the better off for that.

5.2.4 Labour Productivity and Employment Capacity

In the developed countries the dry areas are used for extremely labour-extensive production systems. Animal-labour ratios are between 320 to 810 and gross output per labourer between $ 8 000 and 15 000 for Australian ranches (Table 5.6). On modern African ranches it is common to employ one herdsman for 100 head of cattle. The animal-labour ratio expressed as TLU per man would thus be about 70. At an offtake rate of 20% and prices as in Table 5.6 the gross output per labourer would be in the order of $ 1 600. But these figures relate to ranching. In pastoral systems animal-labour ratios and labour productivity figures are radically different. For the arid zone of Tropical Africa as a whole which is dominated by the pastoral land use system an animal-labour ratio (TLU/ME) of 3 has been estimated (compare section 2.3). For every economically active rural person there are 3 TLU or about 5 head of cattle rather than 100 in modern African ranching or hundreds in Australian ranching. In dry countries that are particularly rich in livestock and dominated by pastoral land use like Mauritania, Somalia and Botswana the national ratios are 7.7,

Table 5.6: Indicators of Livestock Production and Labour Intensity and Labour Productivity in the Dry Areas of Australia (1968-1969 to 1970-1971)[a]

Indicator	Relatively favourable	Less favourable	Poor
Stocking rates (ha/TLU)[b]	8-12	30-40	100 and more
Livestock: labour ratio (TLU/ME)[c]	320-570	670-810	about 705
Area: labour ratio (ha/ME)	3 000-7 700	13 600-29 000	52 000-69 000
Cattle offtake rate (%)	21-34	12-19	26
Cattle offtake per labourer[e] (head p. a.)	101-106	95-173	184
Offtake per labourer ($/ME)[d f]	8 000-8 500	7 600-13 800	14 700

a) Three-year averages for average properties in the different regions as defined by the surveys of the Bureau of Agricultural Economics. All figures rounded

b) The original statistics use cattle units (an adult bovine) which has been taken to be equivalent to a TLU

c) ME = man equivalent; equivalent to one person working on the property for 50 weeks a year

d) Converted from Australian $ at the rate of 0. 9 per US $

e) Including operator

f) Average selling price of $ 80 per animal

Source: Bureau of Agricultural Economics, Australia (1970).

12.3 and 7.9 TLU/man respectively. Labour productivity is in the order of $ 50 per man instead of over a thousand or thousands in ranching. Labour productivity in pastoral systems is therefore very low, or to put it the other way around, pastoral systems are labour-intensive; they have a high employment capacity at low levels of renumeration*.

In spite of the high labour availability there is evidence that a labour constraint may be operating in pastoral production systems (Barth 1973; Dyson-Hudson 1972; Jacob 1963). Torry (1973) provides the most detailed quantitative evidence of a labour constraint for the case of the Gabra in Kenya near the Ethiopian border. Gabra normally work 9 hours per day and about 3 000 hours per annum, only to secure subsistence. Children above the age of 7 years are fully employed in the production process. Two to three families (of about three to four persons) group themselves into homestead units to economize in herding and watering. Conspicuously high are the labour requirements of watering which absorb roughly half of the total working time. Camel watering is toilsome. It implies walking over long distances, a time-consuming organization of water use at the well, and in particular working in a "human chain" to bring the water from a deep well to a through. Torry estimates that 80 to 90% of the total population are required for herding, watering, management and domestic tasks. Ruthenberg (1980) concludes that labour hours per labourer are higher and return per hour of work lower among the Gabra than in any other tropical farming system.

5.2.5 Human Supporting Capacity

Pastoral production systems are the dominant form of land use in the arid zone. They are essentially aimed at subsistence. The low productivity of livestock, land and labour combined with the high animal-man ratios lead to the question of the human supporting capacity (FAO, Higgins et al 1978) or the critical population density (Allan 1965) of that zone. Relationships between the natural

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* With 160 kg of milk and 16 kg of meat per TLU total production is 336 GE kg which can be valued at $ 54 ($ 0.16/kg). The value of livestock and meat exports per agricultural worker in 1978 was $ 66.2 in Mauritania, 50.3 in Somalia and 122.1 in Botswana. This does not take into account subsistence production; the exported livestock products on the other hand are valued at higher prices.

productivity of the land and human supporting capacities have been established on different bases for West Africa and for East Africa (Table 5.7).

Table 5.7: Estimate of Human Supporting Capacity (HSC) of Low Rainfall Areas in West and East Africa

West Africa		East Africa	
Annual rainfall mm	HSC ha/person	Agroecological zone	HSC ha/person
		very arid	189.0
200	75.5		
300	53.3		
400	41.3	arid	48.0
500	34.0		
600	28.5		
		semi-arid	14.0

Source: Blair Rains and Kassam (1980), Pratt and Gwynne (1977).

These figures have been translated into equivalents for zones defined by growing days (Blair Rains and Kassam 1980), the classification used in this study. For the zone with the number of the growing days ranging from 1 to 74 the average calorie production per ha from livestock was put at 20 000 kcal. Since protein is not limiting calculations can be made on a calorie base alone. At a daily requirement per person of 2 300 kcal an average of 42 hectares is required in this zone. The zone with less than one growing day is 183 660 ha in extent, the zone with between 75 and 89 growing days 82 517 ha. Using the figure of 20 000 kcal for the total arid zone (less than 90 growing days) the arid zone of 7 422 sqkm could carry a human population of 17 million. This figure holds if the population is to subsist on livestock alone. FAO (Higgins et al 1978) has made more detailed calculations that include cropping but strictly adhere to ecological principles of land use which demand long rest periods of the land in this zone and which reduce the stocking rates to the sustainable level in the long run. They estimate the human supporting capacity of the arid zone to be 12 million people. These figures stand against an estimated rural pastoral population of 20 million alone (Helland 1980) and a figure of 29 million for the total rural population in this zone as derived from the 1975 population figures by administrative unit and extrapolated to 1980. The arid zone and by implication the pastoral land use system appears to suffer from acute overpopulation. The notion of pastoralism under pressure is on the whole more valid than the notion of a free-ranging husbandry man with an abundance of livestock and land resources at his disposal.

5.3 Development Possibilities

5.3.1 Marketing and Stratification

Marketing is of particular importance for pastoral production systems in the arid zone:

- The arid zones constitute the source of the livestock flow. They are the extensive breeding grounds from which marketing starts.

- Marketing poses particular problems in the dry areas where distances are great and infrastructure is lacking.

- The opportunity for marketing cattle is important in the context of taking cattle off the range, thereby tackling at least the symptom of the pastoral overgrazing syndrome.

All pastoralists sell at least occasionally some of their livestock for cash. Evidence on the price response of supply by traditional cattle owners is conflicting. Reports of inverse supply/price relationships (Carlisle and Randag 1970; Lele 1975, p. 58, Doran et al 1979) conflict with others of "normal" behaviour (Hill 1970, Khalifa and Simpson 1972). There appear to be two reasons for this conflicting evidence. Firstly it is not always easy to differentiate between the cause and effect of price and supply movements; an observed negative price-supply relationship may as much be the result of reduced marketing forcing prices up as the other way about. Secondly the observations may be partial relating to only one market or one season or to only one function of livestock (cash income versus total income that includes subsistence versus the asset function of livestock); interpretation of price responses is then easily carried too far.

The justification of marketing projects does not generally venture into the sphere of pastoral behaviour. On the contrary their particular attraction lies in the possibility of staying clear of the complexities of production, operating on the doorstep of the system rather than getting involved in it. Existing traditional marketing systems are perceived to suffer from inefficiencies, abuses in market conduct and technical imperfections the relief of which would benefit the pastoral system (Herman 1979). But studies of traditional marketing systems show that, in spite of being complex and traditionally based, they generally perform well their function of distributing livestock and meat products at reasonably low costs (Herman 1979, SEDES 1969 a, Staatz 1979). For the case of Upper Volta Herman specifies evidence of a high degree of competition at most stages of the marketing circuit, as shown by low concentration ratios and the absence of overt collusion. Cattle flows appear responsive to changes in relative prices among alternative markets and over the year. Market information seems to be readily available to producers and marketing circuit does not support an abundance of non-productive individuals, as is commonly alleged; the much maligned "intermediary" is found to provide useful services to both producers and merchants. Spatial price differentials and traders' margins are reasonable consistent with transportation and transaction costs. Even the traditional marketing method of trekking has its advantages and wholesale replacement by more modern methods like rail, lorry or even air is seldom justified because they are more expensive; in rail and truck transport in particular skrinkage losses become a major cost item.

Efforts to develop pastoral production systems via marketing therefore have to take into account

- that the structure and performance of existing traditional marketing is generally satisfactory;

- that the existing system does not appear to discourage production and supply of livestock from the dry areas, and

- that trekking as a method of transport is more efficient and less costly than commonly assumed.

There is the question then in which way marketing projects could have a beneficial effect on pastoral production systems. The reasoning normally takes recourse to the stratification of the livestock industry that is to be achieved via marketing efforts. Most, if not all, of the many studies relating to West African livestock development have endorsed in principle a livestock development strategy based upon the stratification of production*. The term stratification, literally to arrange in layers, normally bears two different though related meanings for livestock development:

- The arrangement of the process of meat production into separate stages - breeding cow/calf herds, growing out, fattening, processing - with each stage located geographically to make use of the comparative advantage of each eco-climatic zone;

- the arrangement of land use management in district systems, extensive grazing, extensive crop production, intensive fodder/pasture production, intensive crop production, mixed farming etc., again to make best use of the differing resource endowment.

In the 'ideal' regional model production units in the extensive range areas would specialize as primary producers. They would be encouraged to sell all surplus males as "immature" rather than mature range animals. Intermediate stage producers in more favourable areas would grow out the immatures to larger sizes suitable for slaughter or for fattening. The fattening units located close to the consumption centres would constitute the final stage in the stratification chain.

Two key assumptions underly the proposed beneficial effects of stratification on the arid areas:

- By selling animals at younger ages, the stocking rate of extensively managed rangelands could be initially reduced, and, by maintaining somewhat larger and more productive breeding herds on a given range site, incomes could be equalled or improved through the sale of large numbers of immature animals, albeit at substantially lower per kilogramme and per head prices.

- Stock owners would collectively agree to limit stock numbers in accordance with approved stocking rates in order to increase fertility and milk yields and at the same time decrease mortality.

* Ferguson (1979) summarizes the literature. The following paragraphs on stratification follow closely his account.

Stratifications strategies do not normally contain any elements that would render the second assumption a likely direct outcome. With respect to the first assumption Ferguson's analysis has done much to reduce expectations. This is the result of three factors:

- The existing marketing system is fairly efficient and there are no great margins available for distribution neither to the pastoralists nor to production stages down-stream as pointed out above.

- The significance of hoarding of animals and of the availability of animals apparently unneccessary for the pastoralists tends to be greatly exaggerated. For West Africa Ferguson estimated that even if all non-breeding herd males could be sold at the age of 18 months, the maximum possible increase in cow/calf herds would only be in the order of 10-20 per cent. If reduction of animal numbers is the aim a reduction in the number of animals in all categories must be achieved.

- Demand and consequently the price structure of animals is such that cattle which double in weight between the age of two and six years more than quadruple in value. Because the incremental cost per unit of time/cash of retaining an animal beyond two years of age is very low the logical strategy is to keep males in herds until near peak values are obtained.

Ferguson calculated that the price per kilogramme of immature animals would need to double before it would be more advantageous for primary producers to sell immature rather than mature categories. Such a doubling of the weight price is hardly possible because the price differential for higher quality animals in Tropical Africa is generally very low and may even be negative. There are therefore also on the part of the intermediate or final stages of production no great margins available for redistribution.

Expectations from the possibilities of marketing and stratification are generally exaggerated. Practically all attempts of stratification suffer from under-supply of livestock from the pastoral areas and government interventions in marketing tend to replace perceived inefficiencies in the marketing system by real ones. There is undoubtedly a place for marketing projects and stratification schemes but the effects on production and productivity in the pastoral areas will remain modest.

5.3.2 Livestock Improvement and Disease Control

Marketing efforts operate on the doorstep of pastoral production systems. Efforts of improving the livestock take place within the production system acting on the livestock resource directly. In principle this refers to selection, breeding, and disease control but one may also include improved husbandry methods like culling, castration, herding practices and supplementary feeding. In practice the possibilities are limited. With respect to general husbandry practices one has to assume that the pastoralists already do the best they can given the environmental conditions, the pressure on the resources and the basic production objective of subsistence. In this respect pastoralists are no differnt from other tropical farmers (Ruthenberg 1980, p. 4). Innovations like the introduction of exotic livestock breeds or massive supplementary feeding and the like are of a purely hypothetical nature for the environment concerned. There remains disease control as the classical approach to improving pastoral systems. It also is a logical one given the interest of pastoralist in their livestock resource and the limitations of other approaches.

Pastoral production systems are particularly vulnerable to certain types of disease. Thus long treks and frequent intermingling of different groups of animals provide ideal opportunities for the extensive spread of rinderpest, anthrax, blackleg and contagious bovine pleuro-pneumonia, the great infectuous diseases of African livestock; exposure to wildlife on route and concentration of stock on river and lake shore grazings during the driest part of the year provide further opportunities for infection (Ellis and Hugh 1976, Sere 1979). Efforts at controlling these diseases have a long history in most African countries. With the advent of improved vaccines they are now effective and safe for the stock treated. The problem lies in the mobility of the herds, the extensive nature of the production system and a continued measure of distrust among many pastoralists. Comprehensive control approaching eradication is therefore difficult to achieve and foci linger on. This is aggravated by the lack of control of herds moving across national boundaries. Thus international efforts are called for. A good example is rinderpest which could only be brought under a measure of control as a result of the international J P 15 campaigns (Lépissier 1971).

Disease control, particularly rinderpest control, has been subjected to a number of evaluations (Tremblay 1969, Gaspary and Dillmann 1976, Felton and Ellis 1976, Sere 1979). The technical achievements have often been overstated and in spite of successes these diseases are far from eradication (Provost et al 1980). But it is likely that favourable cost-benefit ratios have been achieved. The most detailed study confirms the high economic returns from the disease control in the case of Nigeria (Felton and Ellis 1976). An interesting aspect of the study is the importance it attaches to the assumed productivity increases and the general effects on the pastoral production system. It is critical whether a disease control programme in a pastoral situation simply reduces losses, increases herd numbers and thereby increases pressure on the land, or whether it can be assumed to improve productivity. The conclusions Felton and Ellis (1976, p. 35) drew in this respect for the case of Nigeria deserve to be quoted:

> "The success of J P 15 in eliminating outbreaks of the disease must have restored producer confidence and enabled them to concentrate more on productivity than on survivability of their animals. Willingness to send an unusually high proportion of females for slaughter from 1968 onwards suggests that the removal of the rinderpest risk enables owners to respond to ecological pressures by changing herd structure towards greater efficiency. It may be argued, therefore, that J P 15 was more likely to have lessened the impact of the drought which began in 1972 than to have increased the problems that were experienced. Further support for this view may be drawn from the fact that the numbers of animals saved by J P 15 represented such small proportions of the total cattle population that rinderpest eradication per se could not have contributed significantly to the overgrazing problem in the drought."

Rinderpest control - and rinderpest may stand as proxy for most diseases that can be dealt with by vaccination (Sere 1979) - therefore constitutes an effective means and a commendable first step in pastoral development, particularly since successful veterinary campaigns, probably more than anything else, help to gain the pastoralists' confidence and to prepare them for further development efforts. They have the advantage of showing a quick effect while other improvement measures may have a long gestation period (Sandford 1980). The apparent danger of simply adding to an overstocking problem by allowing more animals to survive is not borne out by the Nigerian experience. The elemination of the disease hazard seems to have induced the pastoralists to keep more efficient herds. In any case the alternative of leaving these diseases unchecked is not feasible; indiscriminate mortality of all animals regardless of sex and ages renders any production system a wasteful exercise. No one can therefore seriously advocate the withdrawal or curtailment of communicable disease control as a method of limiting livestock populations (Ferguson 1979, p. 103).

The argument is more difficult for other diseases. Internal and external parasites impair animal productivity. Tick-borne diseases, in particular East Coast fever, are the cause of high calf mortality with consequent reduction in herd performance. Others like foot and mouth disease affect most African cattle only lightly but are barriers to international trade. Given the low productivity of the system it is doubtful whether all diseases should be tackled with the same degree of intensity as sometimes demanded (Boudet et al 1980, p. 99). A go-slow approach as advocated by Ferguson (1979, p. 103) appears more realistic. In particular the disease control measures that have to be carried out in regular and short intervals like tick control or that require accompanying veterinary diagnosis to be effective (tryponosomiasis, internal parasites) require a higher level of organization and productivity than is common with pastoral production systems. Cost reimbursement by the livestock owners deserves careful examination when expanding control to other diseases, while in the case of the potential great epizootics there is general agreement that for control to be effective the service has to be rendered free of charge.

Disease control as such does not affect the basic mode of production. Pastoral systems function more smoothly with effective disease control but they are still production systems aimed primarily at subsistence and operating under the contraints of a marginal environment, communal land tenure and high population pressure. Disease control may be a pre-requisite but the extent to which general development of this production system can thereby be achieved is obviously limited.

5.3.3 Land and Water Development

Again the improvemnt of the natural resource base can take many forms. In principle improvements can include fodder conservation, drainage, removing scrub, fencing to permit rotational grazing, fertilization, water supply and others. A particular improvement lies in abstention from use of the grazing land at appropriate times (Crotty 1980). Timing and density of stocking greatly affect the productivity of grazing land. If land is grazed heavily during seasons of sparse growth, the valuable species that grow during these seasons will be exterminated and the pasture will be populated by less valuable species. If part of the land is left ungrazed during the growing season - and preferably a different part every year - grazing can be conserved and used as fodder during the dormant season, when fodder has a much higher value. It is well known that such practices alone and in combination increase primary productivity as illustrated by relatively recent results provided by ILCA (1980) for the Sahelian rangelands (Figure 5.3).

ILCA also showed that the use of the inputs tested was not economically feasible. But this is not the whole story. Given communal grazing with many cattle owners each having a small number of cattle grazing communal land it will not pay any individual to apply inputs of a land improving nature including deferment of grazing. Even if these inputs were financed from the outside, their beneficial effect depends on the control of grazing. The individual grazier cannot hope, under conditions of communal grazing, to gain from land-improving abstinence from grazing; rationally, the guiding principle for the individual operating on communal grazing land as understood here, must be, "graze it or lose it". That is, if the individual keeps his cattle off the communal grazing to conserve valuable species or fodder for use in the dormant season, the pasturage that his cattle forego will be eaten by the cattle of other people (Crotty 1980). The obstacle to land improvement is therefore a multiple one:

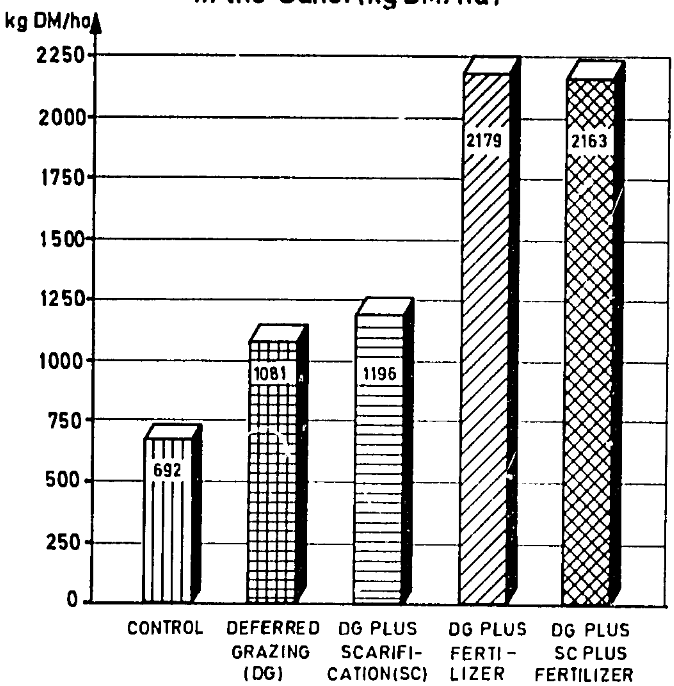
- The communal grazing land tenure prevents an individual from making an effort,

- economically the use of modern inputs to the land can hardly be justified,

- if nonetheless efforts are undertaken they cannot be brought to technical fruition because this would require control over grazing for which there is generally no adequate mechanism.

A particular aspect of resource management are grass or bush fires. The regular firing of the vegetation has beneficial effects like facilitation of herbacious regrowth after the rains, bush control, and destruction of parasites like ticks. There is also the detrimental effect of destruction of vegetation as reserve feed. The call to suppress fire altogether (Boudet et al, p. 94) is problematic. The differential effect of different types of fire (point in time, intensity) on the vegetation demands judicious use of this instrument rather than abandonment (see Pratt and Gwynne 1977 for a more detailed discussion). Again, however, there is the need for institutional arrangements to implement and control these measures and to bring about a reconciliation of the differing interests of individuals.

Figure 5.3.
Effect of Yield-increasing Practices on Range Production in the Sahel (kg DM/ha)



Source: ILCA (1980a).

Water development does not show the same degree of dependence on institutional arrangements as other aspects of resource improvement, at least not directly. Prima facie water development shows its beneficial effects irrespective of the grazing practices. The installation of a new water supply is technically possible without any form of grazing control. It is understandable therefore that water development rather than range improvements has been the major line of development in the arid zone. More funds have probably gone into water development than into any other improvements in the arid zone, particularly over the last two decades. There is, however, a conspicuous absence of any assessment of costs and benefits. The basic effect of water development on pastoral production is

- to allow the keeping of more animals in a given area,

- to open up additional areas,

- to allow dry-season grazing of certain areas,

- to permit a more even distribution of animals and of land use,

- to reduce walking distances,

- to reduce the risk and potential impact of a drought.

The counter-effects of water development can be the destruction of the vegetation in the vicinity of a water point through high animal concentrations and the lifting of an effective limit to animal numbers to the detriment of the range and its long-term carrying capacity. In relatively good years a higher number of animals can be kept through water development. In poor years when the primary productivity of the range becomes the binding limit the crash of animal population and consequent human misery may be all the more dramatic. It is probable that water development in the Sahel has contributed to the seriousness of the effects of the drought in the early 1970s. It is now generally agreed that water development in order to avoid the potential negative effects has to be seen in the context of resource management as a whole (e. g. Boudet et al 1980, Pratt and Gwynne 1977). This includes institutional arrangements for the utilization of the water but also for the management of the pasture resource.

5.3.4 Institutional Development and Ranching

The natural environment already puts a strict limit on improvements that are possible and economically feasible in pastoral production systems. Communal land tenure restricts possibilities further and adds the risk that improvement measures simply add to the existing overgrazing syndrome. Therefore - and also because the need is felt for local decision-making bodies in the development process - an increasing number of projects combine the introduction of technical improvements with an attempt at institutional development and tenure reform. This normally takes the form of pastoral associations in which pastoralists are encouraged to group themselves together, to be associated with a more or less rigidly delimited piece of land and to be collectively charged with a number of functions. These functions are different and include not only land tenure reform and communal resource management, but also the provision of services, communication of information, external relations and the building and maintenance of community cohesion and morale (Sandford 1980).

While land tenure reform is only one of many functions, the association of a group of identified pastoralists with an identified piece of land by its very nature implies a move in the direction of a situation in which responsibility for livestock and for land is in one and the same hand. Such a development has the additional advantage of involving the local populace in decision-making and providing a forum for discussion within and with the outside. The question of interest here is whether such institutional development provides the necessary conditions for production development as well. This would imply that overuse of the range is stopped and that new inputs can be used to increase production and productivity rather than entailing stock increases to the long-term detriment of the production system. This is linked to the question of why pastoral societies have not developed appropriate institutional arrangements in the first place. In any society if there is a serious discrepancy between social and private interests people get together and formulate binding rules for the common good. Examples of such rules governing grazing exist in many pastoral societies (Horowitz 1978, Sandford 1980). The most elaborate probably is the "dina" codified in its present form by Cheikou Ahmadou (1818-1845), regulating usage of the interior delta of the Niger Riger in Mali (Horowitz 1978). Most traditional grazing control measures, however, are oriented toward ethnic groups rather than individuals and livestock numbers. They are effective against outsiders but hardly against rising population pressure from within*.

By and large therefore existing institutional arrangements are insufficient for effective grazing control. The weakness of pastoral societies in this respect is sometimes attributed to the colonial regime (Sandford 1980) and to deleterious development notions of African governments (Baker 1975). The view emphasized in this study is that human population due to its unprecedented rate of increase has simply outgrown its own capacity for institutional adaptation. If pastoral societies had only been slow in adopting adequate institutional measure this could be rectified by fostering such developments in the context of development projects. If pastoral societies have outgrown their resource base institutional change may still be important but cannot by itself provide a solution for all the members. The real problem of communal land then is that it has allowed populations to increase and unnoticeably surpass the threshold of critical densities. In this light efforts at institutional development in pastoral societies take on a different meaning: They are neither a prerequisite for nor a complement to production development; rather they are a means - and probably a necessary one - of bringing the basic resource pressure under which pastoral systems operate to the open.

The group ranch development in Kenya's Maasailand is the oldest approach to combining production development with institutional reform and illustrates the basic dilemma. Land was demarcated, groups were formed and formally registered and committees were set up to represent the groups, organize resource management and take loans on behalf of the group for productive investments (dips and water supplies mainly), but little was achieved in actual land use and production. The fundamental problem overstocking was not solved or even touched on. The group ranch scheme was not able to check the increase in stock numbers. When land adjudication legislation was conceived the allocation of stock rights was to be a central part of the legislation, in the same way that land rights were to be allocated as part of adjudication, but this was not achieved (IBRD 1977).

* The drastic exception is the control the Borana exercise over their own population demanding infanticide if a mother bears a child outside the age cycle.

The root of the problem is in the already high pressure on the grazing resource. This translates into a situation in which a large number of poorer members of the society live on or near the subsistence level. Their interests are in conflict with those of the richer members who benefit from the modern inputs and from commercialization of production. Both groups share for different reasons the unwillingness to reduce stock numbers. Thus 40 to 50% of the stockholders in Kenya's Maasailand (Kajiado and Narok) were in 1972/75 at or below the basic subsistence level (IBRD 1977), and their situation deteriorated as a result of group ranching because traditional redistributive mechanisms like the small man herding the big man's livestock in return for milk and animals becomes less necessary and less attractive for the large herd owner (Jahnke et al 1974). With respect to production and general resource management the group ranch project does not appear to have been sucessful. But there was a real impact in that the Maasai began discussing their problems openly, namely overstocking, land shortage and the need to move out of pastoralism into other profitable occupations.

The endpoint of pastoral development may be seen as a situation in which the pastoralists manage their own resources at a higher level productivity and in accordance with ecological principles of sustained yield while basically maintaining their characteristic life style. It may also be seen as a form of modern commercial ranching to which group ranching and the like are only transitional forms (Pratt and Gwynne 1977, IBRD 1968). Whether either is possible is largely determined by the resource availability. In principle the pastoralist is not opposed to the idea of private land. The few powerful members of the Maasai society who were allocated individual property are the envy of the others. They also show that transition to modern forms of management and commercial production is not so foreign to the pastoralists as might be thought. But the existing resource base simply does not allow the allocation of sufficient land to each individual family.

If arid countries like Mauritania and Somalia organized their land use in the form of modern ranching their agricultural population would have to be reduced by a factor of 50. Millions of people would need to find gainful employment elsewhere to allow a few to reap the benefits from highly labour-productive ranching. Even if the goal is more modest, an intermediate type of "pastoral ranch", feasibility depends on resource availability. In some pastoral situations like in eastern Senegal (Fulani) and southern

Ethiopia (Borana) population pressure on the resources is still low enough (or environmental conditions are favourable enough) to allow progress to be made with technical improvements embedded in new institutional arrangements. But in general this in not the case.

5.3.5 Human Development

The scope for development of pastoral systems is extremely limited. With time and with institutional change accompanying technical improvements the production systems may develop to provide a more ample subsistence and income base but hardly for all of today's pastoralists and their progeny (IBRD 1968, Annex 2, pp. 1,2):

> "A major problem in any move from subsistence herding to commercial ranching is thus (paradoxically) not so much the livestock problem of surplus and under-conditioned animals as the human problem of surplus and under-trained people - for whom some jobs and homes must be found outside the proposed ranch enterprise".

This impasse of the pastoralists is worsened by aspects that Grigg (1974) treats under the heading of the secular decline of nomadism. The pastoralists lost their military advantage over peasants with the development of modern weaponry, with colonization and with the building up of stronger governments. They also lost their power over arable farmers through the abolition of slavery and through the establishment of the colonial rule. Finally, pacification and modernization ended the nomads's monopoly of desert transport.

By and large development efforts in the pastoral arid zone have to take on a defensive nature with the aim of

- reducing the effects of drought on the human population

- reducing the effects of overgrazing like land degradation and desertification

- improving the subsistence basis through the introduction of grain into the systems.

A particularly important measure achieving all these ends consists of encouraging the trading of animals directly for grain (Pratt and Gwynne 1977). This improves the subsistence basis of pastoralists and reduces stock pressure on the range, but it also increases dependence on external factors (availability of grain) and therefore the vulnerability of pastoral people.

Pastoral systems are production systems in a waiting room of development. The term does not mean that development can be expected to set in this area at a later date although this possibility can never be excluded. Rather development must be expected to set in elsewhere. Meanwhile the pastoral system fulfills the waiting room or ante-room function and the policy-maker is held to relief measures to avoid catastrophies.

Human rather than livestock development is the task in the arid zones. The livestock production system can only marginally be improved upon, and from a certain degree of aridity onwards the migratory form of land use through livestock is the most efficient. Human development does not mean teaching pastoralists better methods of stock raising, but making them fit for occupation in other zones and sectors, so that the arid zone can be used within its capacities and continue to be a valuable resource for the African economies.

6 Crop-livestock Production Systems in the Lowlands

6.1 General Characteristics

6.1.1 Definition and Delimitation

Crop-livestock production systems denote land use systems in which livestock husbandry and cropping are practised in association. This association may be close and complex or livestock husbandry and cropping may be parallel activities without interaction, possibly not even belonging to the same management unit. In this case the association is reduced to geographical proximity. Essentially then the term crop-livestock production is used for livestock production that takes place in arable areas or in areas with an arable potential. The term crop-livestock production system is thus used in a dual sense: Firstly it refers to farming systems entirely based on livestock but practised in proximity to and perhaps functional association with other farming systems based on cropping. Secondly it refers to the livestock sub-system of crop-livestock farming. The term mixed farming will be reserved for such farming systems in which crop production and livestock production display pronounced and mutually beneficial interactions within a farm.

The crop-livestock area in the lowlands spans three ecological zones from the semi-arid to the sub-humid and the humid. Livestock production systems in the highlands are excluded here because of their special features and dealt with in section 7. One might still question the usefulness of such a large grouping covering the production systems in the semi-arid, sub-humid and humid zone. Several smaller deliminations are thinkable but they all have disadvantages:

a) A grouping by ecological zone cuts aribitrarily through some livestock production systems or types that are essentially similar in the semi-arid and the sub-humid zone on one side, and types that are common to the sub-humid and the humid zone on the other; also it does not corrspond with boundaries of tsetse infestation.

b) A grouping into tsetse-affected and tsetse-free areas insinuates a clearcut break of production systems and potentials when reality shows much more an influence of degree with seasonal fluctuations.

c) A rigid grouping by farming systems and types in the area considered does not take account of the geographical coexistence of the different systems,of their interaction and of the mobility particularly of livestock systems; a geographical delimitation would become impossible.

The large grouping is therefore preferred. However, as a corollary it is important to think in terms of several gradients that distinguish and characterize the livestock production systems by degree. These gradients are:

- Agroclimatic conditions, in particular rainfall, and connected to this the cropping systems;

- the human population pressure as also expressed by the cultivation intensity;

- the tsetse challenge* and, in West Africa connected to it, the importance of trypanotolerant animals;

- the overall importance of livestock as partly expressed by livestock densities and livestock species.

These interrelated gradients shall be used for the specification of the types of livestock production systems and their geographical distribution in addition to the livestock-specific functions of species, products and manangement. For a finer differentiation additional considerations would be necessary; in particular soils play a role for the agronomic potential of the higher rainfall zones.

6.1.2 Types and Geographical Distribution

Pastoral systems in arable areas: Cropping is the predominant form of land use and production in the zones considered but pure grazing systems are also found. Ranches have been dealt with in the preceeding section. They can be abstracted from here because they do not interact with crop farming while pastoral systems

* Tsetse challenge refers to the degree to which livestock is exposed to trypanosomiasis. It can be measured by the frequency of infection if the animals are medically examined at short intervals and given therapeutic trypanocidal drugs upon positive results (Whiteside 1962). In the folloing the term is used more informally and not based on measurements.

generally do. They may extend into the semi-arid and even the sub-humid zone as an important form of land use because the reliability of rainfall and the rainfall pattern renders cropping marginal. In general a growing period of 90 days allows reasonably safe millet yields in the order of 400 to 500 kg/ha (FAO, Higgins et al 1978). For aggregate considerations a growing period of 90 days has been assumed to correspond with about 500 mm of rain and, under a monomodal rainfall pattern as prevails in West Africa, this is generally sufficient for a reasonable millet crop. It may be insufficient under a bimodal pattern as is common in parts of Eastern Africa. The longer growing period may then have less than 75 days, the shorter one less than 50 days (Kassam 1980) and cropping becomes decidedly marginal. Consequently the long term human supporting capacity is determined more by livestock production than by cropping (Pratt and Gwynne 1977). Pastoral production systems in the semi-arid zone of East Africa have to be largely seen in connection with the marginality of cropping at low input levels. Parts of the Maasai area in Kenya and Tanzania and the Karimoja area of Uganda are examples.

A different phénomenon are the aristocratic herding societies (Helland 1980) in East Africa which by tradition do not engage in cropping although the land would stand cultivation. Examples are the Bahima in south western Uganda and the Tutsi in Rwanda and Burundi.

West Africa displays on the largest scale the coexistence of arable farming systems and grazing systems in areas definitely suitable for cropping. There is a long tradition of at least seasonal penetration of pastoral herds into the more humid areas (Ford 1971, Fricke 1979). During the dry season when fodder and water become scarce in the north and when at the same time the tsetse challenge is reduced in the more humid areas, pastoralists move south with their herds. There is also a tendency of pastoralists to remain in these more southerly areas where the tsetse challenge allows this and/or where an acceptable degree of tolerance of the livestock has developed. In some regions pastoral Fulani keep trypanotolerant breeds and are therefore able to practise a pastoral land use system unaffected by the presence of tsetse flies. Whether the penetration is seasonal or permanent, important complementary and competitive relationships develop between cropping agriculture and livestock production.

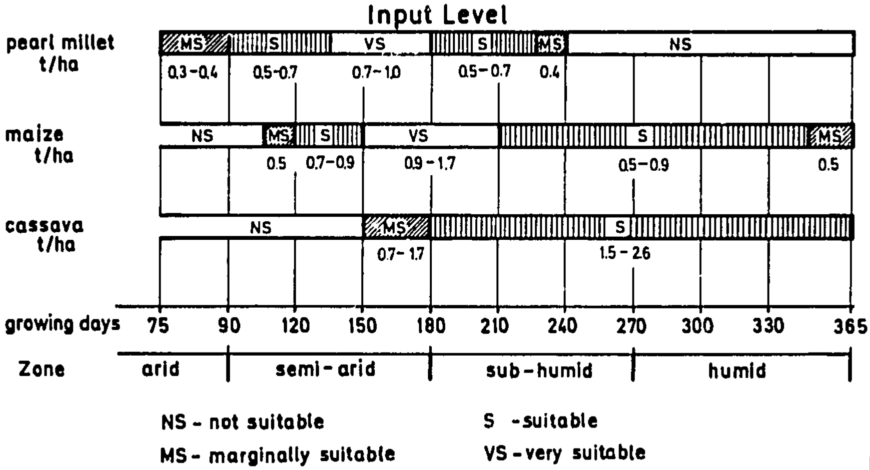
Crop-livestock systems: Most of the livestock in the region considered is held in crop-livestock systems. They are best characterized by the agroclimatic conditions and by population pressure. On the lower end of the rainfall scale millet predominates as the crop and provides some yield however low. As rainfall increases crop yields increase and become more secure but under traditional production techniques the upper yield limits are reached quickly. With rainfall increasing further the different crops change their comparative advantage. Figure 6.1 illustrates the relationships for the three major food crops in the lowlands of Tropical Africa. The yield figures imply traditional production techniques and the absence of particular constraints like poor soils, slopes, overuse and the like (FAO, Higgins et al 1978).

In the more arid parts millet yields 300-400 kg under very dry conditions but has an optimum towards the sub-humid zone of up to 1 000 kg. Maize is the optimum crop in the transitional zone between the semi-arid and the sub-humid with up to 1 700 kg but extending far into the humid zone still yielding 500 to 900 kg. Cassava gains in comparative advantage as conditions become more humid. The yield is up to 2 600 kg but of course its nutritional value per unit of weight is less. All of these crops may be grown in mixed stands with each other and with pulses, but as lead crops they allow an agro-climatic typification that goes beyond a mere rainfall figure. Locally these crops also have important competitors. In West Africa yam and coco-yam are important root crops accompanying or replacing cassava. In East Africa the bimodal rainfall pattern allows the cultivation of bananas which are superior in their starch yields to most other crops (Ruthenberg 1980). Grain legumes are grown throughout the semi-arid and sub-humid zone. Typical cash crops also differ with the ecological zone. Groundnuts and cotton predominate in the semi-arid and sub-humid zone. The wetter the zone the more important become tree crops as cash crops (cocoa, oil palm, coconut). The importance of rice mainly as a cash crop but also as a subsistence crop increases with humidity as well. The different cropping systems in the different ecological zones differ in general characteristics but also in terms of the fertility economy, the labour economy, and in terms of their problems and development potentials as elaborated by Ruthenberg (1980). Partly as a result they also differ in terms of the actual and potential role of livestock.

A second gradient besides humidity that differentiates the cropping systems and strongly influences the livestock systems indirectly and directly is population density. In all zones examples of extremely high and extremely low population densities are found. Population density finds its expression in the intensity of land use expressed as the R-value* (Joosten 1962, Ruthenberg 1980). The

Figure 6.1.

Suitability Classification and Yields of Major Food Crops in the African Tropical Lowlands by Ecological Zone at Low Input Level



Source: FAO (Higgins et al 1978)

* The R-value is calculated as the number of years of cultivation multiplied by 100 and divided by the length of the cycle of land utilization; the length of the cycle is the sum of the number of years of arable farming plus the number of fallow years.

R-value by itself is not an indicator of land pressure. A cultivation factor of 40 may indicate overuse in one area but underuse in another depending on the fallow requirements. The function of the fallow in a more arid environment is primarily to store and augment soil moisture and is therefore also practised on high levels of technology. At low input levels the fallow has additional functions which stand in the foreground with increasing humidity (Young and Wright 1980):

- Restoration of plant nutrients from the atmosphere and the base material of the soil,

- improvement of the organic matter status and of the soil structure,

- control of weeds, pests and diseases, and

- erosion control.

Fallow requirements have been quantified on an empirical base in relation to climate and soil types by Young and Wright (1980). The results for the mixed farming lowlands of Tropical Africa are given in Table 6.1. It should be noted that the definition of ecological zones differs slightly from the one commonly used in this study.

From the relative importance of the different soil types one can derive average figures of fallow requirements or maximum values for the cultivation factor which are 40-50 for the semi-arid zone, 35-40 for the sub-humid zone and 25 for the humid zone. With these figures and with the yield figures of Figure 6.1 critical population densities can be calculated i. e. the population densities that can be supported on a low level of technology and yield while observing the fallow requirements.

The ecological conditions and the cropping systems on one side and the population pressure on the other can be used as a grid of gradients to characterize the farming systems in the mixed farming areas (Figure 6.2). The points marked with letters represent examples of farming systems.

Examples of farming systems:

A   Aristocratic herding societies on cultivable land, no crop-

Table 6.1: Suggested Maximum Sustainable R-Values by Soil Type and Ecological Zone

Soil type	Ecological zone/growing days (GD) Rain forest 270-365 GD	Savanna zone 120-269 GD	Semi-arid zone 75-119 GD
Regosols and Arenosols	10	15	20
Ferralsols	5-50	15	20
Acrisols	15-50	15	20
Luvisols	25	30	35
Cambisols	35	50	40
Nitosols	25-40	30-55	40-75
Vertisols	40	55	45
Fluvisols and Gleysols	60	70	90

Source: Young and Wright (1980).

ping practised (e.g. Tutsi in Rwanda and Burundi, Bahima in Uganda).

B Pastoral systems with cropping in semi-arid areas (e. g. Karimoja people in Uganda).

C Pastoral systems penetrated into cropping areas, livestock products are bartered for grain (e. g. Fulani in West Africa).

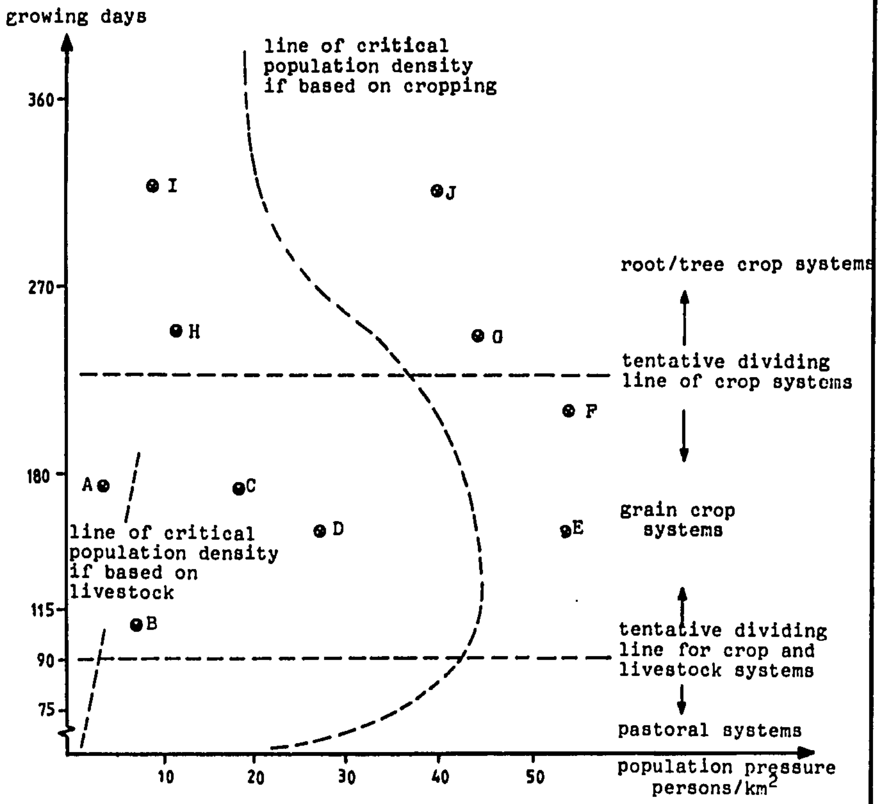
D Extensive shifting cultivation systems (e. g. in parts of Tanzania, Sudan, Chad).

E,F Permanent grain cropping , high population density (e. g. northern Nigeria, Sukumaland in Tanzania, under more humid conditions in northern Ghana and northern Ivory Coast).

G,H Maize and root crop farming in the sub-humid zone; G

Figure 6.2.

Diagrammatic Representation of Farming Systems by Ecological Conditions and Population Pressure in the Lowlands of Tropical Africa



Source: Compiled by the author with information from Kassam (1980), FAO (Higgins et al 1978) and Ruthenberg (1980); for further explanation, in particular of the letter symbols, see text.

low population pressure (e. g. in the middle belt of West Africa); H high population pressure [e. g. in the West Lake Region of Tanzania (bananas)].

I Extensive shifting cultivation in the rainforest (e. g. in Zaire).

J Intensive root/tree crop systems under very high population pressure e. g. in SE Nigeria).

The scheme in Figure 6.2 is highly simplified. Soil types, valley bottom cultivation and other factors lead to significant local deviations from what is termed the line of critical population density. Extremely high population densities are found across the zones and without apparent correlation with ecological conditions as well as extremely low population densities; the intensity of the farming systems varies accordingly. Taking the averages for the zones there are population concentrations in the semi-arid zone which is largely unaffected by tsetse flies and in the humid zone where cultivation of root crops and tree crops is possible; the sub-humid zone shows relatively speaking the lowest population pressure.

As the tsetse challenge grows it becomes increasingly difficult and eventually impossible to keep domestic stock because they succumb to trypanosomiasis. In Eastern and Southern Africa the distribution pattern of the tsetse flies is more or less the negative of the livestock distribution pattern (Figure 6.3).

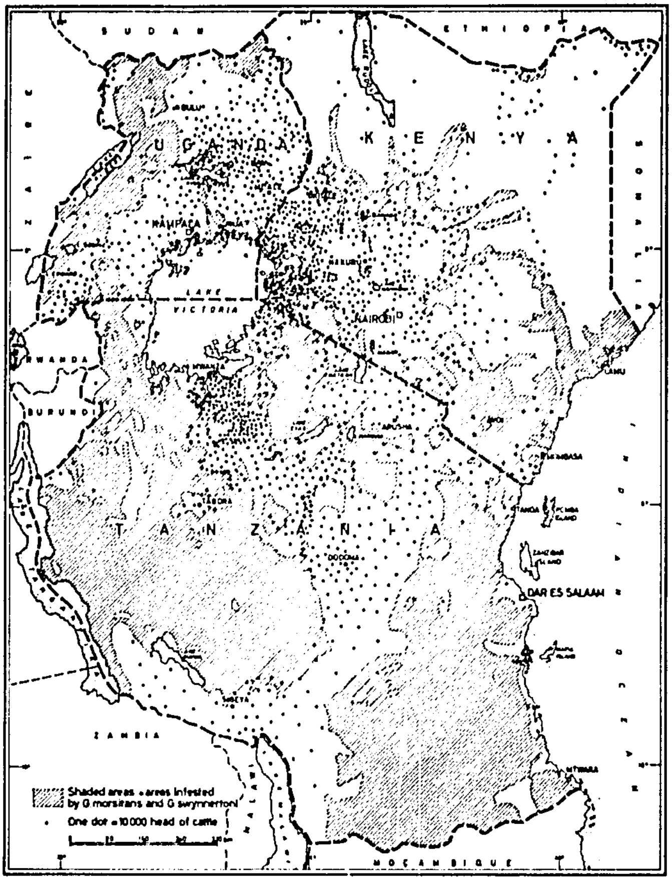
In Western Africa two factors render this relationship less clear-cut:

- There is the described tradition of seasonal southward migration of livestock whose regularity is favoured by the arrangement of the ecological zones in broad bands across the region. This generalized movement is assumed to have led to a degree of adaptation facilitating even permanent exposure of the livestock to light tsetse challenge (Ford 1971).

- There are trypanotolerant breeds of cattle, sheep and goats that replace the trypano-sensitive ones under higher tsetse challenge and make the keeping of ruminant livestock possible.

The trypanotolerant livestock population is not a homogeneous group*. Three major cattle breeds are distinguished, the N'dama, the West African Shorthorn, and the crosses of these and similar breeds with zebus.

Figure 6.3: Tsetse and Cattle Distribution in East Africa

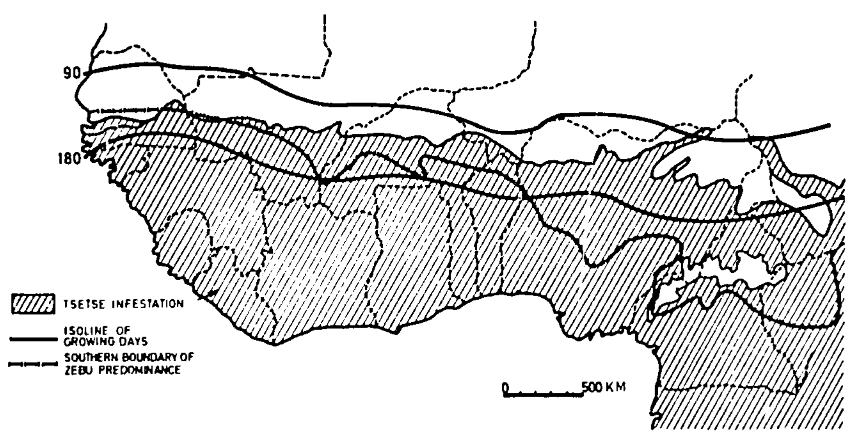


Source: UNDP/FAO (Mac Gillivray et al 1967)

* The first account of West African livestock and of their ability to survive in tsetse-infested areas is by Pierre (1906). Other basic works are Curson and Thornton (1936); Stewart (1937, 1938); Doutresoulle (1947); Faulkner and Epstein (1957); Epstein (1971); Pagot et al (1972), Pagot (1974) and most recently ILCA (Trail et al 1979).

Further sub-divisions can be drawn. With sheep and goats there is less certainty about their systematics; the type-breed of trypanotolerant small stock is known under the name Fouta Djallon or Djallonké. The trypanotolerant breeds of both cattle and small-stock are generally characterized by their small size. There is no rigid division between tolerant and non-tolerant breeds and no rigid geographical delimitation of their distribution. As the tsetse challenge grows more trypanotolerant blood is crossed into the animals and the relative numbers of tolerant and non-tolerant animals change. Figure 6.4 illustrates the gradual nature of the transition from non-tolerant to tolerant livestock as one penetrates into the tsetse-affected zones in West Africa.

Figure 6.4.
Delimitation of the Semi-Arid Zone in West Africa in Relation to Tsetse Fly Distribution and Zebu Cattle Predominance



Source: Adapted from FAO (Higgins et al 1978) and ILCA (Trail et al 1979) and ILCA (1979a).

The total trypanotolerant livestock population is estimated at 7.6 million cattle and 26.7 million sheep and goats. These figures include the different pure-breeds but in the case of cattle also the cross-breeds (trypanotolerant x zebu). The major cattle group are the N'dama (45%). A systematization of the different breed groups and an estimate of their quantitative importance is given by ILCA (Trail et al 1979).

In spite of the existence of trypanotolerant breeds the density of ruminant livestock (in relation to the land and to the human population) decreases with increasing humidity and increasing tsetse challenge. There is also a change in the species mix with cattle decreasing more strongly than smallstock and with goats gaining predominance over sheep in the humid zone.

The distribution of the non-ruminant livestock population follows different patterns. The equine population is concentrated in the semi-arid zone. The distribution of the chicken population appears to be determined by that of the human population rather than that of the ecology or tsetse flies although the lack of precise information must be stressed. Pigs become more important in the humid zone where islamic taboos are less predominant. Both pig and poultry production systems are dealt with in a later section as landless production systems.

6.1.3 Characteristics of Livestock Population

Livestock functions: By definition a major characteristic of livestock systems or sub-systems in crop-livestock systems is the interaction between livestock production and cropping. Within one management unit livestock may provide agricultural inputs like work and manure and render the enterprise more productive and more secure by using residual capacities of production factors with low opportunity costs like non-arable land, excess labour and child labour, by converting crops and crop residues into high-value animal products, by balancing the production and market risk etc. Crop-livestock linkages also exist if cropping and livestock husbandry are practised in different management units. Mc Cown et al (1979) proposed to distinguish (1) resource competition linkages, (2) ecological linkages and (3) exchange linkages. The competition linkage refers to the situation in which the same resource, normally land, is claimed for both livestock and crop production. Where this is the case, relative political power is likely to determine the land-use pattern. During the centuries prior to colonization much control was exercised by belligerent pastoral groups. With pacification and increased central authority, the balance of power shifted to the cultivators. In the case of an ecological linkage the practise of one activity influences the other through its effects on the ecosystem. For example, during the dry season natural forage is in short supply, and the quality is normally very low. The residues of most crops, which are of little or no value to the cultivator, provide a superior diet for the pastoralists' herds while at the same time, manure is deposited on the fields as the cattle graze. This type of symbiotic relationship, as well as others such as the transport of residues, the breaking up of ridges and the stripping of stalks to be used later as building materials, are considered benefical (van Raay 1975, Mc Cown et al 1979, Fricke 1979). The exchange linkage consists of the transaction between cultivators and livestock producers, involving goods and services. Thus nomadic pastoralists such as Moors, Tuaregs, Fulani and Baggara camp for at least part of the year in close proximity to agricultural areas, during which time they exchange products, e. g. milk, ghee, meat and hides, for millet and sorghum etc. Again, cultivators buy cattle from pastoralists and have them herded by the pastoralists in exchange for milk, calves or money.

The provision of farm inputs (work and manure) and the general interaction of livestock with cropping are important functions of livestock but they continue to fulfill other functions as well. Generally speaking the output function of livestock (subsistence, income and nutrition) is much reduced in relative importance in comparison to either ranching or pastoralism. In terms of the products this reduction is particularly pronounced for milk. In many parts milking of cattle is not practised at all. Two gradients appear to operate. The relative importance of livestock outputs in total farm income decreases with increasing humidity and appears to increase with increasing population densities. Von Rothenhan (1966) gives the contribution of livestock to farm income in semi-arid Sukumaland, Tanzania, as slightly over 20%, Norman (1972) in semi-arid Nigeria as 18% while data for the humid zone suggest figures closer to 10% (Lagemann 1977; ILCA, de Haan et al 1979). However, Lagemann found a significant increase of that contribution in the humid zone with increasing population densities. Apparently livestock still provide an income potential under extremely high population pressure.

The asset and security functions of livestock and their social and cultural role continue to be important in the mixed farming areas.

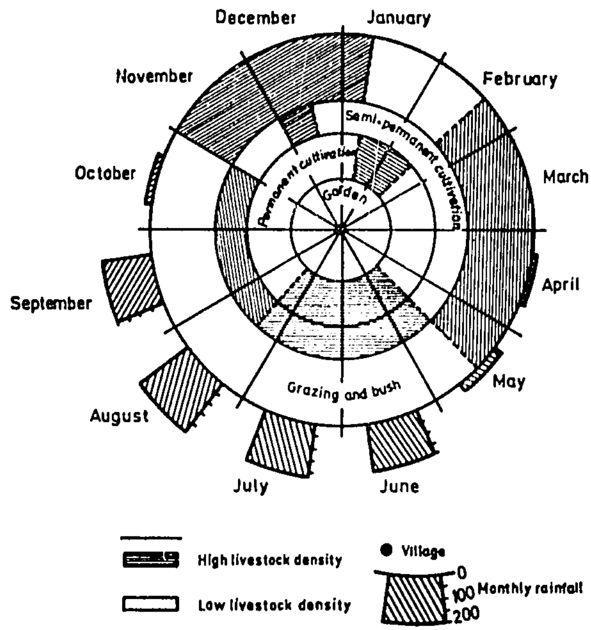
While not being as all-pervading as in pastoral systems they certainly play a larger role than in ranching. For Sukumaland von Rothenhan (1966) lists the functions of livestock in the following order: Social status, balancing of risk, bride price, nutrition, work. For south-eastern Nigeria Lagemann (1977) gives the ranking: Financial reserve, social and cultural value, source of manure, conversion of non-marketable food residues into market products.

Livestock management: Also in the mixed farming areas there is the tradition of communal tenure of the grazing resource. Since it is cropping, not livestock, that provides the mainstay of subsistence and income and since there is not such pressure on the land relative to its potential as in the arid zone the feature is less exacting in its consequences for land use. The limitation on improvement possibilities without institutional change remains. A special aspect are stubbles as a grazing resource the importance of which is outlined in the following section. Here the cultivator maintains a degree of individual control which enables him to use it for his own animals or to enter arrangements with livestock owners for its use in return for manure, food products from livestock or money. Major determinants of the feed economy and of livestock management are the dry season constraint on one side and the danger of crop damage by livestock on the other. The management system attempts to balance the feed requirements of livestock with the use of distant grazing resources and stubble grazing while trying to avoid proximity of livestock to crops during the growing season.

Figure 6.5 illustrates the principle for the case of a village in northern Cameroon. At the beginning of the rainy period in June or July, the animals graze on the arable land that is not yet cultivated or is lying fallow. As cropping progresses, the animals are concentrated on the fallows, which are 2-3 km from the village. In October, millet straw from the permanent gardens provides additional fodder. At the beginning of the dry season, the animals are driven to bush grazing further afield. This is interrupted in January and February, when harvest residues are eaten. The animals spend the rest of the dry season, from February to May, in the more distant grazing areas. In addition, the leaves and fruits of acacias (Acacia albida) scattered in the arable land are used.

The need to meet the animals' feed requirements and the need to protect the crops translate into demand for the farmers' labour,

Figure 6.5.
Distribution of Cattle on the Village Land During the Different Seasons in Golonpoui, Northern Cameroon



Source: Guillard (1965), adapted from Ruthenberg (1980 p. 40).

and this may be in conflict with the labour requirements of cropping. According to Delgado (1979) this provides the fundamental explanation for the practice and the extent of contract herding in West Africa. The owner entrusts his animals to herdsmen (usually a pastoralist) to take them on more or less extended migrations. These herdsmen are believed to be superior in livestock management. In addition the feed constraint is taken care of, crop damage is guarded against and agricultural labour which is scarce during the cropping season is unburdened.

A further livestock management system that requires mention pertains to smallstock, usually of trypanotolerant type, in the humid zone of West Africa. It is common to allow these animals to roam freely in the village and to live on household refuse. It is in fact difficult to speak of a management system at all since efforts are limited to preventing crop damage, often children paying attention to the fields, and to periodical slaughter of an animal. Many millions of smallstock are kept under these conditions in the forest belt of West Africa.

6.2 Production and Productivity

6.2.1 Fodder Productivity

In the low rainfall areas fodder productivity is a function of annual rainfall. This functional relationship via primary productivity is complicated by a number of factors as one proceeds into the more humid zone:

- The woody vegetation becomes denser and influences herbaceous growth,

- the quantity constraint on feed in the dry season is more and more replaced by a quality constraint,

- more and more land is used for cropping; livestock are excluded from year-round grazing, while on the other hand stubbles and crop residues are provided as feed.

Carrying capacity of natural pastures: To account for increasing competition for woody plants Blair Rains and Kassam (1980) propose to decrease calculated feed availability from natural pastures by the factor 0.4 from a rainfall level of 700 mm onward. This produces an abrupt break in the functional relationship between rainfall and primary productivity. The figures in Table 6.2 are based on a straight line connection between feed availability in the arid zone and feed availability for the high rainfall zones as proposed by Blair Rains and Kassam. This implies that feed availability continues to grow with rainfall but at a lower rate than in the arid zone because competition from woody plants becomes stronger and because the proportion of losses is higher. A survey of more detailed estimates of fodder productivity and carrying capacity (Fricke 1979) shows them to be generally within the order of magnitude of those in Table 6.2. They also correspond with

Table 6.2: Feed Availability and Carrying Capacity in the More Humid Lowland Areas of Tropical Africa

Annual rainfall mm	Feed availability (DM) kg/ha	Carrying capacity ha/TLU[a]
600	450	5.1
800	530	4.3
1 000	620	3.7
1 200	700	3.3
1 400	780	2.9
1 600	870	2.6
1 800	960	2.4

a) 6.25 kg per TLU and day i. e. requirements of 2 280 kg p. a.

Source: Adapted from Blair Rains and Kassam (1980).

the figures given by Pratt and Gwynne (1977) for East Africa for the lower rainfall scale. The assumption is that their eco-climatic zone IV (semi-arid) is comparable to the rainfall interval 500 to 1000 or the semi-arid zone as defined in this study. For the higher rainfall zones Pratt and Gwynne give higher carrying capacities. This appears to be due to the fact that they are dealing mainly with edaphic or fire-induced grassland and exclude forest from the areas under consideration, while the figures in Table 6.2 allow for the competition by woody plants.

Feed quality: The constraints of the dry season for feed quantity diminishes with increasing humidity but feed quality may constitute the more serious constraint. Quality in this respect refers to the crude protein (CP) and digestible crude protein (DCP) content of the feed which varies sharply through the year (Blair Rains 1963, Fricke 1979, Table 6.3). A DCP content of less than 2% in total dry matter is generally assumed to be insufficient even for maintenance; modest levels of growth and production increases this requirement significantly (Riviere 1978). A large proportion of the total production during the year is therefore insufficient in quality for maintenance and production (Table 6.3). It should be noted that the figures in Table 6.3 refer to production as measured by cutting and weighing not to production available to grazing animals.

The traditional responses to the fluctuations in quantity and quality of feed are passive and include both migration and the spreading of the herd over larger areas and adaptation of the stocking and production cycle.

Table 6.3: Yields and Nutritive Value of Upland Savanna in the Katsina and Zaria Survey Areas 1967-69[a]

	By months							By season	
Katsina survey area upland savanna	May	June	July	Aug.	Sept.	Oct.	Nov.	May-Nov.	Dec. -April
DM kg/ha	50	150	200	200	200	400	300	1 500	1 000
DCP content (% DM)	10.0	10.0	7.7	3.0	2.0	1.0	0.0	3.3[b]	0.0
Zaria survey area upland savanna and fallows									
DM kg/ha	300	400	300	500	1 000	500	500	3 500	1 500
DCP content (% DM)	7.7	7.7	3.0	2.0	1.2	1.2	1.0	2.7[b]	0.0

a) From cutting experiments

b) Average weighted for monthly DM quantities

Source: Fricke (1979) adjusted, based on Van Raay and de Leeuw (1974).

Stubble grazing: Fodder production for livestock in the crop-livestock areas is also influenced by cropping. At first sight cropping appears to be directly competitive with livestock keeping since it takes areas out of the land available for grazing. However, there is growing evidence that this has no negative influence on total feed availability to livestock (van Raay and de Leeuw 1970 and 1974, Charreau 1975). Also the grass fallow between cropping years is not necessarily of lower value than natural grassland. In order to make the figures in Table 6.4 comparable to those of Table 6.2 they have to be reduced to the proportion actually available for livestock. If that proportion is the same as for natural pastures it is in the order of 30%.

In northern Nigeria the herds spend up to 71% of their grazing time in December eating the remnants of the sorghum, millet, cotton, groundnut and cowpea crops. The amount of time increases up to 92% in January, then falls to 58% in February. Total stubble grazing amounts to almost one fifth of the annual grazing time (van Raay and de Leeuw 1974, Fricke 1979).

Table 6.4: Straw Yield and Nitrogen Content of Crop Residues in the Semi-arid Zone (Means)

Crops	Straw (DM) t/ha	Amount of nitrogen kg/ha
Grass fallow	3.0	24
Pearl millet	5.0	90
Sorghum	7.0[a]	21
Maize	3.0	24
Groundnut	2.5	70
Cowpea	1.5	21

a) Appears very high

Source: Charreau (1975).

Stubbles as a feed resource have the disadvantage that they are more variable in quantity and quality than natural pastures over the years (Ruthenberg 1980) and that their availability within a year is more strictly limited in time.

6.2.2 Livestock Productivity

Table 6.5 gives meat and milk productivity data for countries that lie within the zone considered, i. e. countries whose national averages are not significantly influenced by figures from the arid zone or the highlands or from ranching enterprises (e. g. Zaire). Some smaller countries had to be left out because of the influence of rounding errors in the statistics. The weighted averages show no significant deviation from the averages for total Tropical Africa. This is to a certain degree due to the statistical base into which already enter 'average assumptions' resulting in an apparent homogeneity of the figures. Nevertheless there is no firm base from which to challenge the 'average assumptions'. Among the selected countries the low meat productivity in Tanzania is significant which may be due to pastoral systems accounting for a high proportion of livestock production. Furthermore the low milk yields in Upper Volta, Guinea, Ivory Coast and Ghana are notable. In these countries the practice of milking is less common.

The FAO figures were also examined for productivity of smallstock in these countries. No significant deviation from the average for Tropical Africa (3.5 kg per head) was found in the case of meat. Intercountry differences do not lend themselves to any obvious explanation. Milking appears to be less common leading to lower than average (6.5 kg) milk yields but the distinction between "no yield" and "no information" cannot be drawn.

In the zone considered livestock contributes to overall agricultural productivity by providing draught for work and transport and manure. To quantify the productive effects of these farm inputs and of the overall farm integrative role of livestock the following considerations can be made (compare section 3):

a) Livestock provide about 3 000 kg of manure (DM). Fully applied to crop fields this could lead to a yield increase of 100 or more kg of grain her hectare.

b) A pair of animals used for agricultural work increases the work capacity of a farm two-to-threefold and can be attributed some or all of the accompanying increase in net income.

c) An animal systematically used for transport performs up to five tonne-kilometers per day the value of which can be derived from local markets or via the valuation of alternative means of transport.

Table 6.5: Meat and Milk Productivity of Cattle in Selected Countries of the Lowland Crop-livestock Zone of Tropical Africa 1979

Country	Beef production	Milk production	
	kg/head of cattle	kg/head of cattle	kg/cow
Senegal	15.0	35.6	350
Sierra Leone	14.8	51.9	350
Guinea	11.2	22.9	185
Upper Volta	12.2	28.5	180
Ivory Coast	15.4	13.8	85
Ghana	14.0	8.0	55
Nigeria	16.7	28.5	285
Uganda	16.6	71.4	350
Tanzania	8.4	47.8	325
Malawi	12.7	43.0	466
Weighted average	12.9	40.9	298
Average Tropical Africa	13.4	38.3	333

Source: FAO (Production Yearbook 1979).

In all cases it would appear reasonable to reduce the figures for trypanotolerant livestock on account of their smaller size. Of the different trypanotolerant breeds only the N'dama are generally considered suitable for heavy agricultural work. All the additional functions mentioned can also be provided by the equines, of which there are sizeable populations in the semi-arid zone. A more detailed assessment can be made of the role of animal traction in the zone by estimating its contribution to total labour requirements in crop agriculture (Table 6.6).

Table 6.6: The Importance of Animal Draught, Tractors and Hand Labour in Meeting the Labour Requirements of Crop Agriculture[a] in Lowland Tropical Africa 1975

Region	Draught animals No	Draught share[b] %	Tractor share[b] %	Hand labour share[b] %
Western/Central	3 486	4.1	4.8	91.9
Eastern/Southern (excl. Ethiopia)[c,d]	6 419	13.1	10.9	76.0
Total (excl. Ethiopia)[c]	9 905	9.9	7.9	82.2

a) Total labour requirements of crop agriculture as calculated by FAO (AT 2000, 1979)

b) Share of draught animals and of tractors as determined by power model of AT 2000;this provides for a minimum of 30 hectares of cultivation per tractor and for about 2.5 ha per pair of draught animals; share of hand labour as a residual

c) Ethiopia has 5.5 million draught animals and a draught share of 26.6 %. As an approximation these figures can be taken to represent draught animal use in the highlands; the balance then refers to the lowland zones

d) Also excluding Namibia and Botswana

Source: Jahnke and Sievers (1981) on the basis of FAO (AT 2000, 1979).

In Western Africa the draught animals are concentrated in the semi-arid and sub-humid areas of the Sahel countries of Nigeria. The highest contribution to labour requirements is in Mali with over 17 percent. The humid countries of the West African Coast and of Central Africa have practically no draught animals and also a low level of tractorization. Eastern and Southern Africa, excluding Ethiopia, show a higher level of mechanization. Draught animals have the highest contribution in Madagascar (23%) and in Kenya (11.4%). In total the ten million draught animals in the lowlands of Tropical Africa contribute slightly less than ten percent to the total labour requirements of crop agriculture; over 80 percent are still provided by land labour (FAO, AT 2000 1979, Jahnke and Sievers 1981).

6.2.3 Productivity and Tsetse Challenge

If livestock are present at all tsetse challenge influences livestock productivity in two ways; directly by reducing animal performance and indirectly by necessitating the use of trypanotolerant animals whose productivity may be different. Table 6.7 gives productivity indicators for tolerant and non-tolerant stock under different levels of management and of tsetse challenge. The overall productivity index relates total production to a hypothetical unit of 100 kg of liveweight to be maintained thereby abstracting from liveweight differences between trypanotolerant livestock and other livestock (ILCA, Trail et al 1979).

Table 6.7 shows no significant differences between zebus and trypanotolerant breeds under zero and light challenge. As the tsetse challenge increases the productivity of all breeds including the trypanotolerant ones decreases, but that of zebus more strongly so. The statistical base of the figures is insufficient for firm conclusions but they provide quantitative empirical evidence for the hypothesis that humped and humpless cattle are of similar productivity in the absence of trypanosomiasis; that the humpless cattle gain a relative productivity advantage as the tsetse challenge grows; and that eventually tsetse challenge is too high for zebus while trypanotolerant animals still allow livestock production to be carried out albeit on a reduced level of performance.

The influence of management is overlain by that of tsetse challenge and requires a more differential treatment (Table 6.8). There is no productivity difference between the two trypanotolerant breeds in spite of the difference in size. Management influences productivity significantly. The major determinant is the degree of tsetse challenge, which may reduce performance by as much as one half. The use of trypanotolerant cattle can therefore be considered as a means of keeping livestock in spite of the presence of tsetse flies and trypanosomiasis but not as a means of completely avoiding their impact. It must be stressed that high levels of management usually also lead to a reduction of the tsetse challenge (bush clearing, rotational grazing, early slaughter, no feed stress) so that management level and tsetse challenge, to a degree, are interdependent.

Table 6.7: Productivity of Trypanotolerant and Zebu Cattle in Three Locations at Different Levels of Tsetse Challenge and Management

Country:	Nigeria			Ivory Coast		CAR[a]	
Challenge:	zero			light		medium	
Management:	station			village		village	
Indicator	N[b]	S[c]	Z[d]	S[c]	Z[d]	S[c]	Z[d]
Cow viability (%)	100	100	100	98	96	96	95
Calving percentage	100	96	91	70	72	68	63
Calf viability to 1 year (%)	97	95	100	55	60	80	65
Calf weight at 1 year (kg)	131	101	101	200	75	90	120
Annual milked out yield (kg)	-	-	-	70	-	-	71
Cow weight (kg)	266	183	343	200	270	190	320
Productivity index[e] (kg)	48.1	50.2	52.8	18.5	20.5	26.3	18.2

a) Central African Republic

b) N'dama

c) Shorthorn

d) Zebu

e) Total weight of one year old calf plus liveweight equivalent of milk produced per 100 kg of cow liveweight maintained per year

Source: ILCA (Trail et al 1979).

Table 6.8: Productivity of Trypanotolerant Cattle Groups Under Different Management Systems and Levels of Tsetse Challenge

Variable	Number of sources	Calving %	Calf viability %	Calf weight kg	Cow weight kg	Index/100 kg cow kg
Overall mean	30	69.1	78.4	96.4	205	28.5
Breed						
N'dama	21	70.1	79.9	113.7[a]	248[a]	28.7
Shorthorn	9	63.1	76.9	70.1[b]	162[b]	28.3
Management						
Ranch/station	16	76.4[a]	85.8[a]	107.1[a]	212	33.7[a]
Village	14	61.8[b]	71.0[b]	85.7[b]	198	23.3[b]
Tsetse challenge						
Zero[e]	3	92.4[a]	81.5	97.7	216	40.1[a]
Low	13	73.1[b]	84.6	98.1	212	31.9[b]
Medium	10	34.8[c]	79.7	96.7	200	23.2[c]
High	4	56.1	67.8	93.1	192	18.8[c]

a-d) Any values within a subgroup with different subscripts are significantly different at the probability level of 1 percent

e) Zero tsetse challenge is confounded with a very high level of feeding and management

Source: ILCA (Trail et al 1979).

The figures for sheep and goats are less well defined with respect to specific breed types, management levels and levels of tsetse challenge. Productivity data for sheep and goats in areas known to be tsetse-free are compared with available data for trypanotolerant sheep and goats generally found in tsetse-affected areas. The productivity index is adapted to small stock and expresses total production in meat equivalents in 5 months per 10 kg of female liveweight to be maintained (Table 6.9). Trypanotolerant smallstock appear to be more productive than non-tolerant stock in spite of their smaller size, their exposure to tsetse challenge and the generally low management levels.

Table 6.9: Productivity Traits of Trypanotolerant and Non-tolerant Groups of Sheep and Goats

Indicator	Sheep		Goats	
	non-tolerant tsetse-free	tolerant tsetse-affected	non-tolerant tsetse-free	tolerant tsetse-affected
No of situations	10	9	11	3
Breeding female viability %	94	86	94	88
Lambing/kidding %	123	179	148	224
Progeny viability %	76	68	71	77
Progeny weight (kg at 5 months)	15.5	11.5	10.5	7.5
Breeding female weight (kg)	33.1	23.6	28.0	21.3
Productivity index	4.5	6.4	4.1	6.9

Source: ILCA (Trail et al 1979).

The productivity index used is not directly related to commercial productivity. Variables like age of first calving, culling rates, age of maturity and slaughter affect the latter but this of course holds irrespective of the breeds kept. It should also be noted that the index relates to liveweight and not to metabolic weight. On the basis of metabolic weight smaller animals would show lower indices which may be relevant for fine calculations in situations in which feed is known to be a scarce factor.

6.3 Development Possibilities

6.3.1 Mixed Farming

The term crop-livestock farming has been used to denote a general association between crops and livestock. Mixed farming as a development venue has a more specialized meaning: The intensification of the output function of livestock within the farming system parallel to the development of the farm input function (work and manure) and the increased integration of livestock for the benefit of soil fertility and overall farm productivity; livestock development is viewed in the context of the farming system as a whole including the crop sub-system. Crop cultivation benefits from a number of advantages as rainfall increases i. e. as one moves from the more arid to the more humid areas:

a) Many grain crops show a higher yield potential in the sub-humid zone (FAO, Higgins et al 1978).

b) The relative advantage of high-yielding root crops increases. The sub-humid zone offers interesting prospects for producing low-cost starch from improved root crop species and through the application of mineral fertilizers. There are also prospects for improved grain legumes (Ruthenberg 1980).

c) A considerably longer growing period opens up possibilities for continuous cropping, higher cropping indices and higher overall yields (Ruthenberg 1980).

In contrast to these advantages there is a number of problems imposing serious constraints as humidity increases (Ruthenberg 1980 and others):

a) A relatively higher proportion ot total organic matter and of nutrients are bound in the standing natural vegetation. Clearing for cultivation leads to losses. Organic substances from crop residues alone are quickly broken down and do not benefit soil structure a great deal.

b) Intense rains lead to much leaching and severe erosion even on moderate slopes unless the rainfall is broken up by a canopy of plants or a surface mulch.

c) High night-time temperatures and lower radiation intensity, especially during the latter part of the rainy season when there is a high incidence of cloud cover, reduce the photosynthetic capacity (Kassam and Kowal 1973, pp. 39-49).

d) The more favourable conditions for plant growth also lead to more vigorous weed growth which may become quite unmanageable particularly under conditions of near-permanent cropping.

e) The general increase of biological activity also favours the development of pests and diseases.

f) Even high rainfall regions may suffer moisture stress because of the poor water-retention capacity of most upland soils. Droughts of only five days may depress yields significantly if they occur during the period of tillering.

g) Fertilizers tend to be less effective here than in drier climates or in irrigation farming because soils are predominantly acid, are low in organic matter and deficient in silt and clay particles. Their cation exchange (i. e. nutrient holding) capacity is low. Nitrogen fixation by legumes is also lower (Kassam and Kowal 1973, p. 49).

The disadvantages express themselves in overall greater difficulty of maintaining soil fertility. The function of fallow periods in restoring soil fertility is considered more essential the more humid the environment (Ruthenberg 1980, Young and Wright 1980). The transition to permanent cropping which has taken place on low levels of technology in many semi-arid areas is more problematic in the more humid zones. When population densities grow and fallow periods are reduced land degradation develops much more quickly. In spite of relatively low overall population densities land degradation is already wide-spread in the sub-humid zone*.

For development with known and proven technologies the semi-arid zone has considerable potential. Faster maturing and higher-yielding varieties of grain crops, particularly efficient in connection with fertilizer, are available and increase production and improve security. Mechanization increases the productivity of the land (deep ploughing, moisture conservation, timely field preparation, reduction of harvest losses). In the very humid areas on the other hand proven development paths lead to garden agriculture, valley bottom development for cultivation and tree crop development in the upland areas, all stable farming systems on a high level of productivity. The development of irrigated water-controlled rice growing in the depressions and flood plains provides the basis for further intensification and high human supporting capacity.

It is in the sub-humid zone that the transition to permanent cropping and high yields is still a matter of great uncertainty. The question is whether to substitute for the fallow by high inputs of

* Satellite images of the sub-humid zone in West Africa analysed by the Land Resource Division, Ministry of Overseas Development, London, shown at the ILCA symposium in Kaduna (ILCA 1979 a).

mineral fertilizer and/or by green manure crops, whether to concentrate cultivation on the hydromorphic locations or whether to promote mixed farming (Ruthenberg 1980)*. There is little dispute about the agronomic advantages of mixed farming in the sub-humid zone as expressed for the case of Nigeria (FAO 1966, p. 10):

> "Unlike the forest zone to the south, the middle belt needs livestock as an essential adjunct to farming. It lies to the north of the economic limit for tree crops; it is ecologically suited to field crops. For this purpose the animal is needed as a provider of fertility and as a beast of burden. No system of permanent farming, that is a system which will avoid erosion and maintain soil fertility without resource to "bush fallow" can exist in this zone without animal manure.
>
> Given the possibility of keeping cattle, along with other livestock, the middle zone has the capacity to become the mixed-farming area par excellence of Nigeria. The higher rainfall and shorter dry season will make possible a wider range of crops than farther north; in particular it will afford better natural conditions for growing of annual and perennial fodder crops as a food basis for a livestock industry. Livestock in turn will enrich the soil, and along with better moisture conditions than in the classical areas for field crops, should lead to substantially higher yields".

Also in Tropical Africa there is at least one case where a form of mixed farming has developed autonomously out of traditional farming and demonstrates its feasibility and advantage under practical farming conditions (Ludwig 1967, Ruthenberg 1980): The farming system on Ukara Island (Lake Victoria), where climatic conditions are sub-humid. The Wakara have lived for a long time under conditions of high population density, recently estimated at over 200 persons per km. The average Wakara family has only a hectare of arable land at its disposal, and this is cultivated by hoe. The need to guarantee food for a large population on these soils has led the Wakara to develop and apply highly refined practices to preserve fertility. In this respect livestock play a key

* Zero tillage techniques as an alternative or complementary approach appear to be at too early a stage to be judged for their eventual contribution to permanent cropping in the sub-humid and humid tropics.

role. The high population densities have not resulted in declining but increasing herds, simply because livestock provide an essential means of maintaining soil fertility. Livestock densities increased from 131 per km^2 in 1925 to 154 in 1957 and from 0.6 TLU per person to 0.7 (Ludwig 1967). Also in comparison with surrounding mainland areas of much lower human population density, the stocking density of Ukara is higher, indicating the need for more livestock as population pressure increases.

The high livestock densities necessitate intensive feeding practices. Grazing is only occasionally practised; stall feeding is the principal feed supply system. The livestock, 3.4 TLU on average per farm consisting of two to three head of cattle, three to four goats and occasionally a sheep, spend most of the time in the stables. These are pits up to 1 metre deep which are lined with rocks along the edges towards the exit for stability. The lined part of the pit also serves as a kind of feeding trough. Bulls only rarely leave the pits, but cows, young stock and small stock are allowed out for grazing at certain seasons of the year. Grass, sometimes even grown under irrigation, leaves, weeds and crop by-products are brought to the pit and either fed or used as litter. Thus the pit fills up two or three times a year. The contents are then placed on a heap on the compound and as required taken to the fields distributed and worked into the soil. The quantities of feed transported to the stables and of the dung carried to the fields are estimated at 202 and 158 kg respectively per day on every farm. Some 10 to 13 tonnes of manure become available every year. In addition to manuring, leaves are worked directly into the soil, household refuse and night soil are utilized and rich alluvial soil dung from pits is carried to less fertile parts of the island. The predominant function of livestock is the supply of a farm input, manure. Meat and milk are produced but more as by-products in comparison with manure. The livestock and manure economy together demand on average two hours of labour per day on a typical farm throughout the year. For conditions of Tropical Africa this is close to one full man equivalent, essentially engaged in preservation of soil fertility. A family of five with typically 2.5 man-equivalents devotes almost 2/5 of its work capacity to measures aimed at maintaining the yield levels.

The case of Ukara Island demonstrates the feasibility of mixed farming under conditions of Tropical Africa. Yields are low but the success of mixed farming lies in the fact that very high population densities can be supported while sustaining the soil fertility level. But this does not mean that the system could be easily transferred. Firstly Ukara Island is free of tsetse flies. This might be a result of the high population densities itself. Over most of the sub-humid zone the initial obstacle to livestock development is trypanosomiasis. Either tsetse control operations have to be carried out or trypanotolerant animals must be used, whose number is small in comparison with the zone under consideration. Secondly it is a very complex way of farming to which the experience of generations has contributed. Thirdly the mixed farming system yields very low return on labour; as a consequence those Wakara who transfer to the mainland abandon mixed farming for the benefit of shifting cultivation and extensive livestock keeping (Ludwig 1967, Ruthenberg 1980). The farming system of Ukara Island developed over generations of high population density and of preoccupation with soil fertility. Such conditions cannot be quickly created elsewhere. Mixed farming remains the long-term objective, but it can hardly be created in all its complexity in one step. The development of the output function of livestock (meat and milk), of the input function in the form of traction and the elaboration of appropriate measures to overcome the tsetse problem are therefore not to be seen as alternatives to mixed farming. Rather they serve to strengthen the role of livestock, render the farming system more productive and thus constitute steps in direction of productive mixed farming.

6.3.2 Strengthening the Role of Livestock

The use of livestock manure for soil fertility is widespread in the ecological zones considered here. The higher the population pressure and the higher the cultivation intensity the more value is placed on manure. But the other functions of livestock like meat and milk production and the use of animals for draught also require strengthening in the process of livestock integration, though there is little evidence of this within traditional African farming systems. Development efforts have concentrated on animal draught more than on other functions (1) to increase crop production and productivity directly, (2) to provide the starting point for improved livestock husbandry and therefore increased meat and milk outputs and (3) to lead eventually to productive mixed farming systems.

Animal draught: In Tropical Africa the use of livestock for draught purposes is not traditional; the important exception is Ethiopia with its own agricultural history, but this country largely falls into the highland zone excluded from the present considerations. Arab influence is likely to have played a role in Sudan and in some of the Sahel countries but, by and large, animal traction constitutes an introduction by Europeans. In Eastern and Southern Africa this introduction dates back a long time (in the former Portuguese territories well before the turn of the century, in many Eastern African countries during the early decades of this century). In Nigeria the beginning of animal traction is put in the 1930s. In francophone West Africa the earlier mechanization efforts (including tractorization) largely failed; from the 1950s on a series of new programmes were launched two of which are considered particular successes: The introduction of the animal drawn plough in Mali for rice and cotton cultivation, and the introduction of the animal drawn drilling machine for groundnut cultivation in Senegal (Casséet al 1965).

Tractorization is strongly dependent on the development of agricultural incomes and wages; increased tractorization is predicted for Tropical Africa but also increased use of draught animals simply because income levels will not allow large-scale tractorization (FAO, AT 2000 1979; Jahnke and Sievers 1981). Furthermore past experience with tractorization programmes and prospects of rising energy costs are not encouraging. There is therefore room for the expansion of animal draught particularly in the semi-arid and subhumid zones where ecological conditions favour this form of mechanization. In the more humid areas tsetse infestation reduces performance of livestock, also of trypanotolerant stock, which is compounded by the stress of work. Also the natural woody vegetation becomes too dense for animal traction to be feasible.

In comparison with hand cultivation the following effects are ascribed to animal traction (Cassé et al 1965):

- Reduction of the drudgery of labour,

- increase of labour productivity,

- possibility to have a greater proportion of lucrative cash crops in the cropping pattern, and

- increase of land productivity.

There is conflicting evidence as to the realization of the different effects and to their relative importance (CEEMAT 1975; Dupont de

Dinechin 1969, Cassé et al 1965, Munzinger 1981). But generally the increase in the labour capacity of a farm is an important advantage in semi-arid environments. The soil is usually too hard for working at the end of the dry season and the loss of soil moisture would be disadvantageous; the first rain showers have to be awaited. But then time is very short to put the seed in the ground to make maximum use of the short growing period. Thus the animal drawn plough and the animal drawn drill are essential instruments to overcome this labour constraint. All evidence shows that the introduction of animal traction is accompanied by a significant increase in the area under cultivation. The increase in cultivated area is in excess of the subsistence requirements and can be put to cash crops. The overall productivity of the farm is thereby increased although labour requirements, even on a per hectare basis may indeed not be reduced. The productivity of the land may be increased if the cash crops have a higher return than the subsistence crops. Whether animal traction has a direct yield effect is again a matter of controversy.

Integrated Crop Development: If no other development measures accompany the introduction of animal draught, and if animal draught were to be practised for food crops or cash crops at low yield levels only, its attraction would be limited, because there are considerable efforts and costs involved in animal traction. The oxen have to be trained, their sale for slaughter is postponed by years during which they have to be fed for relatively small weight gains, the equipment is expensive - FAO (AT 2000 1979) puts it at $ 325 for a pair of oxen in 1975 prices and Munzinger (1981) uses a value close to $ 400 in 1979 prices - and there is hassle both in handling the animals and in replacing broken parts of the equipment. In addition there is the considerable though not immediately visible danger of soil degradation. Manual cultivation puts a check on the extent of cultivation which implies observation of fallow requirements by necessity. When this check is eliminated additional agronomic measures become necessary to maintain soil fertility. Both economic and ecological considerations demand that the introduction of animal traction be viewed as part of an overall approach to agricultural development.

Detailed calculations of the farm economics of animal traction show that yield increases are necessary to make traction competitive with hand labour operations (Munzinger 1981, p. 303). This appears to be a necessary prerequisite for the initial adoption of traction which eventually also leads to increased total farm income as a result of expanding the cultivated area. The performance of the particularly successful programme by CFDT (Compagnie française pour le développement des fibres textiles) in Mali can to a large extent be explained by the integration of animal draught into overall agricultural development (Cassé et al 1965; de Wilde 1967). The introduction of animal draught was linked to the introduction of a remunerative cash crop, cotton. From the start a number of measures like manure application, use of mineral fertilizers, pesticide spraying were promoted to enhance general agricultural productivity (Table 6.10).

Table 6.10: Adoption of Agronomic Improvements (Other Than Animal Draught) and Yield Development in Cotton Growing in Mali 1961/62 to 1964/65

Indicator	1961/62	1962/63	1963/64	1964/65
Number of manure pits and stables	1 532	2 430	2 322	3 705
Cotton area treated with fertilizer (ha)	228	843	1 824	3 884
Cotton area sprayed three times (ha)	n. av.	1 187	2 708	6 429
Area under cotton (ha)	42 503	50 706	57 049	64 489
Yield (kg marketed per ha sown)	138	235	268	314

Source: de Wilde (1967).

By 1976/77 total cotton production in Mali had reached 133 000 tonnes; the number of draught oxen in that year was estimated at 245 000 and the total number of ploughs at between 100 000 and 130 000 (ILCA 1978). There were also 95 000 cultivators, 10 800 harrows, 9 800 seeders and 52 300 carts in the country. This development can largely be viewed as the result of the original CFDT programme.

The following reasons have been identified to account for the success of the CFDT programme (de Wilde 1967):

(a) Agronomic research which has made it possible to select a highly productive variety and to perfect effective means of realizing its yield potential with appropriate fertilizer applications and plant protection measures;

(b) the introduction of an extension service which is capable of working closely and constantly with the farmer, providing him with both the advice and means of production he needs;

(c) the provision by the same company of the equipment and supplies that enable the peasant to change his traditional methods of cultivation, prepare a field for growing cotton in pure stands, fertilize and weed it, and spray it;

(d) the fact that the farmer has been able to sell his cotton regularly thanks to the marketing assured by the CFDT; and

(e) the fact that cotton, with its comparatively high price, has been the most profitable crop for the Malian peasant to grow.

In this light the livestock component, i. e. the use of animal draught, has only been one element of an agricultural package. It has been a particularly appropriate one since it allowed both the expansion of cropping and at the same time a degree of intensification.

The experience in Mali bears out in a classical manner the conclusion Cassé et al (1965) drew from a review of the experience with animal traction in francophone West Africa:

> "The principal attraction of draught power probably lies in the possibility that it offers to multiply by a coefficient the results, and thus the revenue, obtained due to other methods of intensification".

Meat and milk development: The possibilities of meat and milk development in pastoral systems of the arid zone are limited for ecological reasons alone; the highland zone has seen substantial advance particularly in dairying; the crop-livestock systems in the lowland zones are conspicuous for the absence of significant achievements in meat and milk production in spite of a considerable natural potential. Isolated examples of intensification exist and point to the scope:

- Traditional ox-fattening activities in Madagascar;

- fattening operations in Malawi based on the feeding of groundnut residues;

- smallholder fattening operations in the vicinity of large-scale operations based on the feeding of molasses and other crop by-products (Ivory Coast, Upper Volta);

- fattening operations based on artificial pastures the beginnings of which have been studied in considerable detail in Togo (Doppler 1980, Rüdenauer 1981);

- commercial milk production developed in a pastoral setting as e. g. in the Vom area of Nigeria and in smallholder areas of Malawi.

The most comprehensive programme for livestock development in the zone is probably the one implemented in northern Ivory Coast (Bailhache et al 1974). The core objective is to turn the livestock enterprise into a productive line of agricultural production that is valued by the livestock owners for its profitability and with the success of which the livestock owners increasingly identify themselves. The development efforts are cast in an extension project that promotes the construction of holding grounds for villages that serve for protection and as central places for inspection and care, the application of veterinary measures, particularly against internal parasites*, improved sanitary conditions and improved nutrition of the animals (mineral supplements, fodder reserves, agricultural by-products). As a result the total herd grows at 10% p. a. and the meat offtake per head increases from 23 kg initially (for the N'dama) to 29 kg. This performance is achieved at considerable cost, but ex-ante evaluations established their economic justifica-

* The protection of the animals from the great epizootics (rinderpest, pleuropneumonia, blackleg, anthrax and pasteurellosis) is seen as a 'conditio sine qua non' of all livestock development measures.

tion and the indications after several years of operation in the field confirm the feasibility of this approach to livestock development.

With dairying there is even less development activity. There exist dairy ranches as a colonial heritage in semi-arid/sub-humid ares of Kenya, Tanzania, Zimbabwe and Zambia. The development of parastatal dairy ranching has been promoted in Tanzania with limited success so far. As a form of ranching they constitute a different production system from those considered here and their applicability to other regions appears limited. If one classes town dairies, which exist and for which there is further development potential, as 'landless' production systems one is left with the quasi-absence of commercial dairy production from the lowland mixed farming areas. Of course localized efforts do exist (Malawi, Vom in Nigeria) but for the aggregate view the statement holds. A reason for this may be the wide-spread but possibly biased opinion that dairy development has to be based on high milk yields.

The genetic potential for dairy production of indigenous African livestock has been shown to be limited (ILCA/IER 1977). Dairy development is therefore normally based on exotic (usually European) breeds. These breeds are considered as too sensitive for environmental stress, particularly tsetse challenge in the lowland areas. Low management levels as pertain in lowland smallholder situations preclude the keeping of exotic breeds and therefore dairy development. This view is based on the assumption that a significant increase in milk production per animal is a pre-requisite for dairy development. But this need not be the case. The example of India shows that successful smallholder dairy development can set in at lowest yield levels (Brumby 1979). The development approach in India was based on (1) transmitting the high urban demand for milk at attractive prices to the rural producer, (2) organizing marketing and processing efficiently, and (3) supplying concentrate feed at cost price to the producer. With these measures it was possible to continue to expand the urban market, while allowing the farmer with an average of 1.3 cows/buffaloes, each producing not more than one or two litres of milk per day, to increase his income by 50% and more. The essential aspects at the farm level were the effective harnessing of low opportunity cost inputs, namely labour, non-arable land (roadside grazing) and crop by-products. With the additional use of concentrates a significant value-added effect through livestock integration could be achieved.

The relevance of the Indian example for the mixed farming areas of the African lowlands is obvious. Development along these lines would allow use to be made of animals with comparatively low milk productivity but a relatively high degree of adaptation to the environment, particularly pronounced in the case of trypanotolerant animals.

Integrated Livestock Development: The most often cited advantages of keeping livestock, in particular cattle on smallholder farms are: The use of manure as fertilizer on crops, a source of milk for sale and better nutrition, better surveillance of household animals than when they are entrusted to outside herdsmen, the extra weight gains from the use of crop by-products as forage and a source of power for animal traction (Delgado 1980). All these advantages are lost if livestock are entrusted to semi-sedentary herdsmen who live outside the villages or to certain members of the family to take the animals on transhumance. However up to this day contract herding has remained the preferred system of the vast majority of the cultivators, and not even successful attempts to introduce traction have changed this separation of livestock from the rest of the farming system (Delgado 1980, Fricke 1979). The reason for this must be seen in the dry season feed constraint together with the labour constraint in these farming systems.

On low levels of agricultural technology the only response to the feed constraint is migration. Furthermore if animals are kept on or near the farm there is the constant need to guard the animals to prevent crop damage. The main labour constraint in cropping lies at weeding time (Delgado 1980, Eddy 1980) and in the initial stages of animal traction the animals cannot be used for that practice. There is then a clear conflict (Delgado 1980):

> "The prospects for smallholder mixed farming programs are somewhat limited in much of the Savannah. In most cases, farmers do distinctly better to entrust their cattle to the Fulani than to herd them themselves. Even under the most favourable circumstances the maximum increase in farm revenue from keeping two steers is less than 3 percent of the overall income potentially attainable by entrusting household cattle to specialized herdsmen. Against this marginal benefit from retaining large stock on the farm, the peasant has assumed a new risk of crop damage, a greater risk of loss of capital through lack of expertise

in animal husbandry, and a significant degree of extra work in slack periods."

At a higher level of agricultural development the feed constraint could be lifted by measures of pasture improvement like planting drought-resistant species of Cynodon, Cenchrus and Stylosanthes, adopting cutting, fertilizing and burning regimes, making silage and hay and using fodder trees and shrubs and agricultural by-products. To lift the labour constraint during weeding row culture would be practised to allow weeding by animal draught. Damage to crops would be prevented by stabling and fencing. The additional inputs to livestock would be profitable because of the high sales value of milk and fat animals.

There is thus a long way to go to achieve full livestock integration. Successful introduction of animal traction requires complementary agricultural development measures but even then most programmes stop short of a full integration of livestock and mixed farming. Even after a period of seemingly successful practice of animal traction farmers may give up cattle husbandry. This was noted in Nigeria (Fricke 1979) where farmers found it more practical and more profitable to hire tractor-drawn ploughs and to purchase mineral fertilizer. Consequently, the introduction of plough cultivation is by no means a step automatically followed by further integration of the livestock sub-system, however desirable this might be.

6.3.3 Tsetse Control*

General: Tsetse flies and trypanosomiasis they carry are distributed over 10 million square kilometers of Tropical Africa, essentially in the three ecological zones considered here - the semi-arid, the sub-humid and the humid lowlands. They affect livestock productivity adversely and in many areas make the keeping of domestic, particularly ruminant livestock, impossible. Various methods have been devised for the reduction or eradication of tsetse populations (Ford 1970). Until about 1950, virtually only two methods of tsetse control had been used with any degree of success. These were the destruction of the larger wild mammals some of which tsetse species are largely dependent on for their food, and modification of the bush cover of the land, usually by felling trees, so as to deprive the tsetse flies of habitats necessary for their survival. Since 1955, the use of bush clearing and insecticides have

* The discussion follows closely Jahnke (1976b).

gained ground at the expense of wildlife shooting as a method of control. The total area in Tropical Africa which has been cleared of tsetse flies may be estimated at about 300 000 square kilometres and is to a large extent situated in four countries (Table 6.11).

Table 6.11: Areas Freed from Tsetse Flies in Nigeria, Zimbabwe Tanzania and Uganda

Country	Area freed sqkm	Period	Remarks
Nigeria	205 000	1956-1978	by insecticide application; only 9 000 sqkm actually treated
Zimbabwe	25 000	1930-1970	by game hunting, then insecticide application
Tanzania	16 000	1947-1955	by bush clearing, then by insecticide application
Uganda	28 000	1947-1970	by game hunting and bush clearing, then insecticide application

Source: FAO (1980), Matteucci (1974), Jahnke (1976b), Na'Isa (1979), Ford (1971).

Other operations have been carried out in Botswana, Zambia, Chad and Cameroon; more localized ones in Senegal, Niger, Sudan, Rwanda and Burundi and other countries.

Technically it is possible to free land of tsetse flies, although the problems of adaptation of control methods to local conditions, of logistics and organization, of verification of the results and of preventing immediate reinfestation must not be underestimated. The real question relates to the justification of tsetse control operations. A number of authors argue for tsetse control to relieve protein deficiency in Africa (e. g. Kershaw 1970). This appears far-fetched. If a protein deficiency exists it exists among the poorer sections of the population. It is therefore necessary to find cheap sources of protein. Beef and milk produced in outlying areas after costly tsetse control are likely to be the most expensive sources of protein in any country. It is unrealistic to assume that the poor population groups could benefit from this expensive protein. More tangible and realistic benefits from tsetse control could arise in two ways. First tsetse infestation has ill-effects irrespective of the potential of the infested land. Tsetse control is then justified by the elemination of these ill-effects. Second tsetse infestation prevents or reduces the use of infested land. Tsetse control is then justified by the realization of the potential of the infested areas.

The conceptual separation of these two arguments despite their interdependence allows a clearer assessment of costs and benefits of control operations and a better determination of the role of tsetse control in a development strategy.

The ill-effects of tsetse infestation: The following ill-effects of tsetse infestation per se can exist:

(a) Tsetse flies can also act as carriers of human trypanosomiasis (sleeping sickness). Sporadic contact with the human population may result in a level of endemicity; moreover foci of potential epidemics persist.

(b) Tsetse-infested areas provide the possibility of sporadic contacts between tsetse and cattle so that cattle trypanosomiasis may be a problem in tsetse-free areas.

(c) Tsetse-infested areas may constitute a focus of expansion and tsetse-free areas may therefore be threatened by a tsetse invasion.

(d) The presence of tsetse may result in over-crowding in and over-utilization of the tsetse-free areas with negative effects on their productivity.

It is difficult to argue from the existence of these ill-effect for large-scale control operations covering thousands of square kilometres and involving considerable costs per hectare of land treated.

ad (a): Sleeping sickness is now reduced to a very low level of endemicity involving not more than a few hundred cases a year in all of Tropical Africa. The danger of a fla up persists but an outbreak is generally associated with a well-defined focus on which control measures concentrate.

ad (b): Drug protection appears to be the most appropriate strategy against trypanosomiasis from seasonal exposure and from marginal tsetse challenge since it is flexible, direct and cheap. The problem is that imprudent use of these drugs leads to resistence and consequent lowered effectiveness of these drugs*. But if drugs cannot be administered properly this points to low levels of organization and productivity of the production systems attached. It is doubtful whether for such production systems large new areas should be opened up at considerable cost.

ad (c): The tsetse flies spread to areas that provide a suitable habitat and a host to feed on; in general this means bush and wildlife which in turn only exist under very low intensities of land use. The first and best measure against the threat of a tsetse invasion is to consolidate the threatened area through intensification of land use. If intensification of land use is, for whatever reason, not possible tsetse control will not permanently eliminate the threat of a tsetse spread unless carried to the borders of the continent.

ad (d): Opening up tsetse areas can serve to reduce population pressure in tsetse-free areas but this is a static view of the problem. The root of the problem of high population pressure lies in low agricultural productivity often compounded by an institutional environment unsuited for productivity development. A reduction of the human population may bring temporary relief and a postponement of crises. But tsetse control in itself does nothing to improve the productivity level either in the tsetse-free areas or in the tsetse-infested areas.

The existence of adverse effects of tsetse infestation is not contested in principle. What is contested is the inference from such effects to large-scale tsetse control operations. Elimination of any one of these effects would hardly ever justify the costs of tsetse control over large areas. Alternative measures that are more direct, better focussed and less costly are to be preferred.

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* The emphasis in on seasonal exposure and marginal tsetse challenge. It is not proposed to establish livestock enterprises in the middle of tsetse country relying on drugs alone.

The potential of tsetse-infested areas: The degree of under-utilization of tsetse-infested areas is one factor which determines the potential that can be realized by tsetse control and thus the benefits. If the areas are indeed empty and unused it is reasonable to attribute all subsequent net benefits from productive forms of land use to the control efforts. Another factor is the proportion of the freed land which can be put into production. In this respect there appears to be a significant difference between East Africa and West Africa. In East Africa the area treated against tsetse flies is generally taken to be identical with the area freed from tsetse flies. Since a certain proportion of the land is normally unproductive the ratio of "land put to productive use" to "land cleared" is smaller than unity. Most of the tsetse control schemes in Nigeria are characterized by ratios several times larger than unity. Seasonal expansion of the tsetse fly renders large areas "unusable"; conversely seasonal concentration of the fly allows control efforts to be limited to a small proportion of the total area. The effect on the benefit-cost ratio of tsetse control programmes is obvious.

If tsetse-infested areas are already populated and used to a degree the net return from tsetse control in terms of the additional production it makes possible is lower. This reduces the economic justification for tsetse control. It also leads to the question of whether increasing population pressure will not eventually take care of the tsetse problem itself. A first problem is that both the human and the livestock population may for an extended period live under the risk of trypanosomiasis even if the fly density and thus the tsetse challenge has been reduced. A more important argument possibly against autonomous reclamation by the local population is that haphazard patterns of settlement and land use are carried into areas which would otherwise remain available for more productive forms of development. Once an area is taken up by settlers customary rights to the land are established. The important development instrument of land tenure reform becomes difficult to apply and large-scale development projects become very expensive for the government because of compensation payable for houses and cultivated plots which may have to be removed.

The essence of this argument is that the availability of empty areas is an asset for the development of a country. It would be undesirable to have a Tsetse Control Division eradicate the fly from a whole country at great costs while it is not clear what use the land is to be put to and what the benefits are from using the potential of the freed areas. However it would also be undesirable to sit back and wait until population pressure has built up and results in autonomous reclamation. In both cases an important development opportunity is missed, the opportunity of planning land use and of using the instrument of land allocation in accordance with the general development strategy.

Tsetse control and land use planning: To determine when and for what purpose a tsetse-infested area is needed for development is the task of general land use planning as part of the total strategy for economic development. This implies an assessment of the nature and rate of development expected in each ecological area, regardless of the presence of tsetse and trypanosomiasis (Ford 1971).

In addition and irrespective of production planning a country has to define its conservation policy which might involve identification of areas which are to be set aside permanently (e. g. for wildlife) and to be excluded from a livestock development programme. This is essential because tsetse flies by precluding many forms of land use and by being associated with low population densities are effective guardians of ecologically valuable forests and of conservation areas such as the important wildlife areas of East Africa. No police force could be as effective in land conservation as the tsetse flies.

In the next planning phase priority should be given to the development of tsetse-free areas for the following reasons:

- The costs and risks of combatting tsetse and trypanosomiasis are avoided;

- intensification of land use must generally be regarded as an attractive alternative to expansion of land use and is a necessity in the long run;

- intensification of land use in tsetse-free areas eliminates the threat of tsetse invasion;

- possible negative side-effects of massive disease tsetse control operations are avoided*.

Once a tsetse-infested area is to be developed the approach should be determined in accordance with the natural potential of the area. High potential arable areas constitute a special case. The reason for such areas still being under tsetse flies usually lies in the threat of human sleeping sickness and/or in the existence of legal regulations preventing settlement and land use. Such areas constitute a particularly valuable asset for a country and should not be left to haphazard settlement accompanied by the threat of sleeping sickness epidemics. The benefits from organized land adjudication and intensive forms of agricultural development are likely to justify the costs of the neccessary measures to control tsetse flies and trypanosomiasis.

Medium potential areas, marginal for cultivation, with a cattle carrying capacity of 2 to 4 hectares per TLU may be considered for tsetse control with subsequent cattle production if

- the tsetse control costs can be kept low,

- a high proportion of the cleared land becomes available for cattle, and

- the carrying capacity for cattle is high (closer to 2 hectares per TLU than 4 hectares).

If these conditions do not hold systematic protection of the cattle by drugs would generally be preferable to tsetse control. Irrespective of whether drug protection or tsetse control is preferred land adjudication should precede the introduction of cattle. Institutional constraints that may hamper traditional production systems are most easily changed in connection with the opening up of new areas. It provides the opportunity for far-reaching directed changes that is lost once one area has been claimed and production established.

* The use of insecticides per se may be not so problematic because application is far from the human nutritional chain, the application is only once and not regular as common in cropping and the direct effects on the wild fauna and flora appear to be negligible. The important ecological effects arise from the land use made possible.

For low potential areas, particularly areas without an arable potential the benefit-cost calculations of tsetse control require great care. Efficient ranching or pastoralism at low population pressure has been shown to justify the cost of tsetse control. But more often than not ranching is inefficient and pastoral land use suffers from ever-increasing population pressure. If this is the case consideration should be given to leaving such areas to the fly for the foreseeable future without any attempt at productive utilization. The advantage is that overgrazing by pastoralists and subsequent degradation is prevented and that its natural potential possible including wildlife is maintained.

Irrespective of the specific conditions of an area the ultimate objective of a tsetse and trypanosomiasis strategy should no longer be viewed as the control of the disease and its vector. The ultimate objective should rather be to use control as a conscious instrument to direct land use and to create the conditions for higher agricultural productivity. In this sense tsetse infestation represents less of a constraint and more of an opportunity. But considerable strength and foresight on the part of the policy makers are required to make use of this opportunity.

6.3.4 Other Development Paths

Expansion and redistribution of the trypanotolerant herd: Trypanotolerant livestock number some 7 to 8 million cattle and some 25 million sheep and goats. They have shown to be an important resource hardly inferior in productivity to other ruminants and capable of production in tsetse-infested areas. The principal constraint to their more extended use lies in their relatively small numbers and in their limited distribution. The most productive cattle breed, the N'dama, that is also large enough to perform draught functions is concentrated in Guinea, southern Mali and north-western Ivory Coast. The other cattle breeds and small ruminants are more widely distributed but the constraint still holds in principle.

The available empirical evidence confirms the possibility of successful translocation. The most important examples are the N'dama ranches in Zaire and the smallholder programmes (so-called 'metayage' operations) in Zaire and Central Africa Republic. Such translocations in themselves only constitute the beginning of livestock development i. e. of the task of creating viable ranches and of developing mixed farmers out of 'metayage' peasants. For such a beginning, however, it would be important to increase the numbers of trypanotolerant stock where they presently exist. This can be in line with the production objectives of these countries as shown by the livestock development programme in northern Ivory Coast.

Ley farming: The regular establishment of fodder areas on part of the arable land is considered a more stable form of land use than permanent cropping. Attempts at establishing ley farming systems have not met with much success in Tropical Africa, at least not in smallholder situations. A particular type of ley farming has been successfully established in Ivory Coast. On the Sipilou Ranch in northern Ivory Coast forest clearing is followed by rice cultivation. This crop more than pays for the clearing costs. As yields decrease after two or three years fields are sown to stylosanthes and used for grazing by N'damas. In principle these pastures revert to rice production after a number of years. This land use system is still only an isolated example but successful operation for over a decade appears to justify the consideration of its feasibility for other areas (Ruthenberg 1980).

Livestock in plantations: The humid zone is characterized by the importance of tree crops. In areas of low population density these tree crops are grown on large estates or plantations. Attempts have been made over the last decade or so to combine the plantation crops with livestock keeping. This development has been favoured by the growing use of smother plants, usually legumes, in the initial stages of the establishment of plantations. These legumes are to prevent soil erosion, suppress weeds and fix nitrogen. The idea of livestock development in plantations lies in the use of their fodder value. Experience is so far limited. Beside the general problems of cattle raising in this zone (trypanosomiasis; skin diseases of trypanotolerant cattle) practical application is likely to provoke a number of management problems but the idea of using a fodder resource at low opportunity costs remains attractive.

Intensification of smallstock production: Small ruminants, particularly goats are ubiquitous in the humid zone. It is contended that their contribution to farm income could be substantially increased by the adoption of more intensive forms of management and a more rigorous use of their meat production potential (ILCA, de Haan et al 1979, Kross 1981). A major problem is believed to lie in disease which results in high mortality rates and in sub-optimal reproductive performance.

Improved nutrition and disease control, leading to an overall increase in productivity, are to be achieved within four different development approaches:

- Improved fallow grazing,
- pasture grazing,
- intensive rearing and zero grazing,
- intensive finishing.

Preliminary estimates by ILCA indicate that if fertility can be raised by 15 percentage points, mortality reduced by about a quarter and weights increased by one fifth, it might well pay a farmer to make investments (shelter, pasture establishment and other installations) and incur costs for labour, watering, dipping, drenching, pasture maintenance and other items needed for establishing a commercial type of smallstock production. These calculations are based on very high meat prices in Nigeria (Naira 4.40 per kg, equivalent to about $ 6 per kg). It is probably under such conditions only that heavy investment and a transformation approach to smallstock production are justified.

Ranching: The establishment of ranching systems remains a basically suitable development approach for lowly populated areas which prevail in much of the sub-humid and humid zone. Under experimental conditions attractive productivity levels are reached; the principal constraint to a rapid proliferation of this approach lies in the necessity to build up adequate management capacities. The topic is dealt with in more detail in section 8.

7 Crop-livestock Production Systems in the Highlands

7.1 General Characteristics

7.1.1 Definition and Delimitation

Tropical highlands are defined as areas with a mean daily temperature of less than 20° C during the growing period. A second definition sometimes used refers to areas of 1 500 metres or more above sea level; this definition is less accurate since it does not take into account the effect of latitude on the agroclimatic conditions. The farming systems are based on cropping and on livestock husbandry practised in association.

There are a number of features that make the farming systems in the highlands different from those in the lowlands and justify their separate consideration:

- Generally speaking the highlands are favoured by good soils and suitable climatic conditions for farming allowing higher productivity and/or higher population densities than elsewhere. Fodder productivity also permits higher livestock densities than in other zones.

- As a consequence of high and generalized population pressure cropping intensities are high and more or less permanent cropping is common, although fallow farming, ley farming and grazing systems occur.

- Unlike the lowland areas, crop husbandry and livestock husbandry in the highlands are normally practised within the same management unit. The crop-livestock association is therefore approaching more the concept of mixed farming although the degree of livestock integration may be less than the ideal.

- The cropping pattern of highland farms includes crops unsuitable for lowland areas like wheat, barley, teff (in Ethiopia), arabica coffe, pyrethrum, tea and others.

- The area is by and large free of tsetse flies and the farming systems unaffected by trypanosomiasis.

- The area provides ecologically suitable conditions also for farming of the type common in temperate zones and for the introduction of high-yielding plant varieties and animal breeds from the temperate zone.

Originally the highlands probably attracted people for reasons of military security, relative freedom of disease and high potential productivity. The natural conditions as characterized by ample sun, good soils and the absence of temperate extremes are indeed favourable to both crop and livestock production. Actual levels on subsistence farms are, however, not higher than in other ecological zones. This is likely to be the result of the long history of dense human settlement and intensive exploitation.

7.1.2 Types and Geographical Distribution

Table 7.1 shows the highlands in Tropical Africa to be concentrated in eastern Africa. Southern Africa including Madagascar still has a significant proportion of highlands; they are relatively unimportant in western and central Africa, particularly if one excludes the arid highlands which are closer in their land use characteristics to the arid lowlands than to the remaining highlands. Three forths of the total highland areas are found in eastern Africa. The highland areas of Ethiopia, Kenya and Tanzania combined account for over 70 % of the total.

Table 7.1: Extent of Highland Areas[a] in Tropical Africa by Regions

Region	Extent sqkm	Proportion of total highlands %
Eastern[b]	789 820[b]	75.3[b]
Central	62 900	6.0
Western	45 400	4.3
Southern	150 625	14.4
Total	1 048 745	100.0

a) Here defined as areas over 1 500 m above sea level

b) Of which Ethiopia 489 520 sqkm (46.7 %), Kenya 128 300 sqkm (12.2 %) and Tanzania 119 640 sqkm (11.4 %)

Source: Amare Getahun (1978).

Generally the highlands are assumed to have a good agricultural potential. There are nevertheless important areas in which cropping is restrained by the agroclimatic conditions (Table 7.2). Almost two thirds of the highlands have a sufficiently long growing period for most crops. This does not necessarily mean a high agricultural potential since soils, steep slopes etc. may preclude or adversely affect agriculture. A significant proportion of the highlands is affected by aridity and coldness.

Diversity is also found at local level (Brown and Cochème 1969, p. 61):

> "The situation frequently arises that one acre may be suitable for cropping while another 10 km away may not, for ecological reasons not readily understood by the majority of the peasant inhabitants or even by well-educated large-scale farmers."

Table 7.2: Agroclimatic Variation within the Highland Zone

Agricultural potential	Extent 1 000 sqkm	Proportion %
Good[a]	628	63.4
Affected by long dry season[b]	194	19.6
Poor because of aridity[c]	139	14.1
Poor because of coldness[d]	29	2.9
Total	990	100.0

a) Over 180 days of growing period

b) Dry season 180 to 270 days

c) Dry season over 270 days, growing period less than 90 days

d) 24 hr - mean temperature regime over the growing period is less than 10° C

Source: Adapted from FAO (Higgins et al 1978).

The highland zone is much more complex than e. g. the savannas of West Africa or the great Brachystegia woodland belt in southern and central Africa, where relatively uniform tracts of similar type occur over vast areas. One of the consequences is that settlement and land use concentrate on the most suitable parts, creating much higher pressure locally than average figures indicate. With a total agricultural population of 22.8 million the average population density in the highland zone is almost 2.5 times higher than that of the remainder of Tropical Africa (23 persons/sqkm against 19). The highest population densities are found in Rwanda and Burundi where the national averages reach 130 to 150 persons per sqkm.

Land use in the highlands also shows the impact of differential historical and cultural background. Ethiopia, which accounts for 50 percent of the highlands area of Tropical Africa, is different in its agriculture from the remainder of the highlands. Ethiopia is a country of ancient, indigenous agricultural systems although there are influences of long standing contact with indigenous Africa on the one hand and the Arab, European and Asian world on the other. Some of the unique features of Ethiopian agriculture are the indigenous and almost ubiquitous system of ox traction, the use of teff as a cereal and ensete as a root crop and the extensive use of equines for transport. In Kenya European settlement in the highlands has profoundly marked agricultural development in this century. Kenyan agriculture still shows a marked dualistic structure, i. e. a modern sector strongly influenced by Europeans on one side and a traditional sector on the other although the differences are gradually being reduced. In Rwanda and Burundi the "aristocratic" herding societies, the Tutsi, who traditionally had the exclusive right to own cattle while cultivation was practised by the Hutu only, are a distinct feature, as is the predominance of plantain in the farming system.

7.1.3 Livestock Characteristics

The highest livestock density (livestock-land ratio) of all ecological zones is found in the highlands. All the ruminant livestock species are represented. Ethiopia has a particularly high livestock population with a high proportion of sheep and equines. Here the work function of livestock (oxen for draught, equines for transport) is predominant. Otherwise the output function of livestock predominates in the highlands. Meat and milk production from cattle has often reached a significant degree of commercialization. Sheep are used for meat (subsistence and market) and wool for local industries. The population of exotic (European) breeds of cattle and also sheep and goats is relatively speaking the largest of any zone. Particularly in the more modern mixed farming enterprises in parts of Kenya livestock account for a high portion of farm income (Table 7.3).

Table 7.3: Livestock Contribution to Farm Income in Selected Farming Systems in the Kenyan Highlands

Indicator	Molo wheat-sheep	Mau Narok wheat-milk	Kericho maize-cattle	Kericho milk-maize	Kinangop milk-sheep
Gross return					
crops $	16 709	40 240	343	428	695
livestock $	13 129	28 291	220	760	2 354
total $	29 838	68 531	563	1 188	3 049
Livestock %	44.0	41.3	39.0	64.0	77.2

Source: Ruthenberg (1976).

The figures in Table 7.3 relate to highly commercialized undertakings and are not generalizable. However, it is a general characteristic of the highland area that highly developed farms using modern production techniques are found as well as semi-improved farms and traditional systems without improvements. This holds for livestock production as well as for cropping and is partly due to the colonial heritage particularly in Kenya and partly to successful development efforts in more recent times. Development indicators like degree of commercialization, extent of individual tenure of grazing lands, veterinary infrastructure, extension and credit facilities, importance of high-yielding exotic livestock breeds and degree of mechanization vary considerably and cut across the population gradient. Dairy development on a highly commercialized coffee farm in Kenya with full land adjudication means something different from dairy development on traditional subsistence farms in Ethiopia even if ecological conditions and population densities are similar.

Taking the three factors that have been used to characterize livestock management, the feeding regime, the land tenure system and the herding arrangements, the highland areas show some special trends:

- Various levels of intensity of the feeding regime are found in smallholder situations from extensive grazing to stall feeding. High productivity of the fodder economy is not merely a target to which researchers point but a reality on many farms.

- High population pressure has led to much more individualized forms of tenure. In addition formal adjudication of land to smallholders has been carried out over large areas (Kenya) to which must be partly attributed the advances in the fodder economy. The land reform in Ethiopia, although not geared at creating private property has de facto made the farmer master over his land. Communal grazing still exists in large areas of the highlands but it does not have an all pervasive effect on livestock production as is the case in the arid zone and there are possibilities for intensification of fodder production on land over which individual management has control.

- Livestock are hardly ever entrusted to herdsmen and taken away for extended periods of time. Family labour is used for herding and the association of livestock with cropping is much closer.

Essential for the characterization of livestock production and of its development potential is the degree of population pressure. It influences the feed base, the species composition of livestock and the livestock products. It also determines whether a point has been reached where efforts must concentrate on reducing the effects of disaster or whether actual advances in production and productivity are an immediate possibility.

The reaction of the traditional farming system to increasing population pressure is "outward" expansion, taking new land into cultivation as long as it is available. This process is facilitated by animal traction, i. e. in this stage the provision of traction work can be the most important function of livestock. The second stage may be called an "inward" expansion in the sense that no new land is taken into cultivation, but the same land is cultivated more often, fallow periods thereby being reduced. In this stage feed availability for livestock may not really be affected, since all the evidence is that crop residues, by-products and stubble grazing produce at least as much feed as unimproved natural pastures. However, a labour problem may develop since herding and keeping the animals away from the fields during the growing season becomes more time-consuming. In the next step towards intensification higher-yielding crops with a longer vegetation period like bananas and cassava may be adopted. This adaptation may reduce feed availability, but may also be compensated by increasing amounts of crop by-products (e. g. cassava leaves and banana stems). As the cropping index increases further, fertility preserving practices become necessary to maintain yields. This reduces the return on labour. One of the practices is the use of manure, and as long as there are absolute quantities of grazing and feedstuffs available, livestock help to absorb increasing population pressure rather than being in competition with people. The use of manure for fuel is also important because the high population pressure leads to a reduction of forest areas to a point where animal manure is the only source of fuel. The provision of manure may develop into the essential function of livestock within the farming system. It is only in the last stages of increasing pressure on land, when unsuitable land is taken into cultivation, that direct competition arises between livestock and cropping. This stage, however, is a desperate one in terms of its consequences, whether there are livestock or not.

Thus, within a given area increasing pressure of human population does not automatically lead to a reduction of overall feed availability. Problems of labour and seasonality of feed supply may arise but do not become acute if there is plenty of absolute grazing land, i. e. land without alternative use. Absolute grazing is particularly important in the highlands due to the ruggedness of the terrain. The feed base, however, will change in form and composition in systems under population pressure. If it is bush land and potential arable land initially this changes to fallow land, stubbles and other crop residues, and household wastes assume increasing importance.

There is, however, a second indirect effect of increasing population pressure on livestock. This effect stems from increasing parcellization and decreasing farm size. Unless again there is a particularly high proportion of absolute grazing, larger animals become more difficult for a family to maintain, and it becomes increasingly difficult for a small farm to keep a self-sustaining herd of large animals. Thus, in spite of the continued existence of a feed base for the area as a whole, large stock may be squeezed out. At the same time the relative importance of meat from smaller animals increases. Milk also gains in relative attractiveness because labour becomes cheaper and more abundant and because an impoverished population can no longer afford meat. Animal traction, which in the initial stages of taking new land into cultivation is essential, tends to move out of the system as fields become smaller and minimum subsistence levels are reached. This trend has been observed even in Ethiopia, with its long-standing tradition of traction. Manure, on the other hand, remains an important aspect in the context of maintaining fertility, but also as a source of fuel in a situation in which population pressure leads to the disappearance of firewood trees.

For considerations of livestock development it is important to realize the stage of population pressure that has been reached since it determines the role of livestock in the farming system and the development potential. In principle this holds for any farming system and ecological zone. Given the high densities of the human and the livestock populations the considerations are of particular relevance for the highlands.

7.2 Production and Productivity

Production and productivity of livestock in the highlands differ greatly according to farming system, population pressure and development level, but also with respect to the different livestock commodities and functions (farm output, farm input or both). Generalization is therefore hardly possible.

Beef production is not a special feature of the highlands. There are some modern beef production enterprises in Kenya. Some of them are situated in arid areas and therefore compare in their coefficients to those of dryland ranching. Others are feedlots, which are better regarded as landless enterprises. For the rest it may be assumed that beef productivity in the highlands despite the relatively high natural potential is not higher than in the other ecological zones for the following reasons:

(a) The priority that is generally given to milk production, a priority that is justified in the light of the ecological conditions and the population pressure;

(b) the existence of neighbouring arid areas with a comparative advantage for specialization in beef production;

(c) the price ratios of beef to milk, which, notably in Kenya, lead farmers to slaughter the majority of the male offspring after birth;

(d) the importance of draught, notably in Ethiopia, which results in a lower offtake of males for slaughter.

Milk production from cattle must be assumed to be higher in the highlands than in other ecological zones. In Kenya alone the grade dairy cow population may be estimated at about one million head, most of them located in the highlands. The variations in milk yield are considerable depending on the breed management system and the degree of commercialization (Table 7.4).

The correspondence of the farm groupings in Table 7.4 with ecological zones is not accurate. Certainly most of the animals in settlement schemes and most of the grade cows are found in the highlands and their average yield of between 650 and 700 litres is significantly above that of zebu cows many of which are located in lower lying areas. In section 3 milk yields in the highlands were assumed to be 40% higher than in the other zones. For Kenya this is too conservative. On the other hand advances in dairy production have been limited in countries like Ethiopia, Rwanda, Burundi and Tanzania. Average figures across the total highland zone would conceal more than they would reveal.

Similar considerations pertain to sheep and goats. There is no indication that average productivity in traditional farming systems is much different from that in lowland zones. Very productive sheep enterprises are, however, also found in the highlands with exotic breeds and high levels of management. The little wool that is produced in Tropical Africa comes mainly from highland farms.

The functions of livestock as farm inputs (draught, manure and transport) are more important in highland mixed farming than in other zones. There is the traditional wide-spread use of draught oxen in Ethiopia. They are estimated to contribute more than 26% of the total labour requirements of crop agriculture in that country (FAO, AT 2000 1979). Their productivity in draught can be assumed to be lower than in other parts of Africa because of the traditional equipment used. The collection of animal manure is

Table 7.4: Milk Production and Productivity by Management System and Cattle Breed in Kenya 1974

Indicator	Large-scale farms	Smallholdings Settlement schemes[a]	Grade cows	Zebu cows	Overall
Number of farms keeping cows	1 800	49 221	250 000	712 500	1 013 521
Number of cows	175 100	120 000	547 000	1 933 000	2 775 100
Percentage of cows in milk	63	67	68	69	66
Annual milk production ('000 kg)	183 580	83 220	353 400	403 380	1 023 580
Average annual milk yield per cow (kg)	954	693	646	209	626
Percentage of milk production retained on farm	2	32	52	91	59

a) On the settlement schemes 80 % of the cows are grade breeds and crosses

b) Includes pure exotic breeds and crosses

Source: Stotz (1979).

widespread but its effect on agricultural productivity is low, because its main use is for fuel. The transport function of livestock is extremely important in Ethiopia because of inaccessibility of the terrain for alternative means of transport. There is no information on their particular productivity in this function. A donkey is likely to perform up to half a tonne-kilometre several times a week.

Table 7.5: Dry Matter Production (t/ha/year) in the Process of Land Use Intensification (an Estimate of the Orders of Magnitude under the Conditions of Kakamega, Kenya, Rainfall 1926 mm, Altitude 1553 m)

Farming system	Total above-ground DM	DM in fallow and weeds	Above-ground DM of crops	Edible DM
Natural forest	40	40.0	0	0
Shifting systems[a)]	30	27.9	2.1	0.30
Fallow systems[b)]	20	15.7	4.3	0.64
Permanent arable farming				
One maize crop inter-planted with beans, traditional technique[c)]	12	5.1	6.9	1.04
One maize crop not inter-planted, modern technique[d)]	15	4.3	10.7	3.20
Two maize crops, not inter-planted, modern technique[e)]	25	3.7	21.3	6.40
Permanent crop[f)]				
Sugar cane	40		40.0	7.70

Assumptions:

a) A total of 8 fallow and 2 crop years in a 10-year rotation cycle with 1.5 t maize and 0.5 t beans per ha per crop year. Fifteen % of the above-ground DM in crops is edible (80 % of the harvested grains). The estimates for DM in fallows and weeds and in crop DM are averages over the 10-year rotation cycle

b) A total of 5 fallow and 5 crop years in a 10-year rotation cycle with 1.3 t maize and 0.3 t beans per ha per crop year. Fifteen % of the above-ground DM in crops is edible (80 % of the harvested grains). The estimates for DM in fallows and weeds and in crop DM are averages over the 10-year rotation cycle

c) A total of 1 t of maize and 0.3 t of beans per ha and year. Fifteen % of the above-ground DM in crops is edible (80 % of the harvested grains).

d) A total of 4 t of maize per ha and year. Thirty % of the total above-ground DM is edible (80 % of the harvested grains).

e) Two crops of 4 t of maize per ha and year. Thirty % of the total above-ground DM is edible (80 % of the harvested grains).

f) 70 t cane per ha and year. Eleven % sugar. The above-ground DM in the crop includes trash and stems.

Source: Ruthenberg (1980).

Potential production and productivity in the highlands could be much higher than at present because a large number of yield increasing technologies are applicable here. Crop yields can be raised manifold from the depressed level of a traditional farming system under population pressure and, particularly important for long-term ecological stability and for the livestock subsystem, total dry matter production increases accordingly (Table 7.5).

Table 7.5 suggests the possibility for a seven-fold increase of edible dry matter production from a low-level equilibrium state of permanent cropping with traditional technology, and a substantial increase in total dry matter production. Considering that the portion not suited for human consumption is entirely available for livestock (in contradistinction to natural vegetation) the increase in the carrying capacity for livestock is even greater. In addition the highlands are suited to a direct transfer of agricultural practices and innovations from the temperate zones (Brown and Cochéme 1969, p. 251):

> "Because of its geographical position and height the area enjoys mild temperatures throughout the year, thus lending itself to the raising of crops and stock normally found in the temperate conditions of higher latitude, whenever specific length of day or cold period requirements unobtainable in the area are not required. No low winter temperatures intervene to prevent and arrest crop growth and the upper high limit of the area is where night frosts begin to limit crop production."

To determine potential agricultural production and productivity in the highlands it is not unreasonable to draw on indicators from advanced agriculture in the temperate zones. Such a transformation on a large scale could only take place over a long period because a large part of the agricultural population would have to be absorbed by other sectors of the economy. But as opposed to other zones without intensification possibilities (arid) or with great uncertainties about the appropriate development path and the productivity levels actually achievable in practical farming (the more humid lowland zones) the tropical highlands have a realistic considerable potential.

7.3 Development Possibilities

7.3.1 Dairying - the Example of Kenya*

There are not many striking examples of successful livestock development in Tropical Africa. Dairy development in Kenya is one and it therefore appears justified to focus on this example when discussing dairying as a livestock development possibility. The aim is to make the experience transparent and usable for other situations but also to identify factors that are unique to this develop ment and cannot be transferred.

Dairy development 1920-1975: European farmers introduced grade dairy cows and bulls from Europe in the 1920s. While their higher yielding ability could be demonstrated, the problem of tick-borne disease, particularly East Coast Fever, proved formidable. A major breakthrough came only in the 1940s with the introduction of acaricides. Regular dipping with acaricides was effective against ticks and made it possible to keep imported grade cows from Europe healthy in Kenyan surroundings. It also became profitable to upgrade the local zebus by crossbreeding them with exotic stock, especially given the low cost of labour and grazing in the Kenyan highlands.

Largescale dairy production, mainly aimed at the urban market and at exports, reached its peak shortly before independence, when about 600 000 grade dairy cattle were kept on large farms, practically all owned by Europeans.

The availability of grade cows on the one hand and relatively high prices in the densely populated rural areas on the other led

* This section draws heavily on Stotz (1979), and Stotz and Ruthenberg (1978) reviewing original sources the major ones of which are Burke (1973), Chudleigh (1974a,b), Cowen (1974), Goldson (1977), Heyer (1966), Heyer et al (1976), Hopcraft (1976), Kenya Integrated Rural Survey (1977), Kenya Statistical Abstracts (various years), Kenya Stud (Annual Reports), Klemm (1967), Lindstrom and Lindstrom (1973), Mac Arthur (1964 and 1974), Mahadevan (1965), Meyn and Wilkins (1973), Muritni (1976), Owiro (1973), Peberdy (1975), Ruthenberg (1966), Swynnerton (1954), and various government publications and unpublished papers.

African farmers to try dairy farming with grade cattle in the 1930s and 1940s. The capital requirements as well as the disease problems effectively kept this development in check. The Veterinary Department regarded grade cattle enterprises on smallholdings as too risky. It favoured the introduction of Sahiwals, which were however also susceptible to disease, lower-yielding and therefore not liked by the smallholder.

The starting point of smallholder dairy development in Kenya may be considered the implementation of the Swynnerton Plan in 1954, a comprehensive plan drawn up to accelerate agricultural development in the African smallholder sector. It laid the basis for smallholder dairy development through a number of policy reforms:

(a) Consolidation and adjudication of land holdings under individual ownership (which allowed fencing, effective tick control, fodder production and the utilization of crop residues).

(b) Encouragement of cash crop production, which played a considerable role in the financing of dairy cows.

(c) Making credit available.

(d) Establishment of a service structure for smallholder dairying (communal dips, veterinary supervision, feeder roads, milk collection centres, artificial insemination centres).

In spite of initial problems of disease, inadequate feeding and long calving intervals, the interest of the smallholders never subsided. The number of grade cattle kept by smallholders increased from about 80 000 in 1960 to an estimated 550 000 in 1975.

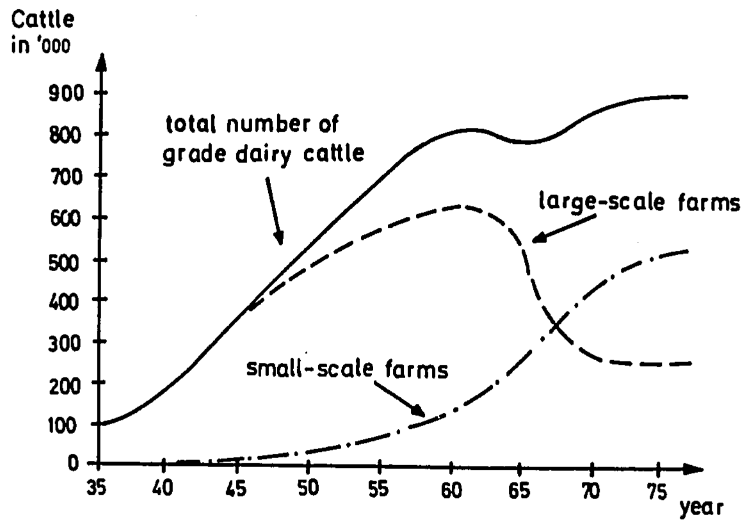
A second major development began with the settlement schemes. In 1965 500 000 ha formerly large European-owned farms were distributed to 35 000 settlers under the "million acre" settlement scheme, and by 1975 the land allocated to smallholders under various settlement schemes had doubled. In that year it was estimated that some 160 000 grade cows were being kept by smallholders* on settlements farms. Complementary services (credit, extension, artificial insemination) were available to facilitate dairy production. After an initial decline smallholder dairy production recovered. Figure 7.1 shows the development of the dairy herd and the growing share of smallholders.

Kenya is the only net-exporter of dairy products in Tropical Africa and has maintained this position in spite of a rapidly growing human population, of greatly increased home consumption on smallholdings and of trade problems subsequent to the break-up of the East African community.

Colonial relict or development policy? During the colonial period the development of the dairy industry was undertaken largely at the initiative of the European farmers who created a structure of services through the government and through their own independent efforts. They established the Kenya Cooperative Creameries (KCC) as the sole official buyer and processor of dairy products, and they successfully lobbied the government to undertake substantial investments in veterinary services and livestock and fodder research. Thus the initial research, the infrastructure, the demonstration effect and the availability of large numbers of improved dairy animals, are all aspects specific to the Kenyan situation. One is led to conclude that the dualistic structure of agriculture in this case served a general development purpose in that the modern sector laid the basis for the development of the traditional smallholder sector. The original initiative in African smallholder dairy development lay with individual farmers who bought grade dairy cows on their own, often in opposition to government policy. However, given all the problems mentioned earlier, smallholder dairy production could not have expanded as rapidly as it did without substantial government support. Apart from the structural specificity of the Kenyan environment, concrete government policies were essential to promote smallholder dairying. These policies included the control of tick-borne diseases, the establishment of extension and credit programmes, the marketing infrastructure and a price policy favouring dairy development.

* In the low-density schemes medium-sized farms (5-20) were established, most of which went into commercial dairy production. The high-density schemes had as their primary objective the provision of subsistence to landless families. Holdings of 2-8 ha were allocated primarily for crop production but also for small-scale dairying operations.

Figure 7.1.
Grade Dairy Cattle Development on Large and Small Farms in Kenya 1935-1975



Source: Stotz (1979).

The role of tick control: Experience in Kenya indicates that control of tick-borne diseases cannot be achieved by individual small farmers, that without control dairy development based on grade-cows is not feasible, and that successful control can only be achieved through compulsory dipping of all cattle in an area supervised at regular intervals by government officers.

Dipping has to be compulsory because the owners of disease-resistant zebus have no incentive to dip their animals; in fact their risk may increase by building up a tick-free susceptible stock which can no longer be exchanged into other zebu areas where there is no tick control. Control of ticks requires government-controlled compulsory dipping with an effective organization, the control of cattle movements and the designation of disease-free ares.

The role of extension: Extension started to become an important element in dairy development in 1967 when the Department of Agriculture took over responsibility for animal production from the Veterinary Department. Extension workers were involved in the administration of credit for the purchase of grade cows and related investments; they organized field days and demonstrations thus contributing to the general interest in dairying. But at the same time it seems that organized extension had little to do with dairy development on the smaller farms, and that some of the significant development in terms of, for example, fodder production took place without the support of extension. Similarly artificial insemination as an element related to extension does not appear to have played an important role initially although it gained momentum from 1968 on.

The role of credit: About 110 000 grade cattle were purchased on credit in Kenya over 20 years, which constitutes a considerable proportion of the total smallholder herd of 550 000 in 1975 taking into account their offspring. One heifer on average cost slightly over $ 400 in 1977 (equivalent to about 2 000 kg of milk at a price of 13 US cents per litre). If in addition it is assumed that some $ 125 are required for facilities such as fencing, water supplies, crush and milking shed, it is clear that capital requirements for dairy development are considerable and that the various smallholder credit schemes instituted in Kenya were essential. For the 1970s it is estimated that some 70% of all smallholder credit was used for dairy development. The major problem with these credit programmes was the high risk element a grade cow constitutes for a small farmer. Beside the institutional credit mobilization of household surpluses took place for the self-financing of dairy development. In this connection cash crop development as a major component of the Swynnerton plan and of later efforts provided an indirect but essential boost to dairy development as well.

The role of marketing infrastructure: Establishing a marketing infrastructure is an essential element of a dairy development policy. The milk processing and marketing system available through KCC, the establishment of more and more rural collection centres, the building of feeder roads (also in connection with tea development) and the existence of attractive local markets in the rural areas all constituted important contributions to dairy development. Small farmers market their milk mainly through cooperative societies, of which about 300 existed in 1975. A typical cooperative has 250 members, collects 1 000 kg of milk per day from five collection points and transports the milk over a distance of 100 km.

The role of prices: Price policy is to be seen in close connection with the marketing infrastructure. The abolition of the quota system related to dry season/wet season deliveries and the establishment of a uniform price system, while initially creating technical and financial problems for KCC, has contributed considerably to the promotion of smallholder dairying. Table 7.6 shows how the terms of trade for milk have improved over the period 1940 to 1977.

In addition to the official price policy the dairy producer was able to benefit from high effective demand for milk in the rural areas, again a result of the successful efforts at cash crop development.

Table 7.6: Prices and Price Indices for Grade Dairy Heifers, Maize, and Milk 1940-1977

Index/price	1940	1950	1960	1970	1977	1977
			Indices (1940=100)			Price \$[a]
Grade dairy heifer price	100	111	139	167	347	312.50 per animal
Producer price for maize	100	90	86	67	212	11.13 per 100 kg
Producer price for milk	100	125	235	265	535	0.13 per kg

a) Converted at a rate of 8 Kenya shillings = 1 \$

Source: Stotz (1979) after Kenya (Ministry of Finance and Planning), Statistical Abstracts, various years, and other sources.

The role of research: Research apparently did not play an important role in smallholder dairy development. The reason is that the smallholders were able to benefit from decades of innovation and trial and error carried out by large European farmers during the colonial period. This is not to say that research could not have contributed, but the essential stages were reached without a noticeable, direct research impact.

Dairy and agricultural intensification: The more recent years show that smallholder dairy development is not limited to the initial establishment of grade cows on small farms. Dairying also plays a key role in progressive intensification of smallholder agriculture. Intensification means that more capital and more work is applied per unit of land, and that consequently the output per unit of land rises. With respect to dairying this tendency implies the following stages: introduction of improved breeds; improvement of fallow grazing; introduction of fodder crops with continued pasture grazing, and, finally, fodder cropping with permanent stable feeding. Table 7.7 shows the changes in farm management parameters in the course of such intensification.

Table 7.7: Changes in Farm Management Parameters in the Course of Intensification

Parameter	Stage of intensification		
	grazing	grazing/ stabling	stabling
Land per cow (ha)	0.53	0.25	0.15
Milk production per cow (kg p.a.)	1 918	2 722	2 518
Investment per cow ($)	65	162	185
Concentrate use per cow (kg p.a.)	174	338	935
Labour input (hours/cow p.a.)	304	416	487
Milk production per unit land (kg p.a./ha)	3 700	12 082	20 728
Return to labour ($/hour)	0.49	0.50	0.46

Source: Stotz (1979).

During intensification milk production increases. This is principally a result of increased production per unit of land, rather than better performance from the animal. At the same time return on labour hardly changes, or at least does not increase. Table 7.8 shows that farm income from dairying does not increase but decreases in the course of overall intensification. The total farm income per unit of land, however, increases steadily. The explanation is that the cows can be kept on a smaller area, and land becomes free for other lucrative uses such as valuable cash crops. The land productivity of cropping and of dairying increases. In addition the figures give an indication of how intensive forms of dairying gain in relative attractiveness as land becomes scarcer.

Table 7.8: Income from Dairying and Total Income in the Course of Intensification

Indicator	Stage of intensification		
	grazing	grazing/ stabling	stabling
Return to land from dairying $/ha	201	675	811
Return to land from all farm activities $/ha	265	403	417
Farm income from dairying $/ha	1 078	988	853

Source: Stotz (1979).

In relation to the farming system as a whole, dairying is a much appreciated source of manure, particularly for valuable perennial crops such as coffee, and constitutes a farm-integrative factor in several respects. Thus fodder growing plays an important role in land use and crop rotation, and residual capacities of land and labour are productively used to increase the overall value added. The effect of balancing the risk of plant production and the regularity of the cash income from dairying are also important.

Relevance of the Kenyan experience: The Kenyan experience has specificities from its colonial past that are not transferable to other situations. At the same time a development policy was established for smallholder dairying whose components can be usefully examined for applicability elsewhere. Furthermore some of the colonial specificities can be reduced to concrete elements like applied research, innovation testing, establishment of an infrastructure and a favourable price policy whose essentials can be implemented without recourse to a colonial past. The Kenyan experience also brings out the interdependence between dairy development and general agricultural development. Cash cropping provides financial resources for investment in dairying, results in high effective demand for dairy products also in rural areas and increases the value of the dairying sub-system in the course of overall intensification. Again the relevance for dairy development elsewhere is obvious.

One aspect of dairy development has not been dealt with because it has never been an issue in Kenya: The organizational form of production. The private enterprise and particularly the small African farm have never been doubted as the appropriate vehicles for dairy development. Dairy production in the form of large c-operative and parastatal enterprises is being attempted notably in the Ethiopian and Tanzanian highlands. The general management problems described in section 8 for ranching hold in an unmitigated form also for large-scale dairying. But dairying is in addition a very intensive form of production as concerns supervision for disease control and breeding and regularity of work outside the normal hours. And for dairying to be economically attractive integration with the farming system as a whole is essential. These aspects make it doubtful whether dairy development based on cooperatives or parastatals can achieve similar results.

7.3.2 Livestock in the Development of Subsistence Farms

Dairy development in Kenya has taken place in the context of overall agricultural development. The introduction of cash crops into smallholder areas was one of the factors that rendered dairying possible and attractive. Subsistence is still the core of most of the farms, but the farms are large and productive enough to secure this subsistence. The subsistence constraint influences development considerations only to a limited degree. In many other parts of the highlands subsistence is the overriding concern. With high population densities, small farm sizes, low productivity levels and with production almost exclusively oriented toward subsistence any development effort must give first consideration to continued and improved security of subsistence. Even in these circumstances development can take place via livestock in particular via dairying. A smallholder situation in Ada District just south of Addis Abeba in Ethiopia is taken as an example*.

The subsistence constraint: With existing production techniques and without any particular traditional or modern practices aimed at intensification, cereal grain yields can be expected to be in the order of 800 kg per ha. A rotation with pulses is normally considered necessary; their yields are some 20% to 30% lower, but the nutritional value is higher, so that for the purposes of subsistence calculations the consideration of all crops can be reduced to that of a cereal, say wheat, as a typical highland grain. The gross subsistence requirement** of the average person can be provisionally put at a relatively high 300 kg of cereal per year. The minimum amount of cropped land per family of five would thus be 1.9 ha. This would, if 100% of the land is cropped, be equivalent to a population density of 263 persons per sqkm. Even the most favourable areas contain some land unsuitable for agricultural use, particularly for permanent cropping. For Ada District it has been estimated that 30% of the total area is unsuitable for cultivation (Haywood 1979) and that 10% of the arable area is under fallow. If 60% of the area is under cultivation year after year, the human supporting capacity for people is 160 persons per sqkm. The figures may be set lower because of the variation in yields and the need of a subsistence economy to provide for the minimum rather

* The following account is largely based on various informal documentation of the ILCA project at Debre Zeit, Ethiopia. The land tenure reform initiated in 1975 did away with the traditional tenancy arrangements. It aims to establish cooperative forms of production but at present the farmers can for all practical intents and purposes be considered individual smallholders.

** Gross because the figure is to account for losses. Seed requirements are not included.

than the average, but then carry-over storage does take place. The trend in soil fertility and population growth become more limiting factors with time. Average population growth rates of 2.5% are usually assumed. This provides for a doubling of the population every 28 years. If the planning horizon is 15 years an increase of the population by almost 50% has to be taken into account. Thus present population densities of 65 to 80 persons/km^2 indicate a stringent subsistence constraint for the near future.*

A tight subsistence constraint, either now or in the near future, implies that the production of subsistence crops cannot be reduced and that any reduction in the area for subsistence crops must be accompanied by a proportionate increase in yields. In addition it must be realized that all natural grazing is heavily used by the existing livestock herd to the extent that they are effectively on a starvation diet (ILCA 1977).

From surveys as well as from the farmers included in the ILCA research station at Debre Zeit it is possible to depict a "typical subsistence farm" for the district. The farm household consists of five persons that translates into 2.25 man-equivalents**. The holding consists of 2.6 ha in five parcels, of which 2.4 ha are cultivated. The household owns two oxen, a cow, a calf and one immature animal, a small flock of sheep and goats (three head), a donkey and some poultry. The livestock is worth about $235 at current prices. Other farm capital, including the farmhouse, may be valued at $ 35. Forty percent of the land, or about 1 ha, is put to teff. The remaining cultivated land (1.4 ha) is used for other cereals (0.75 ha) and beans and peas (0.65 ha). Purchased inputs are negligible so that the gross value of crop production is a good first approximation of the farm income valued at market prices. Its composition is shown in Table 7.9.

* The Stanford Research Institute estimated the total 1966 population at 100 000 from records of the Ada Community Development Centre. The population of Debre Zeit was then about 22 000 giving a rural population of 78 000. A compound growth rate of 2.5% has been used to arrive at the 1978 rural population of 105 000. The area of Ada District is 1 750 sqkm.

** 1 adult male is 1 man equivalent (ME), one adult female 0.75 ME, one child between 10 and 15 0.5 ME; two children below ten are not counted.

Table 7.9: Gross Value of Production and its Composition for a Typical Subsistence Farm in Ada District

Product	Area ha	Yield kg/ha	Production kg	Price[a] cents/ kg	Gross return[a] $	Gross return[a] $/ha
Teff	1.00	700	700	45	312	312
Local wheat	0.35	650	228	25	56	160
Barley	0.20	700	142	21	29	145
Maize	0.20	620	124	20	24	120
Horse bean	0.15	790	119	16	19	124
Lentils	0.15	480	72	23	17	110
Chick peas	0.35	620	217	21	46	130
Livestock	-	-	-	-	18	-
Total	2.4	-	1 602	-	521	209[b]

a) On the basis of Ethiopian Birr converted to $ at the rate of 2:1

b) Crops only

Source: Compiled by the author from ILCA (1978, p. 12) and other sources.

Teff, wheat and chick peas are the major crops grown. Horse beans, field peas and lentils may replace chick peas on the poorer quality soils of sloping areas, but wherever possible chick peas are used in rotation with teff and wheat. Livestock are used for traction, as a form of capital investment and saving, and to provide meat and milk for home consumption as well as cash income. Equines are used for transport. Animal dung is used for fuel. In terms of gross return per unit area the cereals, particularly teff, are superior. An expansion of the proportion of land under teff is, however, hardly possible because of rotational as well as subsistence requirements.

The gross return estimates include subsistence valued at market price. The subsistence requirements of the farm family of five are estimated at 1 500 kg cereal equivalent, and if the seed requirements* are deducted it can be seen that the gross production of some 1 600 kg of grains and pulses only barely meets these requirements.

Livestock and farm development: Table 7.10 shows for the "typical subsistence farm" of Ada District an intensification path for cropping concomitant with a reduction of the area under subsistence crops and the establishment of forage cropping, with their consequences for human subsistence and animal feed production. The key to change and intensification is the application of fertilizer to cereals, increasing their yields by 50%. The area under cereals can then be reduced by some 40%, from 1.75 ha to 1.05 ha, while the production level is maintained. Through additional forage production the total feed production increases form 9.4 tonnes of dry matter by 40% to 13.1 tonnes. This change in the farming system has the following implications:

- The proportion of land under cereals decreases, which is assumed to have a positive rotational effect;

- the regulated ley system which is thereby established also serves to maintain and increase soil fertility;

- the increased forage production allows improved feeding of the livestock; in fact it allows the feeding (for maintenance and low production) of an improved dairy cow;

- dairying provides the cash to pay back the loans that are initially required to intensify and to purchase a dairy cow.

The proposed changes in the farming system thus allow a break out of the subsistence cycle into semi-commercial agriculture, while at the same time improving soil fertility and initiating the improvement of the whole livestock subs-system. Over time all indigenous cattle can be replaced by the offspring from the improved dairy cow.

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* Seeding rates vary widely from less than 100 kg to more than 200 kg per ha for most cereals and pulses.

The changes indicated above lead to a host of indirect further changes and a considerable impact on the whole farming system. Not only is fodder made available for intensive livestock production and soil fertility improved by better rotation, but there are also manure and traction effects. The dairy cow is kept in a stabling system. This allows more efficient manure collection, bringing the manure output beyond the farm's immediate needs in terms of fuel. A family needs about 15 cakes of dung per day for heating and cooking (ILCA 1980 a). One cake weighs about 500 g, so that the annual requirement is 2,740 kg of dry dung, which can be produced by one dairy cow. Manure from the remaining livestock could therefore be used as fertilizer for the crop fields.

Another effect comes into the system through animal draught. Through the use of either the dairy cow itself or its offspring, more traction force can be applied, resulting in reduced time requirements for land preparation and probably also higher standards, leading to reduced weed problems and higher yields. It should also become possible to use the animals more efficiently, increasing the effective traction obtained from the total herd which has to be maintained for reproduction and replacement.

The net total effect of the innovations on the farming systems is hard to predict. Indications are, however, that in the early stages, without all the secondary and tertiary effects having become evident, the farm income increases by 30 to 50% (ILCA 1980a). This increase does not take into account the attractiveness of regular cash income to the farmer, the advantage of balancing the risk of plant production with animal production and the positive effects on soil fertility in the longer term.

7.3.3 Sheep Development

As population pressure increases further and farm size decreases the role of cattle is reduced. In the area with the highest population density it becomes impossible to maintain sufficient oxen for draught cultivation. Livestock are still kept but small ruminants, particularly sheep that constitute less of a competition for arable land predominate. The feed base consists of stubble, straw, fallow and wasteland grazing. It is more a starvation diet than anything else that is provided but then it would be surprising if livestock fared better than people. Such a situation is found over many parts of Ethiopia (Cossins and Bekele Yemerou 1974, LMB 1973). In the long run agricultural development in these areas will need

Table 7.10: Analysis of Subsistence and Feed Production Capacity of Typical Ada District Farm Following Traditional and New Cropping Pattern

	Area		Food grain		Straw[a]		Stubbles/fallow[a]		Forage crop[a]		Natural grazing[a]		Total feed[a]
	ha	%	kg/ha	kg	kg/ha	kg	kg/ha	kg	kg/ha	kg	kg/ha	kg	kg
Traditional pattern													
Teff	1.00	38	700	700	1 500	1 500	500	500	-	-	-	-	2 000
Other cereals	0.75	29	650	488	1 500	1 125	500	375	-	-	-	-	1 500
Pulses	0.65	25	600	390	-	-	500	325	-	-	-	-	325
Fallow[b]	0.20	8	-	-	-	-	2 000	400	-	-	-	-	400
Subtotal	2.60	100	-	1 578	-	2 625	-	1 600	-	-	-	-	4 225
Communal grazing[c]	2.60	n. ap.	-	-	-	-	-	-	-	-	2 000	5 200	5 200
Total	5.20	n. ap.	-	1 578	-	2 625	-	1 600	-	-	-	5 200	9 425
New pattern													
Teff	0.70	27	1 050[d]	735	2 250[f]	1 575	500	350	-	-	-	-	1 925
Other cereals	0.45	17	975[d]	439	2 250[f]	1 013	500	225	-	-	-	-	1 238
Pulses	0.65	25	600[d]	390	-	-	500	325	-	-	-	-	325
Forage crop	0.80	31	-	-	-	-	500[g]	400	5 000	4 000	-	-	4 400
Fallow	-[e]	0	-	-	-	-	-	-	-	-	-	-	-
Subtotal	2.60	100	-	1 564	-	2 588	-	1 300	-	4 000	-	-	7 888
Communal grazing[c]	2.60	n. ap.	-	-	-	-	-	-	-	-	2 000	5 200	5 200
Total	5.20	n. ap.	-	1 564	-	2 588	-	1 300	-	4 000	-	5 200	13 088

a) Feed yields and production in dry matter

b) In accordance with survey results indicating that 90 % of the farm land is cropped; the percentage figure relates to arable land

c) In accordance with survey results indicating that only 1/3 of the total land area is owned and/or cropped (farm land) and assuming that 1/2 of the balance is available for grazing

d) 50 % increase in cereal yields due to fertilizer application, and unchanged pulse yields

e) Simultaneous transition from unregulated to regulated ley farming and the use of the use of the fallow area for forage crops

f) Increase of straw yields of cereals proportional to the increase in grain yield

g) Annual forage crop varieties

Source: Own compilations on the basis of ILCA reports and other sources.

to be accompanied by an outmigration of the population. In the shorter term the cropping or subsistence base of the farming systems would need to be reinforced. Purchase of improved seeds and of fertilizers requires cash and it is attractive to think that also in these cases cash could be provided by developing the livestock enterprise i. e. the sheep.

Development of wool production: Any attempt to improve and increase wool production will have to be guided by the following considerations:

(a) The wool, even of the wooliest of the hairy sheep, is unsuitable for mechanical spinning and therefore unsuitable as the raw material for large-scale industrial processing. Thus not only is clothes production excluded, but also the industrial production of blankets, carpets and the like.

(b) ' nprovement of the wool quality through crossbreeding is possible in principle, but seems to be a very difficult process in practice. Attempts in the past to distribute improved rams have not met with much success. It can be doubted whether the crossbred animals will stand up well to the harsh prevailing conditions.

(c) Improvement of the wool quality through crossbreeding would make the wool less suitable for the cottage carpet industry (the carpets wear less well), and would be accompanied by a decrease in the value of the skin. The thick skins of the highland hair sheep sell at good prices on the international market. In fact the finer skins from crossbred animals are currently not accepted by exporters in Ethiopia*.

(d) Substitute fibres for carpet wool can be imported at a price of $ 0.70 c.i.f. Assab. Local wool, once cleaned and made comparable to these imported fibres, has a cost price of $ 1.00.

(e) Blankets made from such low quality local wool do not find a ready market and have to be sold at a discount from the going price.

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* This line of argument is challenged by some. Thus it is claimed that the problem is merely one of homogeneity, and once enough skins of the finest quality are produced they would be processed and marketed just as well.

The above considerations do not exclude the possibility of sheep development via wool, but they do suggest that the imports of reject and refuse wool to the tune of 150 t per month into Ethiopia* cannot be readily replaced by local production, and that a cross-breeding programme may be counterproductive. The low quality wool presently produced is used in the cottage wool industry. Expansion and improvements are possible but overall the development potential for sheep via wool production appears limited.

Development of meat production: Both the internal and the external (Arab Peninsula) markets seem to be able to absorb more meat at present prices. In 1974 the up-country prices were about $ 0.25/kg LW, while Addis Abeba prices were almost twice as high. The average liveweight was around 20 kg, reflecting a high proportion of young animals. The Arab market pays a premium price. However, the acutest demand is for heavier sheep of over 35 kg liveweight.

It would seem advisable to direct development efforts for highland sheep at the local meat market. The highland areas, with their high population densities and large urban centres, would seem more suited for supplying the local market. In the dry lowlands, on the other hand, marketing poses bigger organizational problems and benefits the bulk buyer relatively more, since the Arab peninsula is closer. This should not prevent private traders from buying up animals in the highlands for an export market if and when a profit margin were to become possible.

A possible way of increasing revenues from sheep would be to fatten the young sheep before sale. Since land scarcity does not allow this in the highlands, the establishment of fattening enterprises in the lowlands might be considered. But Cossins and Bekele Yemerou, and the Livestock and Meat Board state that the best and only approach to sheep development for meat is to try and reduce mortality through veterinary measures, and at the same time to improve the marketing infrastructure to maintain and increase offtake.

* 150 t per month or 1 800 t per year correspond with the theoretical annual production of 8.6 million adult sheep at present production levels and cleaning-out ratios.

7.3.4 Other Development Paths

There is a place for livestock development even under conditions of high and increasing population pressure. Labour-intensive production lines such as dairying, the integration of animals to provide traction and manure and to increase income and economic security all have their attractions for the larger animals. Given the importance of smaller animals in densely populated areas and the predominance of sheep in the highlands development paths based on sheep would be attractive but evidence has been shown to be ambiguous as to the possibilities. There might be a place for even smaller animals like rabbits in the farming systems, though currently this is hindered by a widespread antipathy against rabbit meat, particularly in Ethiopia.

If one abstracts from the high population pressure the highlands would be suited for extensive ley farming systems. Sheep ley farms still exist as remnants of the colonial era in Kenya. They are characterized by a high proportion of ley and often by the keeping of sheep for wool. The size of the enterprises and the fact that wheat constitutes the main source of cash income allow the fluctuations in wool price to be borne; high quality mutton and lamb constitute an important second line of production. The Molo farms, the Settlement Trust farms and the sheep farms in the Kinangop area still reflect this traditional production pattern (Ruthenberg 1980). With redistribution of land and increasing population pressure ley farming is decreasing in importance. Neither in terms of activity budgets nor in terms of gross margins is sheep production competitive with cropping or dairying and is therefore pushed back on to the marginal, non-arable lands. The smaller enterprises are also not in a position to absorb large fluctuations in the wool price, and although the breeds kept are still the wool types, mutton and lamb production gains in relative importance.

By and large there is no place for extensive production systems in the highlands. Livestock can play an important role in the development of small intensive holdings and the concept of mixed farming is closer to reality in the highlands than in any other ecological zone. The large production increases that are necessary to sustain the high human population which in many parts of the highlands grows at above average rates (e. g. Kenya) will have to come from advances in cropping. Livestock development in the highlands means the optimization of the contribution of livestock to the process of agricultural intensification which is based primarily on cropping.

8 Ranching

8.1 General Characteristics

8.1.1 Definition and Delimitation

Ranching systems are range-livestock production systems like pastoral systems, but production parameters, livestock functions and livestock management are radically different. Ranching is a labour-extensive undertaking specializing in the production from one or two livestock species of a marketable commodity, mainly live animals for slaughter, i. e. for meat, skins and hides, but also wool and milk. The function of livestock is therefore to provide cash income. Livestock management is characterized by grazing within fixed boundaries by individual tenure and by intensification possibilities for feeding and watering. This does not mean that ranches always constitute private property. The form of ownership may be parastatal, cooperative or private (companies or individuals) and instead of straight-forward ownership there may be lease arrangements and the like. The tenurial characteristic is that responsibility for the livestock and for the land is in the same hands. Individual tenure means tenure by the individual ranch management as opposed to communal tenure in a pastoral system where many management units share tenure of the land*.

8.1.2 Types and Geographical Distribution

A first differentiation of ranching systems can be effected with respect to:

- Livestock species and product; cattle ranching for meat is the most common type but sheep ranching for skins (Karakul), wool and meat also exist as well as cattle ranching for milk i. e. dairy ranching; the use of other species and the supply of other products from ranching is rare in Tropical Africa;

- intensity and development level; extensive ranches work with a minimum of fixed investments and with extensive management practices; intensive ranches have considerable investments and improvements and an intensive and intricate system of managing the

* By this definition the group ranches of Kenya - correctly in the author's opinion - are classified as a pastoral rather than a ranching system.

grazing resource and the livestock;

- stratification stage; ranches may specialize further in breeding and weaner production or in store cattle production or in fattening, thereby entering a division of labour among ranches and with other production systems.

Ranching systems in Tropical Africa are found throughout the continent in all ecological zones. A further distinction can therefore be made according to the natural environment. Ranching in the arid and semi-arid zone is of importance in eastern and southern Africa (Kenya, Tanzania, Zambia, Zimbabwe, Botswana, Namibia and Angola). Only sporadic examples are found in the drier parts of West and Central Africa (IEMVT/SEDES, 1968). Humid zone ranching on the other hand is of greater significance in West and Central Africa but the systems have to be considered as individual undertakings rather than predominant forms of land use. An exception is Zaire and, to a lesser extent, Angola where ranching in some parts can be considered as the major land use system. Ranches are also found in highland areas. Where they are in arid parts of the highlands they are better considered as arid zone ranching because then elevation does not result in any essential difference of the ranching systems. In Kenya there are also ranches in the humid highlands that date from colonial times but numbers are small. The more humid the natural environment the greater the degree to which it is affected by tsetse flies. In addition to rainfall tsetse infestation and the measures taken to cope with it characterize the different ranching systems.

Ranching is a relatively modern land use system and has been called a child of the industrial revolution (Grigg 1974). It has been introduced into Tropical Africa by Europeans during the colonial period. This by itself does not make ranches less important for Tropical Africa as a source of food and income but care has to be taken to extrapolate in space and time from the particular context of ranching development. European ranches have been taken over by Africans (particularly in Kenya) and there have been more recent efforts at ranching development under African management. These ranches have different problems from those of the established European ranches. They determine by and large the prospects of ranching development in Tropical Africa and are therefore given emphasis here.

8.1.3 Production Characteristics

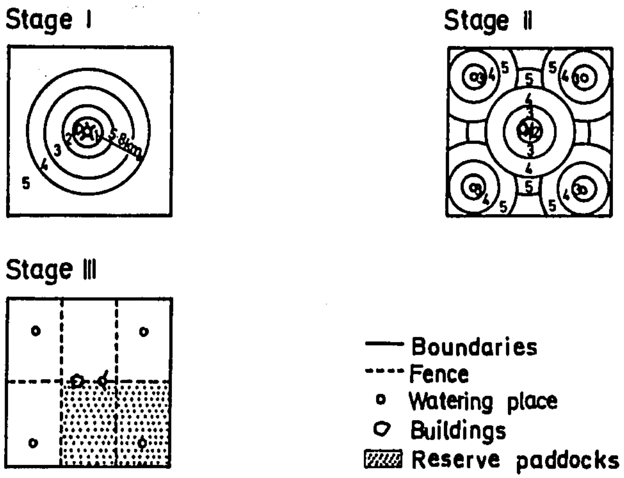
The individual tenure system that by definition characterizes ranching systems allows management to control both livestock and grazing. There is no other livestock production system that illustrates in a clearer way the task of adapting the livestock requirements to the feed supply through management practices and the role of on-farm investments and improvements to facilitate this task in the course of development. The specialisation of the production system (in terms of species, products and functions of livestock) and the very fact that one or few forms of livestock production are practised to the exclusion of other lines of production also serves to demonstrate the specificities of livestock production: Two "crops", livestock and fodder have to be managed; fodder management, livestock management and the productivity of the basic resource land all interact, and decisions in one production period influence the production cycle in the many years to come.

One of the basic management tasks is to adapt stocking rates to carrying capacity. The unimproved situation is characterized by sharp fluctuations of the fodder supply through the year and variations over the years. The simple herd management system with yearly sales does not correspond with the carrying capacity pattern. Periods of scarcity alternate with periods of surplus. Improved systems attempt to influence both the development of the stocking level through time through the sales strategy, the calving regime, possibly also through the choice of the most appropriate product and stratification stage. Fodder availability on the other hand can be improved and adapted to the livestock requirements through rotational grazing, reserving parts of the grazing for the dry period (standing hay), fodder conservation, irrigation but also through the purchase of feed.

An additional mangement factor is water. Water development is closely related to herd and pasture management. This is illustrated by the principal stages in the development from open grazing systems to paddock systems (Figure 8.1).

Stage I: Where a ranch has only one watering place, concentric grazing rings are formed. Zone (1) is bare ground and secondary bush round the water, with scarcely any fodder in the dry season. Zone (2) is an over-grazed area with predominantly weed growth and little fodder in the dry season. Zone (3) is over-grazed land with weeds and annual grasses. Zone (4) is a reasonably used area

Figure 8.1.
Stages in Ranch Development and Water Development



For explanation see text

Source: Ruthenberg (1980), adapted from Webster and Wilson (1967) and Andreae (1966, p. 23).

with good pasture and fodder reserves available according to the grazing technique. Zone (5) is scarcely used natural vegetation, since it is a long way from the water and either provides fodder reserves in the dry season (if not too far from water) or is grazed only when it carries surface water after rain.

Stage II: During the season when fodder is scarce, the fifth zone is a reserve. In so far as the dry season coincides with the cool of the year, the animals can travel further and make use of the fodder growing in the outer zone. As several watering places are dug, the marginal zones of the ranch can be more easily developed. The distances covered by the animals become shorter. The result is the formation of vegetation zones round each watering place, with a better distribution of grazing and less over-grazing.

Stage III: Dividing the pasture into paddocks combined with fencing reduces the damage from over-grazing, facilitates separation of the animals into age groups, and allows reserve paddocks to be formed with hay on the stalk. The reserve paddocks are grazed in the dry season.

Most improvements in ranching aim not only at increased production and productivity but also at a reduction of environmental risks. As in pastoral systems the two major sources of production risk are drought and disease.

Improvements in herd management, pasture management and water management require efforts. Supervision of on-ranch production becomes closer and more regular; records are kept; herding patterns are more closely adapted to the needs of different animal groups; more current inputs are used (labour, purchased feed, inputs for animal health, transport); and, most importantly, investments are made in breeding animals, water points, fencing, roads, fire breaks, dipping tanks, vehicles, irrigation equipment etc., increasing the capital stock of the ranch. Improvements in production and productivity and in economic security are closely related to the capital intensity. If one includes the livestock capital improved ranching is one of the most capital-intensive forms of agricultural production. Intensification in ranching implies increased inputs of labour and capital per head of livestock.

Livestock themselves normally constitute the largest component of the capital stock of a ranch. While livestock have the inherent capacity for reproduction and growth this growth is slow and continues to be checked by unfavourable years and periodic disasters due not only to drought and disease but also to poor prices and liquidity problems that force ranchers to oversell. The period it takes to stock up a ranch is more often measured in decades than in years. So is the period it requires to develop fixed ranch capital to the stage where high levels of productivity and security are reached.

Intensification is also related to stratification. In the initial stages of intensification the product variation may increase (instead of only store cattle also calves and more cull animals). With further intensification production tends to become more specialized and more adapted to the specific conditions of the ranch as determined by the natural environment, market distance and the physical infrastructure surrounding it. Both intensification and stratification require the development of more specialized skills on the part of the ranch management. A specialized breeder will hardly move into weaner production and ranchers are distinguished not only according to the livestock species and product but according to the breed and the production stage in which they specialize.

8.2 Production and Productivity

8.2.1 Fodder Productivity

Production and productivity figures on long-established well-managed ranches approach those of experimental stations and demonstrate what is technically and economically feasible. With due discounts they normally serve as the planning base for the establishment of new ranches. The differences in the natural environment are reflected mainly in the carrying capacity of the land or the fodder productivity. The increase in fodder productivity is generally assumed to be less than proportional to the increase in rainfall due to more intensive competition from woody species (Blair Rains and Kassam 1980). But ranching systems provide a suitable framework for intensification of fodder production through the application of capital and management. The technical and economic possibilities of raising fodder productivity over that of natural pastures under rainfed conditions multiply as precipitation increases. In the arid zone of the Sahel a trebling from 700 to 2 100 kg/ha of dry matter yields has been shown to be possible by deferred grazing and fertilizer application (ILCA 1980a). In the more humid areas with e. g. a rainfall of 1 200 mm i. e. in the sub-humid zone a completely unimproved pasture would be expected to yield no more than 3 000 kg (Blair Rains and Kassam 1980). This is in line with the observed stocking rates on unimproved pastures on Zairian ranches (2-5 ha/TLU; ILCA, Trail et al 1979). Already the systematic clearance of the woody vegetation and the introduction of <u>Cynodon dactylon</u> leads to yields of about 6 000 kg DM/ha and judicious grazing allows a stocking rate of 2.3 TLU/ha (Doppler 1980 for Avetonou, Togo). Various experiments in West Africa show the annual dry matter yields of <u>Panicum maximum</u> without fertilizer to be between 10 and 18 t/ha (Leteneur 1973; Talineau et al 1977; Messager 1977). Through the use of mineral fertilizer, the application of cutting regimes and the choice of a suitable species mix artificial pastures yield up to 30 tonnes of dry matter per hectare and year (Doppler 1980). These yields may be inapplicable in practical agriculture but stocking rates of 2.8 TLU/ha/year without supplementary feeding are considered feasible, i. e. a ten-fold increase over stocking rates observed on natural pastures in Zaire. The potential for intensification is therefore great although economic considerations constrain the full realization of the technical potential.

8.2.2 Livestock Productivity

Beef ranches are the most common ranch type in Tropical Africa. Both reproductive performance and weight gains are essential indicators of animal productivity. But there are complex interactions with other traits and data from different locations are difficult to compare because of differences in management systems, environments etc. The principle holds that performance levels on experimental stations in Africa are within the realm of possibilities of a well managed commercial ranch. Table 8.1 presents in a greatly simplified form the results of a detailed and comprehensive productivitiy comparison using figures from Niono, Mali, as a baseline.

The data can be converted to two commonly used indicators: Calving rates of 80% and daily weight gains of 300 g are productivity levels that should be achieved by ranches even at medium levels of management and intensity. Most of the data used for comparison in Table 8.1 stem from more arid situations. Cattle husbandry in more humid areas is affected by trypanosomiasis. Depending on the degree of tsetse challenge only trypanotolerant breeds of small size can be kept. In order to allow a direct comparison with the productivity of cattle with larger body size the productivity index constructed by ILCA (Trail et al 1979) can again be used, which relates total production (meat and milk) per annum to 100 kg of cow liveweight to be maintained. No indication has been found that the Zebu are significantly more productive than the trypanotolerant animals. However, Zebu and Zebu cross-breds are not often found alongside humpless cattle essentially because Zebu do not tolerate the tsetse challenge, and thus field-level comparative data are scarce. The general impression is that trypanotolerant animals are no less productive than Zebu breeds and perform well under a tsetse challenge that precludes Zebu stock altogether (ILCA, Trail et al 1979).

Exotic breeds and cross-breds may show higher productivity under a good feeding regime, good management and in the absence of a tsetse challenge; but trypanotolerant cattle of the N'dama breed show a comparative advantage if there is any trypanosomiasis risk and also because they better tolerate occasional feed shortages (Doppler 1980). Management aspects like the seasonal timing of

Table 8.1: Productivity Indicators of Indigenous Cattle in Tropical Africa Based on Figures from Niono. Mali

Indicator	Niono figures[a]	Niono in comparison with other locations[b]
Age at first calving (months)	43	similar
Calving interval (days)	468	rather long
Milk production[c] (kg/year)	457	similar
Weight gain (6-30 months (g/day)	267	rather low
Cow body weight (kg)	317	slightly low
Mortality (total herd) (%)	7	similar

a) Maure and Peul cattle and their cross-breds

b) 16 locations but comparisons incomplete due to lack of data

c) Including quantity suckled by calf

Source: ILCA/IER (Trail et al 1977).

calving and the feeding regime are probably of more practical importance than breeds as such*. Daily liveweight gains can be significantly improved with pasture improvement as is possible in the more humid areas. The essential determinants of liveweight gains are the type of pasture and the feeding regime during the dry season (Table 8.2).

In practice liveweight gains in Table 8.2 would have to be related to the area of grazing available to the stock. Moreover since pure fattening ranches are rare the performance of the breeding herd

* Ruthenberg (1974) in his survey of available data found daily liveweight gains of N'dama to vary from 250 to 699 g, of Baoulé from 191 to 496, of Zebus from 320 to 651, of Jersey-N'dama crosses from 433 to 444.

Table 8.2: Liveweight Gains of Adult Zebu Steers under Commercial Conditions (Mokwa Ranch, Nigeria)[a]

Rainy season	
- natural grazing of mainly Andropogon gayanus	300 g/day
- intensive pasture of Panicum maximum	500 g/day
Dry season	
- natural grazing	0 g/day
- pasture improved with Stylosanthes	100 g/day
- maize silage and cotton seed	300 g/day
- Panicum silage, molassis, cotton seed and dried brewer's draft	600-700 g/day

a) Data based on the fattening of 10 896 Zebus, mainly Gudalis and White Fulanis between 1965 and 1973; the fattening period is 7 months; during the first weeks compensatory gain brings figures up to 1 000 g/day

Source: Lutterloh (1974, p. 51), taken from Doppler (1980, p. 88).

would have to be considered as well. In addition supplementary feeding renders stocking rates difficult to interpret.

8.2.3 Physical Performance and Financial Viability

The existence for decades now of a private ranching sector in Africa is sufficient indication that ranching can be a profitable enterprise. Most of these ranches operate below the level of maximum technical intensity, particularly as far as fodder production is concerned. A comprehensive comparative assessment of physical and financial performance of newly established African ranches is impossible for lack of data, but indicators of performance can be given. The key performance indicator in cattle ranching is the calving rate. This coefficient reflects the management standards more clearly than any other single coefficient. The calving rate affects production and productivity not only in the current year but also has an important carry-over effect to the subsequent years. In the setting up of a new ranch it is commonly accepted that initially the calving rate is close to that in the traditional sector often taken to be around 50%. A central element of the whole ranch development exercise is to bring up the calving rates. The target figure is often 70% to be achieved within in five-year period. Calving rates are correlated with other performance indicators like mortality rates of young and adult stock, weaning rates, weight gains, age at maturity and offtake rates. The schedules in Tables 8.3 and 8.4 show the combined effect of calving rate, mortality rate and age at maturity on overall productivity indicators like growth rate of the herd and offtake rate.

Table 8.3: Possible Growth Rate (% p.a.) of Cattle Breeding Herd as a Function of Weaning Rate and Heifer Mortality[a]

	Annual mortality of heifers after weaning		
	5 %	3 %	1 %
Weaning rate			
40 %	- 2 %	- 1 %	0
60 %	7 %	8 %	9 %
80 %	16 %	18 %	20 %
100 %	25 %	27 %	29 %

a) Underlying assumptions: Cow culling rate 18 %, cow mortality rate 2 %, maturity of heifers 2 years after weaning; the growth rate figures relate to the cow herd

Source: Schaefer-Kehnert (1978b).

Table 8.4: Possible Offtake Rate[a] of Self-contained Cattle Herd as a Function of Maturity Age and Weaning Rate[b]

	Maturity age of steers and heifers (years)			
	4-5	3-4	2-3	1-2
Weaning rate				
40 %	14	17	20	23
60 %	17	21	26	32
80 %	19	24	31	38
100 %	20	26	35	44

a) Expressed as annual units of output per 100 animal units of opening stock

b) Underlying assumptions: Mortality rate of adult stock 2 %; maturity age of heifers not less than 2-3 years

Source: Schaefer-Kehnert (1978b).

With a 50% calving rate, the weaning rate will be between 40 and 45%. Tables 8.3 and 8.4 show that with such low weaning rates it is very difficult to achieve growth rates of the cow herd and acceptable levels of offtake which determine economic success. On the other hand the tables also point to the high performance levels that can be achieved. Growth of the cow herd is important in the initial stocking-up period and a growth rate of say 18% is well within the realm of possibilities, so is an offtake rate of between 25 and 30%.

The hypothetical figures in Tables 8.3 and 8.4 can be contrasted with achieved figures in Table 8.5. The latter relate to ranches built up over the past decade with assistance by the World Bank.

None of the newly-established ranches achieved the planned levels of performance. Development trends are erratic without any clear upward trend. To transform the calving rates into weaning rates

Table 8.5: Planned and Achieved Calving Rates (%) on Newly-established Ranches in Tropical Africa

	Ranch development year			
	3	4	5	6
Planning figures[a]	60	65	70	75
Achieved figures				
Congo[b]	49	61	55	n. av
Kenya[c]	67	43	47	44
Tanzania[d]	n. av.	64	63	58
Zaire[e]	63	51	29	65
Zambia[f]	n. av.	65	49	66

a) Informal average of common planning figures

b) One ranch

c) Weighted average of several so-called company ranches

d) Weighted average of five parastatal ranches

e) One ranch

f) Weighted average of ten ranches

Source: Sandford (1980).

some five to ten percentage points have to be subtracted. With weaning rates significantly below sixty per cent a satisfactory growth rate of cattle herds is difficult to achieve (Table 8.3) and offtake rates will hardly exceed 15 per cent (Table 8.4).

Given that ranching is capital intensive and constitutes a fully commercialized undertaking physical performance levels are quickly reflected in financial viability. The financial viability demonstrated by the private ranching sectors in Kenya, Tanzania, Zambia, Zimbabwe, Zaire and other countries contrasts with the financial problems met on the newly established ranches. Physical performance and financial performance of ranching in Tropical Africa have to be viewed in this dichotomy between the possible levels on one side and the achieved on the other. This dichotomy weighs heavily on the development prospects of ranching.

8.3 Development Possibilities

8.3.1 Basic Opportunities and Constraints

Ranching development as a form of livestock development for Tropical Africa has a number of attractions in theory (Baker 1968; Jahnke 1976b; IBRD 1977; Sandford 1980): A previously unproductive and unused piece of land can be rapidly brought to high levels of production and productivity through the unhindered application of scientific techniques, strong management and large amounts of capital. The burden of working through traditional techniques and ideals is absent. The problem of overpopulation by man and stock does not exist. The starting point is empty land or manageable numbers of man and stock.

At a time when expectations from ranching development were still high in Kenya, von Kaufmann (1976, p. 267) wrote:

> "With the aid of plenty of loan capital and the existence of known technology and quality cattle, development is extremely rapid. A ranch may go from virgin bush to having three dips, 30 miles of piping, 200 miles of road and the facilities to handle seven thousand head of cattle in four to five years. Such a process would have taken the early Europeans thirty years."

The experience does not bear out that such a speeding up of the ranch development process is feasible. Poor performance of practically all of the recently established ranches became obvious in the second half of the 1970 (Jahnke 1976a; IBRD 1977; Sandford 1980). At the basis was poor livestock performance as indicated by the calving rates (Table 8.5) supported by other indicators like calf mortality, adult mortality, maturity age, growth rate, offtake and slaughter weight. Poor physical performance quickly endangered the financial viability of the ranches. In some cases financial rescue operations were undertaken despite profound doubts about their economic justification (Kenya, Tanzania). In other cases ranching development stopped altogether (e. g. Zambia). In this same period the old-established ranching sector, while also suffering from inflation and drought, continued to perform well.

It is a contention of this study that the problems of newly established ranches reflect a problem of management compounded by unrealistic time expectations and the over-availability of capital.

Management requirements in ranch development are related to capital and time requirements in a double sense. Firstly higher capital intensity as implied by ranch development requires higher management skills for general supervision, delegation of responsibilities, technical supervision and maintenance, herding tactics, book keeping, strategic marketing etc. Secondly it takes time to build up these management skills since they are much more the result of specific ranch experience than formal training; it may be postulated that it takes as much time to build up the management capacity as it takes to build up a ranch from its own resources. It is common for European ranches in Tropical Africa to be in the hands of the second or third generation and still being in need of development despite of relatively high initial levels of know-how and despite of various forms of indirect support by colonial governments to the politically powerful group of ranchers. This implies a long and intensive learning process. It is this feature that characterizes the European ranches in Africa and that makes them different in respect to ranches under African management where external sources provide finance and lift the capital constraint to ranching development. The factor that invariably becomes the tightest constraint is management. The problem of African ranches lies in the latter's youth and the lack of management experience. Financing a quick ranch build-up is more likely to throw the enterprises into financial trouble than to achieve the desired development result. Calving rates as the most sensitive indicator of management in ranching are clear evidence. A low calving rate combined with heavy capital expenditures characterizes the management problems of African ranches and points to the trouble ranching is heading for.

The management problem is common to all ranching development irrespective of the ecological zone and the specific technical problems and irrespective of the institutional form of ranching development (private ownership of individuals or partners, company ranches, cooperative ranches, parastatal ranches etc.). But certain institutional forms are beset with problems that compound the management constraint. This holds for cooperative and for parastatal ranches which are preferred in Africa for equity reasons and ideology. Here management is neither given incentives nor held responsible for poor performance. Continuity in management is generally lacking. Supervision and control are hindered by work relationship determined outside the ranching enterprise. Management is often separated from accounting and cost consciousness is not called for. Finally there is continual pressure toward overstaffing and overemployment.

Inadequate management compounded by unsuitable institutional forms constitutes a formidable check on ranching as the quick and unhindered path for livestock development in Tropical Africa. It has to be realized that here as in other world regions ranching development has a long time dimension.

8.3.2 Ranching Development in Arid Areas

In this context the arid areas refer to areas of the arid and semi-arid zones where livestock production has an ecological preferential over cropping and where the tsetse problem plays a marginal role if any at all. The established European ranching sector is basically found in these areas (Kenya, Tanzania, Zambia, Botswana, Zimbabwe) with the exception of ranching in Zaire. At the time of its establishment population densities were lower and appropriation of land for ranching purposes was possible. The establishment of new ranching enterprises in these areas today can mean two things:

- The transformation of pastoral production systems into ranching systems. This is basically a problem of institutional (in particular land tenure) reform on one side and of human population pressure on the other. The solutions to both problems can only be found in the long run, but this type of ranching development is viewed by Pratt and Gwynne (1977) as the basic development path for occupied rangelands, though usually with a lengthy intermediate phase under grazing associations or group ranches.

- The establishment of ranching enterprises in empty areas, i. e. areas that are not used or claimed. The exclusion of pastoralists from land on which they hold a claim is for African governments of today no feasible solution. The basic constraint is then availability of such empty land. On the aggregate the more arid areas of Tropical Africa are already overpopulated but pockets of unused land exist. In Kenya it has been estimated that 220 000 square kilometres or 5% of the dry rangelands can be considered unoccupied and available for ranching (UNDP/FAO 1969). The disadvantage is that these areas are often unused for good reasons (lack of access, prevalence of disease, lack of water resources) so that ranching development is confronted with additional problems.

Whichever view of ranching development is taken the large-scale establishment of ranching enterprises in the arid areas in the foreseeable future is unlikely. Ranches will not account for any significant portion of the livestock industries' total output. But ranches, even if few in numbers could play a significant role in specialized functions. Stratification is one example. The scope for stratification is limited by the availability of animals from pastoral systems (see section 5.3.1), but there are nevertheless specialized markets that pay for high quality meat and would justify some effort at ranch establishment in this area*. The maintenance of pure-bred studs and the supply of high quality breeding animals is another example. The existence of at least some ranches as a source of technical know-how to be used in the gradual transformation of pastoral systems may be relevant. Finally there are specialized enterprises like game ranching or Karakul sheep ranching that may be of local importance.

* Expectations have to be modest. A degree of stratification has been successfully implemented in Kenya. Elsewhere the underlying assumptions of excessive trade margins and availability of surplus animals from pastoral systems proved wrong (Sandford 1980). Ferguson's (1979) review of so-called calf-saving centers and growing out ranches in the Sahelian region, of medium to long-term fattening ranches in areas to the south of the arid zone (in Senegal, Cameroon, Upper Volta and Niger) and of short-term fattening ranches and feedlots in the sub-humid zone point to the same management problems as found in other ranches. They are only compounded by the fact that the expected stratification effects do not take place which is among other things expressed in the chronic lack of animals for purchase and further fattening and by the presence of tsetse flies and trypanosomiasis.

8.3.3 Ranching Development in Humid Areas

The more humid areas show different opportunities and constraints for ranching development:

- The carrying capacity of the land increases with rainfall, in particular the possibilities of raising fodder productivity through the application of capital and management multiply.

- There are huge stretches of land that classify as empty or unused. They generally have a potential for crop agriculture but the low population densities prevailing make relatively extensive forms of land use like ranching feasible.

- One of the very reasons for the emptiness of the areas is the presence of tsetse flies and trypanosomiasis. That problem is almost ubiquitous in the more humid areas of Tropical Africa and constitutes a very specific constraint to any form of livestock development including ranching.

The principle of ranching development in tsetse-affected areas can also be seen from a different angle. In areas of high population density land use is so intensive that tsetse habitat is largely eliminated. Such high land use intensities as a protection against tsetse flies are near impossible to achieve in a short time span. Land use expands on the fringes of the densely populated tsetse-free areas but continues to be under high trypanosomiasis risk for a long period. Ranching development would use livestock in their 'classical' role of pioneers of land use. Through livestock large areas can be taken into a form of extensive land use if the tsetse problem can be overcome. Eventually extensive ranching may yield to more intensive forms of production. The advantage of initial ranch delimitation is that land use development can be controlled to avoid haphazard encroachment by undesirable land use systems and to preserve large tracts of land for suitable intensive forms of agricultural production in future (Sacker and Trail 1968; UNDP/FAO 1967). With respect to the tsetse problem two basic approaches must be distinguished*: (1) ranching in tsetse-infested

* A third approach is to keep animals under drug protection. Applicability of this approach is controversial because of the problem of resistance. The fact remains that many a ranch has used drugs against trypanosomiasis for long periods allowing successful beef production.

areas with trypanotolerant animals and (2) ranching development after tsetse clearance.

Ranching with trypanotolerant livestock: Zaire is the country with the largest tradition of ranching with trypanotolerant cattle. Development there is essentially one of European ranching. It deserves attention in the present context because there is continued interest in the use of trypanotolerant animals*. Practically all cattle have been introduced into Zaire from the outside. The most important trypanotolerant breed in Zaire is the N'dama. They were first imported from Guinea in 1920, initially kept on commercial farms and ranches in Bas-Zaire and then distributed in Bandundu and Equateur Regions. The total number of N'dama cattle in Zaire is now estimated at about 245 000 head. About one half are kept on ranches covering an area of 350 000 ha.

The ranching system in Zaire is based on natural savanna grazing, except at Mpaka in Ubangi Sub-region. Herds of N'dama, Meteba, Ituri and Angola crossbreds are generally kept on fenced pastures in Equateur and Bas-Zaire Regions and with permanent herdsmen in Bandundu. Herds vary from 1 000 to 25 000, and the carrying capacity is 2 to 5 ha per head. Where pastures are fenced, the cattle graze day and night; where herdsmen are used, the animals are kept in night paddocks or pens. Seasonal burning of the natural pasture is common and has a number of advantages: The costs are low and, in addition to stimulating regrowth, burning reduces the population of tsetse flies, ticks and other insects and larvae, controls the growth of shrubs and disperses wild animals. Production based on artificial pastures has never been economically feasible due to low meat prices, which were only 24 Mukuta ($ 0.22) per kg liveweight in 1975 for first quality.

Given that the animal productivity of trypanotolerant livestock is not inferior to that of other breeds the high calving rates achieved point to the high level of management. Under extensive conditions the calving rate is 75 to 80% including only calves alive two weeks after birth; under more intensive conditions the calving rate is as high as 100% while mortality rates are generally very low.

A particular problem of expanding ranching based on trypanotolerant livestock is the availability of such animals. Technically the

* The account of ranching in Zaire follows ILCA (Trail et al 1979) and Wissocq, personal communication.

problem of ranching with trypanotolerant animals is largely solved as a result of the experience with European ranching in Zaire. The financial and economic viability is shown by the fact of the existence of this private sector for decades and its reestablishment in recent years after expropriation and nationalization. However, the establishment of new ranches on that basis (in Gabun, Congo and Zaire) organized as parastatals has run into problems which can be traced back to the basic constraints of management and institutional forms of production that have been dealt with earlier.

Ranching development after tsetse clearance: Tsetse control operations are not normally carried out with the specific purpose of allowing the establishment of ranching. Exceptions are Zimbabwe and Uganda (Jahnke 1976b). In Zimbabwe 25 000 km^2 in the Zambesi basin were freed from tsetse flies between 1930 and 1970 primarily by shooting large wild animals, the hosts of the flies, to protect the ranching industry in that country. In Uganda 28 000 km^2 were freed between 1947 and 1970, initially by game destruction, then by insecticide application; a prime aim of the operations was to allow ranching development in the freed areas. The basic issues like the costs and benefits of tsetste control and its place in overall land use planning as elaborated in section 6 apply here as well. Two specific questions need to be raised about the tsetse-control-cum-ranching approach:

- Is ranching a suitable from of land use to prevent reinfestation?

- Can the economics of ranching carry the additional burden of the tsetse control costs?

Ranching itself does not prevent reinfestation. It is a relatively extensive form of land use allowing the continued presence of bush and trees and thus of tsetse habitat. In addition the livestock themselves serve as hosts to the flies and attract them back. Additional measures are therefore needed. In Zimbabwe extensive fencing and regular spraying is intended to maintain the separation between the tsetse-infested wilderness and the ranching areas. In Uganda the policy of preventive reclamation was practised, i. e. an area once freed is protected from reinfestation by reclaiming the neighbouring areas from the tsetse flies as well. Cheaper methods based on judicious use of trypanocidal drugs, of localized on-ranch spraying and of bush clearing along the ranch boundaries have also been found to be possible (Matteucci 1974). This leads to the question of economics. The conclusion from detailed economic analyses of tsetse control and ranching is simple. Ranching systems that are economically marginal anyway never justify the additional cost of tsetse control; well-managed ranches on high levels of productivity justify tsetse control easily if the control operations are carried out efficiently (Jahnke 1976b, pp. 85). An example of successful ranching development after tsetse clearance still is the Ankole-Masaka scheme in Uganda (Sacker and Trail 1968, Marples 1980, personal communication). If ranching can be made successful in Africa the tsetse problem can be overcome both technically and economically. But this statement hardly refers to the hole of the 10 million square kilometers of tsetse-infested land but rather to specific ranch perimeters.

9 Landless Livestock Production Systems

9.1 Definition and Delimitation

Landless livestock production systems refer to systems in which the importance of land for livestock production is significantly reduced in comparison with the systems so far dealt with. This is particularly the case with species that do not obtain their feed requirements through grazing, notably pigs and chickens. On low levels of intensity pigs and chickens are fed on household refuse and crop by-products; at higher levels concentrate is fed. Such concentrate feed may be produced on the farm but it may also be purchased in. The possibility of purchasing the feed thus substituting for farm land on the enterprise itself again emphasizes the "landless" aspect of the production system.

Ruminants can also be kept in landless production systems, but normally this implies high levels of capital intensity and management as found e. g. in beef lots.

As a corollary landless production systems are also less dependent on the specific ecological conditions. Availability and quality of feed need not be determined by the environment and the more advanced production systems provide protection from the direct climatic influences (housing, controlled lighting, even air-conditioning). Their distribution and maybe more so their development prospects are less rigidly tied to ecological zones. The term ecology-independent systems is therefore also sometimes used although the notion of complete independence of ecology appears to be too strong.

9.2 Pig Production Systems*

The total pig population in Tropical Africa is estimated at 7.3 million head. The largest concentration of pigs is in the coastal belt from Senegal to Cameroon which accounts for almost fifty per cent of the total population. Of all countries with a pig population of 100 000 head or more there are nine in Western Africa, two in Central, one in Eastern and four in Southern Africa. The distribution reflects ecological conditions, religious - particularly islamic - taboos and development efforts of the past.

Three basic production systems are distinguished (Meyn 1978a;

* This section draws heavily on Meyn (1978b).

Serres 1973): Traditional systems, commercial and advanced commercial systems within an overall stratification of production.

Traditional systems are found in smallholder farming communities. The animals are indigenous small breeds and live on waste products of the household and the fields. There are practically no fixed investments. Management is characterized by the absence of supplementary feeding, health care (vaccination and deworming in particular) and housing. Only about 3-4 piglets are weaned per sow and year and the carcass weight hardly exceeds 50 kg. Production is destined for home or village consumption.

Commercial production systems producing for the market use concentrates for feeding and incur costs for current inputs and investments. They are therefore dependent on breeds with better conversion rates and generally a higher performance capacity than indigenous ones (Table 9.1).

Table 9.1: Comparison of the Performance of African Indigenous Pigs with Swedish Landrace in Southern Africa

Weight	Swedish Landrace kg	Indigenous pigs kg	Difference absolute kg	Difference relative %
at birth	1.6	1.0	0.6	60
at weaning weight	15.6	9.3	6.1	66
at 120 days	41.8	18.3	23.0	122
at 200 days	95.9	43.3	52.6	121
of mature male	315	83	232	280
of mature female	265	71	194	273

Source: Hammond et al (1961),taken from Meyn (1978b).

The commercial systems are normally self-contained units engaged in both breeding and fattening. They can be distinguished according to the end product they specialize in (Table 9.2).

Table 9.2: Types of Commercial Pig Production Systems and Major Production Characteristics

Characteristic	Porker system	Bacon system	Heavy hog system
Slaughter age	5 months	7 months	variable
Slaughter weight	50-80 kg	90 kg	120 kg
Killing out	65-75 %	75 %	78 %
Feed conversion	3.0 : 1	3.5 : 1	4.0 : 1

Source: Meyn (1978b).

The economics of the different systems are largely determined by the prices and price differentials for the different meat qualities produced. Fat meat is in relatively higher demand in Africa than in industrialized countries which in part explains the premium paid in Africa for pig meat over beef (Serres 1973).

Finally there are advanced systems within an overall stratification of production. Central units engage in stud breeding, selection and experimentation on feeding and health care. Other units engage exclusively in piglet production, which still requires a high level of management, while fattening is carried out in either specialized large enterprises or in smallholdings. Such stratification and specialization is seen as the long-term development path for pig production also in Tropical Africa but has not been implemented on a large scale yet (Serres 1973).

Total pork production in Tropical Africa was 247 000 tonnes in 1979 (see section 3.2.1). Per head of the human population this comes to 0.7 kg. Pig productivity in Tropical Africa appears to be the lowest of any world region (Meyn 1978b; FAO Production Yearbooks). The indicators in Table 9.3 are not the ones commonly used in pig production but the only ones that can be calculated from available statistics.

Table 9.3: Estimate of Pig Production and Productivity of Traditional and Commercial Systems in Tropical Africa 1979

Indicator	Total/ average[a]	Commercial	Traditional[c]
Pork production (MT)	247 000	49 000[b]	198 000
Offtake rate (%)	75	85[d]	74
Carcass weight (kg)	45.3	65.0[d]	42.1
Standing stock (1 000)	7 273	887	6 386

a) Average/total figures from FAO (Production Yearbook 1979)

b) According to FAO (AT 2000, 1979) about 20 % of the production comes from commercial systems

c) Calculated as a residual

d) Own estimates based on the figures of the small but largely commercial pig industry in Kenya

Source: Compiled by the author from FAO (Production Yearbook 1979), FAO (AT 2000, 1979) and own estimates.

Pig numbers and pork production have increased at a relatively rapid rate in the past (Table 9.4).

Production has increased at a rate above the growth rate of the human population. It has, however, been mainly due to numeric increase; significant productivity increase cannot be detected. This would also mean that the proportion of commercial systems in total production has not significantly increased.

Table 9.4: Increase of the Pig Population and of Pork Production 1969-71 to 1979 (Indices)

Numbers/ production	Year							Annual growth
	1969-71	1974	1975	1976	1977	1978	1979	69-71/79
Pig numbers	100	108	116	117	124	130	135	3.4 %
Pork production	100	105	115	121	127	132	140	3.5 %

Source: FAO (Production Yearbooks, various years).

9.3 Poultry Production Systems*

In this study only chickens are dealt with as poultry. The only other two poultry species on which there are any statistics are ducks and turkeys. According to FAO (Production Yearbook 1979) there are 5.7 million ducks in Tropical Africa (2.5 million in Tanzania, 2.4 million in Madagascar and 565 000 in Mozambique) and 1.2 million turkeys (of which practically all are in Madagascar). Chickens number some 427 million. For reasons of numerical significance alone it appears to be justified to focus aggregate considerations on chickens, but for a country like Madagascar ducks and turkeys obviously play a role. Data on meat production generally include all poultry species but this error carries no significant weight given the relative flock sizes (Madagascar would again be an exception). In the following the terms chickens and poultry are used interchangeably.

The distribution of the chicken population appears to be influenced by the distribution of the human population more than by any other factor. On average there are 1.8 birds per person if related to the agricultural population, or 1.3 if related to the total human population. The two countries with by far the largest chicken-

* This section draws heavily on Meyn (1978c).

flocks are Nigeria (110 million birds) and Ethiopia (52 million).

Poultry production systems show a clear distinction between traditional, low-input systems on one side and modern batch production systems using advanced technology in housing, feeding, breeding, marketing and processing on the other. Once a farmer starts producing for the market, the use of modern technology appears to be so much more efficient than the traditional system that the producer will make a quantum jump very quickly, and adopt production technology as has been developed in the industrialized countries. If successful, he will also increase the size of his operations to utilize economies of scale. Poultry production in Africa is therefore a combination of a large number of small subsistence producers selling also some of their produce to the market, and a few large-scale producers supplying urban consumer markets. Meyn (1978c) refers to the first group as farm-yard poultry production while he distinguishes the second according to their specialization.

Farm-yard poultry production is probably the most common form of animal husbandry in Africa, being practised by virtually every rural family. The main features are minimum inputs - with birds scavenging on the farm and no investments beyond the birds and their simple enclosures - and low productivity. Meat and egg productivity are both low. The system encounters enormous losses through recurring disease such as Newcastle disease, fowl pox, fowl typhoid, Marek's disease, and coccidiosis from parasite infestations. The disease risk must be regarded as the main obstacle for smallholders to intensify the management of their flocks, because in some situations only one out of 10 chickens born will reach marketable age. In addition farm-yard poultry is beset by a strong seasonality according to the rainfall and temperature regimes. Otherwise, it would be quite attractive in many African countries to feed surplus farm-produced grain to chickens, and to sell eggs and slaughter birds to the market and thus generate cash in such small portions as is convenient for the cash economy of smallholders.

Specialized egg production units are one type of commercial poultry production system. They can be found in the vicinity of many African cities. Being labour-intensive and guaranteeing regular daily incomes, they are normally smaller operations than commercial broiler units, ranging from about 500 to several thousand birds. Simple housing with a thatched roof, wire mesh on two sides and a deep litter system are the dominant features. Egg production units are normally found close to a source of commercial feed supply which in turn is likely to be linked to the milling industry in that country. The birds belong to one of the improved egg producing breeds (White Leghorn, Brown Leghorn) or dual purpose breeds (Rhode Island, New Hampshire, Sussex) or increasingly they are hybrids being supplied by international poultry concerns which have established outlets in Africa. Chickens are typically bought from one of the hatcheries or they are imported. As an example, Kenyan poultry producers used roughly 30% purebred and crossbred chicks and about 70% hybrids in 1971. Production coefficients vary considerably, but under reasonable conditions an annual yield of 200 eggs may be expected per laying bird, equivalent to 11.4 kg, for which about 40 kg of feed would be required. Egg marketing is mainly direct from the producer to the consumer, or through retailers; organized egg marketing systems through co-operatives or wholesalers is rare.

Commercial poultry meat or broiler production is concentrated in large units near to consumption centers. For example, in 1972, two thirds of Kenya's poultry meat market of 35 ooo birds per week was supplied by the 20 medium- to large-sized poultry producers keeping in aggregate about 250 000 birds. Specialized hybrid chicks are supplied by the hatcheries linked to international poultry firms. Spring chickens are typically sold at an age of 8-10 weeks at a liveweight of 1 kg, having consumed in the order of 2.5 kg of compounded feed. Birds are normally slaughtered on the farm and sold through supermarkets with cooling facilities. Birds are produced in large batches, which are slaughtered on the same day.

Hatcheries: A number of hatcheries licensed by overseas poultry companies compete for the market of day old chicks in many African countries. The producer has thus access to genetically superior material at reasonable cost. Hatcheries are either importing eggs or parent stock for day-old chick production. Large poultry firms combine hatchery with egg production or broiler units.

Total production from poultry in 1979 was estimated at 561 000 t of meat and 467 000 t of eggs (FAO Production Yearbook 1979) which gives an average of 1.3 kg of meat per bird and 1.1 kg of eggs (given their small size this corresponds with 28 eggs or more). Productivity differences between production systems are likely to be greater in the case of poultry than pigs. Specialized commercial production demands high management standards in health care, in the feeding regime and in general husbandry standards and has considerable investment requirements but the rewards are drastically improved performance levels. Intermediate systems are few and far between; development efforts at improving traditional systems have in the past lagged behind efforts at establishing modern large enterprises. FAO (AT 2000 1979) estimates that 30 per cent of the total poultry production comes from commercial systems. Their meat and egg productivity should easily be twice as high (2.6 kg of meat and 2.2 kg of eggs) as the continental average. The productivity estimates for the traditional systems would then of course have to be lowered accordingly.

The availability of poultry products was 1.7 kg of meat and 1.4 kg of eggs per person (2.4 and 2.0 kg respectively if related to the agricultural instead of the total population). Poultry production even more so than pig production has increased rapidly in the past. It has in fact shown the fastest increase of any form of livestock production in Tropical Africa (Table 9.5).

Table 9.5: Increase of the Chicken Population and of Poultry Production 1969-71 to 1979 (Indices)

Numbers/ production	1969/71	1974	1975	1976	1977	1978	1979	Annual growth 1969-71/79
Flock size	100	105	109	113	120	123	129	2.9 %
Poultry meat	100	114	122	141	163	173	186	7.2 %
Hen eggs	100	111	114	124	131	135	141	3.9 %

Source: FAO (Production Yearbooks, various years).

The flock increased at slightly above the rate of human population growth. Poultry are the only livestock species for which in addition significant productivity increases can be noted. The relatively high proportion of commercial undertakings, and the relative absence of intermediate (improved traditional) systems suggest that this is due to a transfer of modern production technology and the establishment of modern production enterprises at a significant scale.

9.4 Intensive Beef Production Systems*

In Tropical Africa feedlots are of relatively recent origin and are still rare. In Kenya feedlots were established in the late sixties; some six to ten units are still in operation. The major feed base is maize and maize chop. The motive in their establishment was very much commercial and the units are privately owned and operated. In West Africa feed-lotting grew out of the concept of stratification of the cattle industry. Cattle on their traditional routing from the breeding zones in the north to the consumer centres in the south are to be fattened and finished on the way. This is either done on ranches with artificial pastures and supplementary feeding or in feedlots proper. A major element of the feeding regime are crop by-products like cotton cake, molasses and others. The units are generally government-owned and -operated or at least government-sponsored.

On a world-wide scale the existence of feed lots is very much connected to the general level of economic development (Schaefer-Kehnert 1978a, p. 342):

> "In the course of economic development personal incomes increase and usually strengthen the demand for animal products including beef. In this process beef prices often increase faster than those of other animal products so that at higher stages of development beef becomes the most expensive meat whereas at low stages of development beef is normally cheaper than pork and poultry meat. The relative increase of beef prices makes it possible to gradually intensify beef cattle feeding and to include grain and other feed concentrates in the feed ration of beef fattening operations. This is usually done in so-called feedlots which are typical for example for the beef industry of the United States."

The scope of intensive beef production systems in principle is indicated by Figure 9.1.

One is led to assume that the transition to intensive feeding systems would entail a similar dynamism in beef production as is the case for pig and poultry production. There are, however, two fac-

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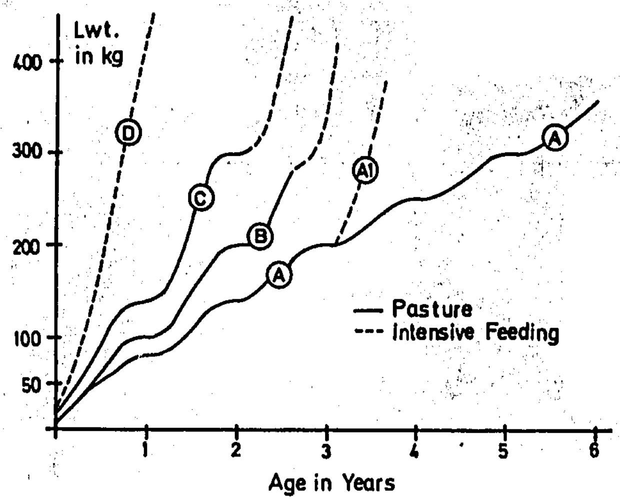
* This section is largely based on Schaefer-Kehnert (1978a).

Figure 9.1.
Effects of Intensive Feeding on the Growth Pattern of Cattle



A Traditional extensive beef production, unimproved breeds

A1 As above, but 180 days for finishing in feedlot

B Traditional breeding, slightly improved rearing and feedlot for 150 days, unimproved breeds

C Improved breeding and rearing and feedlot for 150 days, unimproved breeds

D Very intensive production with zero grazing from birth to slaughter (Italian "vitellone"), specialized breeds.

Source: Auriol (1974).

tors that reduce the scope for beef fattening in Tropical Africa: (1) the price ratios and (2) the conversion efficiency. Beef prices in Africa are still relatively low compared to grain prices and compared to prices for pig meat and poultry products (Klayman 1960, Schaefer-Kehnert 1978). Furthermore ruminants are significantly less efficient in converting feed to meat than either pigs or poultry. The combined effects on the economics of beef fattening in Africa has been demonstrated by Schaefer-Kehnert (Table 9.6).

The higher feed prices in Table 9.6 are the more realistic ones and a conversion rate of 8 : 1 and a daily liveweight gain of 1 kg

Table 9.6: Total Beef Fattening Costs in Dependence of Conversion Ratio and Daily Liveweight Gain

Conversion Ratio[b] kg DM/kg LW	LW gain[c] kg/day	Feed costs[a] (cents/kg DM) 0.05	0.09	0.12
		Total costs[d] cents/kg LW gain		
6 : 1	1.25	0.40	0.64	0.82
8 : 1	1.00	0.52	0.85	1.09
10 : 1	0.75	0.67	1.07	1.37
12 : 1	0.50	0.85	1.33	1.69

a) Based on a maize price of between $ 62.5 and $ 112.5 per t; the feed costs vary with type and quality of the ration and its energy content; a low feed price could refer to a low energy ration at a high maize price or vice versa

b) In kg of feed dry matter per kg of liveweight gain

c) Conversion ratios and daily liveweight gains do not go fully parallel but they are closely related

d) Including an overhead charge of 12.5 cents per animal per day

Source: Schaefer-Kehnert (1978a).

represent a very good level of performance. For such an operation to be profitable the beef price has to be around one US dollar per kg liveweight or twice that amount per kg CDW.* The implied price ratio of beef (liveweight) to feed grain would be 10 : 1. Such price ratios are not common in Africa. An informal survey of

* Dressing-out percentages vary with the quality of the animals. A beef lot animal can be expected to dress out at some points above 50 per cent but this complication is neglected here.

price ratios in 11 countries of Tropical Africa* suggests price ratios of 5 : 1 and narrower. This aspect can be generalized. The price ratio of maize to beef is largely influenced by the supply situation of these two commodities in a country. If there is a surplus situation and the commodities are exported, prices are likely to reflect world market prices minus transport costs, i. e. export parity prices. If they are in short supply, prices tend to reflect import parity prices (world market price plus transport costs). Thus, for the two commodities involved there are four combinations of price levels possible as shown in Table 9.7. The table also shows the price ratios that are typical for these combinations, and some of the countries to which they apply. These ratios are influenced, of course, by the maize/beef price ratio on the world market which has fluctuated over the past but has a tendency to always swing back to the same or a similar ratio (Schaefer-Kehnert 1978).

Table 9.7: Typical Grain/Beef Price Ratios in World Regions

Grain price level	Beef price level	Price ratio beef LW to grain	Typical countries
Export parity	Import parity	1:10 - 12	USA, Canada
Import parity	Import parity	1: 7 - 8	EEC countries
Export parity	Export parity	1: 4 - 5	Australia Argentina
Import parity	Export parity	1: 2 - 3	Ethiopia, Tanzania, Madagascar

Source: Schaefer-Kehnert (1978a).

As can be seen from Table 9.7 favourable maize/beef price ratios are achieved only where the beef price is at an import parity level. Most favourable is the situation where the import parity

* In connection with ILCA/EDI Livestock Development Projects Course, 1978, Nairobi.

price of beef is combined with an export parity price for maize. This situation is unique for North America where a great potential and efficiency in grain production for export exists and a high income population can afford to pay the import parity price for beef. The feedlot flourishes under these conditions. In the EEC countries, where both maize and beef are at the import parity level, the price ratio is still good enough to feed a steer with a medium to high energy ration in a short finishing operation. In Australia and Argentina, however, where both maize and beef are at an export parity level, there is no room for feeding maize to beef cattle. These countries, therefore, export both feed grain and beef. African countries which have a surplus of beef, but are short of grain, have the most unfavourable maize/beef price ratio. Many African countries have turned from net exporters of beef to net importers or are expected to do so in the near future (IICA, Bulletin 3, 1979). By tendency this improves the price ratios for beef fattening but the situation in North America will not be reached simply because the African countries have a deficit in grain production which is likely to grow larger in future (Schmidt 1981; FAO, AT 2000 1979). Economic beef fattening operations are still possible if there is a large price differential between feeder steers and fat steers per kg liveweight, if low-cost rations based on by-products can be used and if the efficiency expressed in conversion rates and daily liveweight gains is high. Compared to pig and poultry production which are favoured by relatively higher prices and by better conversion rates the scope for intensive beef fattening is much reduced.

9.5 Development Possibilities

Production techniques for intensive livestock feeding systems in tropical areas have been well-established (Serres 1973; Bres et al 1973; Creek and Squire 1976). Demand for livestock products is growing and apparently cannot be met by supplies from traditional production systems in Africa. The potential role of intensive feeding systems is largely determined by feed availability and price ratios. Price ratios (and digestive physiology) favour pig and poultry production, but also milk production from cattle, over beef production. Whichever line of production is favoured it is hard to imagine that the expansion of intensive feeding systems can be based on grain when the continent as a whole is short of grain for human consumption. The availability of alternative feeds, in particular by-products, is therefore crucial.

In comparison with the industrialized countries the by-products from grain-milling are less important in Tropical Africa because much of the grain is directly consumed on the farm. The situation is favoured on the other hand by the availability of tropical products and by-products. Table 9.8 shoes the estimated availability of all by-products that could be used for livestock feeding.

According to the evaluation, some 18 million t (DM) of agro-industrial by-products could be mobilized for animal feeds in Tropical Africa. Their average energy and DCP values would be 0.68 FU and 96 g/kg of DM respectively, amounting to nearly 12 000 million FU. Theoretically this is enough to fatten 13-14 million cattle or one tenth of the total cattle herd for a three-month period every year. More detailed estimates which consider also the regional availability of by-products in certain combinations and forms show considerable variation among the country groups but reach similar overall totals. The largest potential is with sugar cane areas. In actual practice only a small proportion of agro-industrial by-products available in Tropical Africa is at present used for these purposes. For the most part, the use of by-products in animal feeds is restricted to commercial poultry enterprises, some experimental stations and a few commercial ranches, together with extension schemes for small mixed farming enterprises launched under agricultural development programmes. The remaining balance is either used for other purposes or is simply wasted, while projects to promote the animal feed industry are apparently confronted with difficulties. Raw material supplies are problematic and several ingredients are imported.

Conventional by-products, in particular oilcakes and cottonseed as well as milling by-products, are traditionally exported to meet the demand from animal feed industries in developed countries. Non-conventional by-products, on the other hand, are being used as fuel (bagasse, cotton and groundnut hulls), as fertilizer or as a raw material for industry. Molasses can be used for making alcohol (rum) and vinegar, or for surfacing roads. Bagasse can be used for making fibre-boards or even pulp for papermaking.

Many crop discards are wasted. In intensive sugar cane enterprises, labour and transport bottlenecks generally mean that the tops are burnt in order to facilitate the harvest. On the other hand, in situations where a large number of enterprises are spread over a wide area, recovering discards (tubers, bananas, cocoa pods) is too expensive and there are no animals available locally to consume

Table 9.8: Potential Availability and Feed Value of Main Agro-industrial By-products Suitable for Animal Nutrition in Tropical Africa 1977

By-products	Dry matter 1 000 t	Feed units[a] millions	DCP g/FU
1. Cereals and tubers	2 999	3 009	95
Milling residues	1 796	1 819	142
Wheat[b]	(946)	(1 088)	
Rice[c]	(691)	(539)	
Maize[d]	(159)	(192)	
Brewer's wastes[e]	135	101	267
Cassava wastes	1 068	1 089	0
2. Oil seeds[f]	3 271	3 401	386
Groundnut cake	1 677	1 828	
Cotton cake	607	631	
Coconut cake	508	488	
Sesame cake	348	334	
Palm kernel cake	131	120	
3. Sugar cane	7 497	3 921	21
4. Other	3 999	1 763	44
Cocoa pods	1 032	444	
Coffee pulp	801	681	
Banana discards			
Plantain	261	250	
Poyo	170	162	
Pineapple wastes	77	68	
Groundnut hulls	1 159	93	
Cotton hulls	499	65	
Total	17 766	12 094	141

a) One FU is equal to 1 863 calories for ruminants, the amount of energy obtained from a kilo of feed barley. It is the equivalent of 0.7 of a starch unit (Kellner). The maintenance ration for an adult head of cattle with a liveweight of 250 kg is estimated at 2.5 feed units (FU) per day and 150 g of digestible crude protein (DCP)

b) Imported and locally produced wheat

c) Locally produced rice

d) Imported maize only

e) Industrial breweries

f) Assuming all seed production is converted into oil and cake

Source: ILCA (1979e).

them. A similar problem arises where the recovery of brewers' grains, pineapple waste or other processed fruit pulps is concerned. Most of the by-products are perishable. Undoubtedly they could be preserved by drying or ensiling, but this would involve rather high processing and transport costs. Ensiling, in particular, implies a combination of farming conditions which is not generally found in Tropical Africa.

Thus, in view of both the processing and the opportunity costs (alternative uses), the utilization of agro-industrial by-products in animal feeds does not yet appear to be generally profitable in Tropical Africa. The opportunity costs of conventional by-products can be estimated on the basis of export unit values. Bran and other milled products sold by African countries were 10 US cents per kilo in 1977 and 15 cents for oilcakes. On the basis of export unit values and domestic meat prices, the price ratios of beef/animal feeds are still lower in most African countries than they are in developed countries, where fattening is mostly intensive.

Meat prices are, however, rising rapidly as supply continues to be short and as demand rises with general economic development. Trade flows of by-products to livestock producers in the industrialized countries then lose their economic justification and more expanded use for livestock production in Tropical Africa should be possible. But this is not an automatic outcome of trends. Nigeria which has the highest meat prices of any African countries has resorted to meat imports mainly from South America while crop by-products continue to be exported on a large scale. Conscious development efforts are apparently required in addition to general economic conditions to establish an intensive livestock production industry based on the feeding of by-products.

10 Conclusions for Livestock Development Planning

This study has focussed on a consideration of livestock production and of livestock development in the context of ecological zones and livestock production systems. Its aim of improving the planning base for livestock development could only be pursued on that level. But development planning most importantly takes place on the national level, i. e. for countries or political units rather than production systems or ecological units and has to be carried out by national authorities. It therefore is appropriate to direct the concluding remarks to some of the implications in principle of this study for national development planning. This is done by outlining the importance of national planning for livestock development (section 10.1), by elaborating on some strategy issues that specifically arise for national planning as a result of considering livestock by production system (section 10.2) and by pointing to some of the limitations of planning for livestock development (section 10.3).

10.1 The Importance of Planning for Livestock Development

Livestock development involves the growth of aggregates like the production of meat, milk and eggs. Structural changes within production systems in production technology, in marketing and processing, in farm organization, in attitudes and the like and changes in the relative place of different production systems in the course of time may be more essential characterisitics of development, but it can be accepted that growth rates in the aggregates mentioned are important targets in development planning and important outcomes of development efforts.

There are no objective and universally applicable criteria for the desirable or necessary growth rates in an economy; i. e. for the planning targets. But there are a number of plausible considerations from which orders of magnitude can be derived, e. g. that production should keep pace with the growth of internal demand as determined by growth of the human population and growth in per caput incomes.* Population growth rates up to the year 2000 are rather uniformly predicted to lie between 2.5 and 3.0 per cent per annum for the countries in Tropical Africa.

* The growth rates used in the following are largely those of the United Nations and its agencies and of the World Bank as summarized by de Montgolfier-Kouévi and Vlavonou (1981).

Economic growth rates can be expected to vary much more. If trends from the past are weighted and extrapolated per caput incomes would grow at an average of 1.5 to 2.0 per cent per annum in real terms over the same period. Income elasticities of demand for livestock products are estimated at close to unity (which probably constitutes an underestimate, compare section 4.1.2). These elements combine for a growth rate of internal demand for livestock products of about four to five per cent per annum. At this rate total demand increases two- to threefold until the year 2000. This sets the orders of magnitude for production targets in international planning exercises like the FAO study AT 2000 (1979). Grosso modo the targets for livestock development in Tropical Africa are set between a twofold and threefold production increase between 1975 and the year 2000. They are modest targets in the sense that they only aim at keeping pace with demand and at maintaining self-sufficiency ratios. They are ambitious targets in the sense that they aim far above the performance levels achieved in the past (section 4.1.1).

There is no reason to believe that the implied dramatic increases in the growth rates of production could happen in an automatic and autonomous process within the production systems. Rather the targets call for huge organized efforts to act on these production systems. Investment requirements alone are estimated to increase ten-fold over the level in the past.* The size of the development task is closely related to the size of the planning task to mobilize the resources, to identify development paths, to determine priorities and to direct efforts on all levels.

International plans like those of the UN or FAO have an important function in outlining the challenge, pointing to development paths and stimulating the national authorities and the international aid community. But they cannot substitute for national planning. It is at this level that information on the production potential takes on concrete forms to which fundamental policy decisions can be related. Such decisions refer to overall objectives of the development

* As one indicator FAO (AT 2000 1979) estimates that to achieve a trebling of livestock production by the year 2000 investments of $ 8 billion in 1975 prices are required. This compares to investments in the livestock sector between 1960 and 1975 of about $ 600 million (Wissocq 1978; see also section 4.1.1).

process, targets within that process, regional and sectoral emphases, the place of a subsector like livestock production and the basic policy instruments to be used. The combination of information and decision at the national level translates into specific and directed development measures more often than not cast in the form of development projects. Such projects situated at the level of production systems require further planning efforts. Tactical questions of development have to be addressed that concern the project targets, its instruments and organization and its likely impact on the production system concerned, in short the questions of project design.

This study has dealt with the whole region of Tropical Africa. The sequence of the approach from the assessment of the resource base and production status by country, ecological zone and production system is in principle that of a national planner as well, i. e. from the strategic to the tactical levels of development*. But the information provided in this study on the different levels by necessity is still insufficient for a concrete national planning exercise. The information on the resource base and production status which gives a first delimitation of the production potential would need to be expanded, tested for the specific conditions within a country and refined. Similarly the large classes of production systems examined would need to be differentiated according to the specific types prevailing in a country and set against the specific development experience, which modifies the development possibilities as outlined for the large classes of system. Furthermore the policy decisions on overall objectives, sectoral strategies and basic instruments would intervene on the national level.

Thus this study can only provide a framework and a starting point for national livestock development planning. Some of the information given on resources and production, production systems and development possibilities may be used directly in national plans, but for the most part the information has to be gathered locally. The contribution of this study then lies in the outline of the approach and of the concepts required to identify the type of data needed and to order information in a way useful for development planning and implementation.

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* The differentiation of policy and strategy levels versus tactical levels that are those of project design is taken from Marglin (1967).

10.2 Production Systems and Strategy Issues in Livestock Development Planning

Production systems are closely related with development planning on the tactical level; project design must take account of the specific characteristics of the production systems affected. But viewing livestock development by production system raises specific issues also on the strategic level. Essentially they concern the relative place of the different production systems in the process of development. The discussion of development possibilities by production system by necessity neglects that aspect, which, however, becomes one of central importance for livestock development planning at the national level.

Only in the simplest (and unrealistic) case would livestock development as measured by growth in some aggregate like value-added of the sector or production of livestock foods result in a parallel expansion of all existing systems in a country. It is more realistic to conceptualize a starting point for a country characterized by its overall resource base and production status and by a composite of production systems in operation and an endpoint (the planning horizon) which differs not only in its overall resource and production status but also in the set of production systems then prevailing. In this process the individual production systems change, and change in different time sequences and dimensions. New production systems complement and replace existing ones. The consequences for livestock development planning may be referred to as specific livestock strategy issues. These strategy issues can be put in the form of various choices which in reality are interdependent but can conceptually be separated for clarification. The weight of the different issues and the actual choice made is likely to be different in each country. Treatment can therefore only be given in an exemplary way.

<u>Traditional systems versus new systems</u>: In the aggregate view the pastoral range-livestock systems, the crop-livestock systems in the different ecological zones and farm-yard pig and poultry production class as traditional systems while ranching and the intensive landless livestock production are modern systems. The strategy choice of which class of system to promote is largely determined by the baseline situation in a country. A country dominated by traditional pastoralism will hardly be able to completely ignore that system. A densely populated country simply does not have the option of going for ranching development and a country practically

void of livestock, as some humid countries in Central Africa, does not have to concern itself much with existing traditional livestock production systems.

The question of traditional versus new systems can be formulated in another way yet. Some production systems of a more or less traditional nature normally exist in practically all countries. Alongside these may be modern systems representing recent introductions. The strategy choice is among the alternatives of

- improving traditional production and expanding these systems;

- improving and expanding existing modern forms of production;

- introducing new and modern systems to exist alongside traditional ones;

- introducing capital and technology into traditional systems at such a rate that complete transformation into modern production systems is achieved.

Combinations of approaches are the most likely outcome of this type of strategic considerations at the country level. Improvement of traditional systems is usually an economic and political necessity but modern systems of production can play an important role in victualling urban centres. Intensive livestock systems to be profitable often have to be based on a demand from higher income groups for high-quality products. They cannot normally be provided by traditional systems and the rapid growth rates of urban demand normally outpace their development capacity. There will therefore often be a case for a dual livestock development strategy that emphasizes very modern production systems as well as traditional systems, that employs different instruments and that assigns different objectives to the two development paths.

Expansion versus improvement: Livestock development without formal planning and unassisted by organized development efforts has in the past largely resulted in the numeric increase of herds and flocks, i.e. an expansion of traditional systems without any productivity improvement. The scope for further expansion is extremely limited in the arid zone and in densely populated areas of other zones but there are still large areas of low population density. To allow such expansion into new areas, however, means missing an opportunity. It is at the point of claiming land and taking it into production that improvements are most easily introduced and, if necessary, enforced.

The alternative of expansion versus improvement is closely connected to the alternative of low potential versus high potential areas. The arid zone with limited technical possibilities for improvement and a low resource potential under population pressure offers least room for manoeuvre. Areas with a high natural potential and low population densities have the biggest scope for increasing production and for instituting measures to raise productivity.

Improvement in productivity on the national level can also be obtained by increasing the share of highly productive production systems. A strategy that allows traditional systems to expand with negligible productivity increases and that also actively promotes the modern sector of ranching or of landless systems based on intensive feeding may achieve noticeable improvements in national averages. In this form the strategy issue of improvement versus expansion is obviously inseparable from that of traditional versus modern systems.

Continual versus discontinual development: Development can be viewed as a continual process by which e. g. a traditional pastoralist gradually improves production techniques, increases output and eventually reaches a productivity level not far from that of a modern rancher, or by which a farm-yard poultry holder expands and intensifies his operations to be eventually the owner of a modern hatchery. The view of development as such a continual process is connected to the notion of a long-term, gradual and 'organic' process which, while being vague, is attractive because it suggests painlessness. But even a cursory look at the process of economic development in today's industrialized countries and at the more recent experience in the developing world gives little indication of painless and 'organic' processes. There is no logical ground either that there should be. Disruption of production systems, collapse, human misery and large-scale dislocation of people stand alongside with extremely rapid rises of production and productivity and accumulation of wealth in other areas, possibly within the same country. Development planning will try to reduce these differences but the countries can hardly afford to lose development opportunities that certain production systems provide or waste resources on others without development potential.

Some livestock production systems have a capacity for rapid development. The dairy farms in the Kenyan highlands are an example. In such cases there is no reason in principle not to induce radical institutional changes like land adjudication, not to build up a modern infrastructure or not to promote massive infusion of capital. High levels of productivity may be rapidly reached and the process is more one of transformation than of improvement and continual change.

But if systems exist for which the transformation approach is suitable there are others whose lack of development capacity has to be recognized. Examples are highland subsistence farming on eroded land under extreme population pressure as found in the famine areas of Wollo in Ethiopia or pastoral systems under resource pressure in Somalia, northern Kenya or the Sahel. These are waiting rooms for development, waiting rooms in the sense that development has to take place elsewhere and that measures to prevent the worst of human misery and to encourage outmigration are the most appropriate strategy choice.

Selective versus comprehensive approaches: Development efforts need not necessarily touch on all aspects of a production system but may have more reduced targets. It may only be one commodity, one species, or one function of livestock that is of interest. Development approaches may also be selective in the instruments applied: To improve the marketing infrastructure only; to rely largely on a price policy; or to concentrate on credit schemes. The combination of selected targets and selected instruments and their variation over time and their variation among the different livestock production systems produce a wide array of development approaches. Thus initially the commodity view may stand in the foreground for modern production systems, or infrastructural and institutional measures without any immediate production impact in a pastoral environment. At a later stage the commodity focus may also be applied to the pastoral system accompanied by suitable production development efforts. For subsistence crop-livestock systems in the highlands initial efforts may be directed towards commercial dairy development to create attractive conditions for the introduction of high-yielding but costly and sensitive breeds. Only at a later stage would attention move to meat production from male calves, to the intensification of the manure economy and to the use of cross-bred offspring for traction.

For certain production systems general education and infrastructure are necessary to prepare the way. Such measures may have priority over production-oriented ones for a long time. This may apply to many pastoral societies. The intricate role of livestock in the social and cultural spheres may constitute an obstacle for production development that cannot be overcome by conventional and direct measures aimed at production. But education which changes the outlook on life, the availability of consumer goods, which creates new aspirations, and the acceptance of banks for savings rather than buying cattle may affect the organization of land use much more profoundly in the long run.

The place of livestock: An essential task of a development strategy is to determine sectoral weights and thus also the weight to be given to the sector 'livestock production'. This is not done in a top-down, once-and-for-all manner. Initial tentative guidelines on the strategic level are carried to the tactical level of projects and production systems. Constraints and opportunities found there lead through a feed-back process to revision of initial decisions. In this process the type of strategic issues arising from the existence of different production systems as outlined above intervene to reduce or increase the scope for livestock development. The appropriate relative place of livestock in an overall agricultural development plan can therefore only be determined once a whole range of strategic and tactical issues in crop and livestock development have been taken up.

The question about the relative place of livestock not only arises at the sectoral level but also at the level of production systems. The development of crop production under irrigation may constitute the most appropriate "livestock" development strategy in over-used areas of the arid zone; intensification of cropping through the application of fertilizers may be the most promising point of entry for developing crop-livestock production systems in densely populated highland areas. Not always will those interested in livestock want to prevail with a livestock-oriented development approach. Livestock production is part of agricultural production and it may well be in the interest of overall agricultural development to leave out livestock from development measures in certain situations.

10.3 The Role of Monitoring for Livestock Development Planning and for this Study

A major aim for this study has been the reduction of complexity associated with livestock production and development. Possibly a more correct expression would have been 'the transformation of seeming chaos into orderly complexity'. Planning for livestock has been shown to be extremely complex in spite - or may be because - of the attempt to elaborate a more systematic view of livestock production in Tropical Africa. In the last analysis there is no logical reason why complex phenomena could always be adequately represented by simple models, why complex questions could be substituted by simple ones, and why a complex task could be achieved by a straight-forward approach. Planning for livestock development remains a complex task compounded by the generalized lack of data. Massive data collection exercises are not a suitable answer because they are costly and time-consuming. More importantly, additional data are not equivalent to additional information and additional information is not equivalent to better planning. And there remains the basic question about the correlation between plan and reality or planning efforts and development achievements.

It is a basic contention of this study that the size of the task of livestock development and the complexity of the planning object, livestock production, render the task of livestock development planning a large and a complex one, and one to which considerable efforts must be devoted. At the same time it is realized that planning exercises also have to be judged by their costs and benefits. They use up scarce time and talents and these costs have to be compared to the benefits eventually realized from the implementation of the plan. If planning efforts are conceived of as such 'production' exercises (the product is not the plan but the benefits from its implementation) they can be conceived to be exercises with a falling marginal return from a point on. It can also be postulated that this point is reached earlier, and the fall in the marginal return is more rapid, the more the planning object is characterized by dynamic interactions, lack of quantitative information about direction and magnitude of these interactions and by uncertainty. These characteristics apply to livestock production in Tropical Africa to a high degree.

The exposure to the vagaries of climate is direct and more consequential in terms of risk the more arid the zone (and therefore the more livestock production becomes the exclusive form of land use). Diseases, it might be argued, strike crop and livestock production in an equally unpredictable manner but unique to livestock is the intricate way in which production decisions are interwoven with the human environment. The subsistence requirements and the income aspirations on one side and resource availability and constraints on the other go a long way in explaining a farmer's decisions in crop production. They only provide one segment of a large spectrum of explanations of decision-making for a pastoralist. A cultivator's decisions about the livestock he keeps for dung as fuel, for traction work in the field to reduce the drudgery of labour, for transport, as an asset and for pleasure can be explained in many ways but possibly the least by subsistence and income objectives. And as organized development efforts are undertaken one and the same measure will show quite different and often unpredictable consequences in the different production systems. The development of arable farming under irrigation in an arid environment may be a technical success and reduce the need to obtain subsistence via livestock from the over-used range but the livestock population on the range may increase over previous levels because all the cultivators now invest their surplusses from cropping in livestock. The introduction of a dairy cow into a highland dairy farm may have been carefully calculated for its economic attractiveness and found marginal; yet the farmers respond enthusiastically and it is only later found that the major reason lies in the yield-raising effect of manure on the coffee trees.

Under such conditions it is a rational strategy to rely less on planning and more on monitoring as a context for information gathering and as an instrument of directing change in the desired directions.

Monitoring - probably an unfortunate term because it bears associations to admonishment, surveillance and other sinister concepts - simply means the collection of data in the course of an on-going development process to understand better the systems under change, to allow timely mid-course correction of the development approach and to contribute to its overall evaluation at a suitable point in time (Jahnke and von Oven 1980). Monitoring in this sense can play an important role as a management information system, as a tool in project evaluation and - maybe most importantly - as an instrument of development policy and strategy; it connects planning with implementation and provides the necessary feed-back to improve planning in the long run both on the tactical and the strategic level.

Monitoring of complex processes in a situation of deficient ex-ante information and great uncertainly about the behaviour of the system undergoing change, as is the case with livestock development, might have rising or constant marginal returns when planning already shows decreasing returns. Almost certainly the marginal returns fall less rapidly than in planning. There is not normally an exact solution to the task of a rational allocation of scarce planning resources between conventional planning and monitoring because the respective returns cannot be adequately quantified. But conceptually the task remains and can guide planning considerations.

To improve the planning base for livestock development has been the aim of this study. Modesty about the achievement is called for. Some of the information provided may be useful but a great deal of it is beset with inaccuracies and often the level of aggregation is too high to be directly useful for concrete planning exercises. The basic approach from the assessment of the resource potential to the identification and characterization of production systems and to the assessment of their development possibilities is believed to have general application. But subjectivity in the selection of key elements, in the use of development experience and in the interpretation of results by necessity intervenes and the development inferences drawn have to be qualified accordingly. On the other hand it will be a long time before a statistical apparatus covers the countries and the continent concerned and supplies all the information one would like to have for development planning; it is in fact doubtful for practical and logical reasons whether such a situation can ever be reached. The improvement of the planning-base - and also the improvement of the contribution this present study can make - is critically dependent on an improved understanding of development processes and here monitoring has a key role to play. Monitoring needs to be foccussed and has to concentrate on major themes in order not to develop into massive and costly data collection exercises with few tangible results in the end. If this study is useful for the formulation of specific development hypotheses for livestock production systems which can be empirically tested in the context of monitoring exercises it has probably achieved all that one can reasonable hope for. It is in this modest sense that improvement of the planning base for livestock development in Tropical Africa as the major aim of this study has to be seen.

ANNEX

Annex Table 1: The Ruminant Livestock Population in Tropical Africa by Country 1979
(1 000 Head/1 000 TLU[a])

Country	Camels	Cattle	Sheep	Goats	TLU
Angola	-	3 120	220	930	2 299
Benin	-	800	950	950	750
Botswana	-	3 300	450	1 200	2 475
Burundi	-	836	336	585	677
Cameroon	-	3 027	2 211	1 720	2 512
Centr. Afr. Rep.	-	670	80	780	555
Chad	410	4 070	2 278	2 278	3 715
Congo	-	71	66	119	69
Djibouti	25	32	310	520	130
Eq. Guinea	-	4	34	8	7
Ethiopia	966	25 900	23 234	17 120	23 131
Gabon	-	3	100	90	21
Gambia	-	280	95	92	215
Ghana	-	930	1 650	2 000	1 016
Guinea	-	1 700	430	395	1 273
Guinea Bissau	-	264	73	183	210
Ivory Coast	-	650	1 150	1 200	690
Kenya	550	10 470	4 000	4 500	8 729
Liberia	-	38	190	190	65
Madagascar	-	8 744	658	1 583	6 345
Malawi	-	790	140	860	653
Mali	206	4 459	6 067	5 757	4 512
Mauretania	720	1 600	5 200	3 250	2 685
Mozambique	-	1 380	105	330	1 010
Namibia	-	3 000	5 150	2 150	2 830
Niger	330	2 995	2 500	6 400	3 317
Nigeria	17	12 000	8 500	24 500	11 715
Rwanda	-	640	257	786	553
Senegal	4	2 806	1 884	1 000	2 256
Sierra Leone	-	270	60	175	213
Somalia	5 400	3 800	10 000	16 000	10 660
Sudan	2 500	17 300	17 200	12 200	17 550
Tanzania	-	15 300	3 000	4 700	11 480
Togo	-	250	835	748	334
Uganda	-	5 367	1 068	2 144	4 078
Upper Volta	5	2 700	1 800	2 700	2 345
Zaire	-	1 144	779	2 783	1 157
Zambia	-	1 800	51	300	1 295
Zimbabwe	-	5 000	754	2 061	3 781
Total	11 135	147 510	103 865	125 287	137 308

a) TLU = Tropical Livestock Unit
(Camels : 1.0; Cattle : 0.7; Sheep/Goats : 0.1)

Source: FAO (Production Yearbook 1979).

Annex Table 2: The Equine, Pig and Chicken Population in Tropical Africa by Country 1979
(1 000 Head)

Country	Horses	Mules	Asses	Pigs	Chickens
Angola	1	-	5	380	5 300
Benin	6	-	1	470	3 500
Botswana	9	2	40	22	620
Burundi	-	-	-	51	3 032
Cameroon	61	-	78	806	10 352
Centr. Afr. Rep.	-	-	1	128	1 433
Chad	154	-	271	6	2 940
Congo	-	-	-	49	1 000
Djibouti	-	-	5	-	-
Eq. Guinea	-	-	-	8	85
Ethiopia	1 530	1 446	3 885	18	52 956
Gabon	-	-	-	6	1 703
Gambia	-	-	4	9	260
Ghana	4	-	25	400	11 500
Guinea	1	-	3	37	5 500
Guinea Bissau	-	-	3	175	390
Ivory Coast	1	-	1	320	11 000
Kenya	2	-	-	65	17 500
Liberia	-	-	-	100	2 200
Madagascar	2	-	-	580	14 082
Malawi	-	-	-	174	8 000
Mali	180	-	489	31	10 884
Mauretania	23	-	220	-	3 000
Mozambique	-	-	20	110	17 500
Namibia	45	6	66	36	450
Niger	230	-	440	-	7 600
Nigeria	250	-	700	1 100	11 000
Rwanda	-	-	-	83	872
Senegal	271	-	202	182	7 306
Sierra Leone	-	-	-	35	3 600
Somalia	1	23	23	9	2 800
Sudan	20	1	680	8	26 000
Tanzania	-	-	160	25	20 700
Togo	3	-	1	275	2 900
Uganda	-	-	16	225	13 100
Upper Volta	90	-	180	170	11 000
Zaire	1	-	-	753	12 411
Zambia	-	-	1	180	14 000
Zimbabwe	15	1	97	218	8 704
Total	2 899	1 478	7 618	7 244	426 180

Source: FAO (Production Yearbook 1979).

Annex Table 3: General Agricultural Indicators of Tropical Africa by Country 1979

Country	Agricultural land[a] (1 000 ha)	Agricultural population (1 000 persons)	Land-man-ratio[b] (ha/person)	Livestock-m ratio[c] (TLU/perso
Angola	30 830	4 024	7.7	0.6
Benin	1 017	1 585	0.6	0.5
Botswana	45 360	646	70.2	3.8
Burundi	1 712	3 658	0.5	0.2
Cameroon	15 690	6 691	2.3	0.4
Centr. Afr. Rep.	5 910	1 903	3.1	0.3
Chad	46 950	3 729	12.6	1.0
Congo	14 967	524	28.6	0.1
Djibouti	245	116	2.1	1.1
Eq. Guinea	334	267	1.3	0
Ethiopia	78 230	25 320	3.1	0.9
Gabon	5 199	418	12.4	0
Gambia	595	460	1.3	0.5
Ghana	13 420	5 894	2.3	0.2
Guinea	7 170	3 941	1.8	0.3
Guinea Bissau	1 565	466	3.4	0.5
Ivory Coast	11 800	6 171	1.9	0.1
Kenya	6 540	12 318	0.5	0.7
Liberia	611	1 268	0.5	0
Madagascar	36 929	7 148	5.2	0.9
Malawi	4 138	5 029	0.8	0.1
Mali	32 050	5 653	5.7	0.8
Mauretania	39 445	1 323	29.8	2.0
Mozambique	47 080	6 671	7.1	0.2
Namibia	53 562	482	111.1	5.9
Niger	12 412	4 556	2.7	0.7
Nigeria	44 840	40 420	1.1	0.3
Rwanda	1 460	4 183	0.3	0.1
Senegal	244	4 135	0.1	0.5
Sierra Leone	2 770	2 224	1.2	0.1
Somalia	29 916	2 852	10.5	3.7
Sudan	31 515	13 828	2.3	1.3
Tanzania	7 665	14 179	0.5	0.8
Togo	1 620	1 793	0.9	0.2
Uganda	10 610	10 421	1.0	0.4
Upper Volta	5 646	5 519	1.0	0.4
Zaire	31 003	20 582	1.5	0.1
Zambia	35 058	3 678	9.5	0.4
Zimbabwe	7 336	4 233	1.77	0.9
Total/average	723 444	238 308	3.0	0.6

a) Agricultural land = arable and permanent crop land plus permanent pastures.
b) Agricultural land divided by agricultural population.
c) Ruminant livestock population divided by agricultural population.

Source: FAO (Production Yearbook 1979).

Annex Table 4: Extent of Ecological Zones in Tropical Africa by Country 1979 (1 000 sqkm)

Ecologic. zone / Country	Total land area	Arid	Semi-arid	Sub-humid	Humid	High-lands
Angola	1 246.7	53.4	274.9	708.1	94.4	115.9
Benin	110.6	-	30.8	76.6	3.2	-
Botswana	585.4	432.2	153.1	-	-	-
Burundi	25.6	-	-	6.0	0.5	19.1
Cameroon	469.4	-	43.2	91.5	323.9	10.8
Centr. Afr. Rep.	623.0	-	30.5	287.8	304.7	-
Chad	1 259.2	871.4	311.C	76.8	-	-
Congo	341.5	-	-	11.3	330.2	-
Djibouti	22.0	22.0	-	-	-	-
Eq. Guinea	28.0	-	-	28.0	-	-
Ethiopia	1 101.1	490.0	111.2	84.9	-	415.0
Gabon	257.7	-	-	-	257.7	-
Gambia	10.0	-	10.0	-	-	-
Ghana	230.0	-	10.1	102.8	117.1	-
Guinea	245.8	-	5.9	197.6	43.3	-
Guinea Bissau	28.0	-	1,2	26.8	-	-
Ivory Coast	318.0	-	-	111.3	206.7	-
Kenya	569.3	425.3	52.4	11.4	-	80.2
Liberia	96.3	-	-	-	96.3	-
Madagascar	581.5	44.8	116.3	225.6	177.4	17.4
Malawi	94.0	-	19.7	61.1	9.0	4.2
Mali	1 220.0	847.9	320.9	51.2	-	-
Mauretania	1 030.4	1.011.9	18.5	-	-	-
Mozambique	765.5	90.3	323.8	321.5	29.9	-
Namibia	823.2	631.9	135.0	-	-	56.3
Niger	1 266.7	1 204.6	62.1	-	-	-
Nigeria	910.8	14.6	323.3	403.5	165.8	3.6
Rwanda	24.9	-	-	6.5	1.1	17.3
Senegal	192.5	23.7	150.7	18.1	-	-
Sierra Leone	71.6	-	-	8.3	63.3	-
Somalia	627.3	624.9	0.7	-	-	1.7
Sudan	2 376.0	1 356.7	591.6	332.6	23.8	71.3
Tanzania	886.0	94.8	258.7	414.7	16.8	101.0
Togo	54.4	-	2.1	37.8	14.5	-
Uganda	199.7	0.9	33.3	99.6	53.1	12.8
Upper Volta	273.8	17.0	195.2	61.6	-	-
Zaire	2 267.6	-	-	412.7	1 805.0	49.9
Zambia	740.7	-	238.5	488.1	-	14.1
Zimbabwe	387.7	68.6	224.9	94.2	-	-
Total	22 361.9	8 327.0	4 049.6	4 858.0	4 136.7	990.6

Source: FAO (Production Yearbook 1979), FAO (Higgins et al 1978) and own estimates.

Annex Table 5: Extent of Tsetse Infestation in Tropical Africa by Ecological Zone by Country (1 000 sqkm)

Country \ Ecological zone	Total infested area	Arid	Semi-arid	Sub-humid	Humid	High-lands
Angola	377.0	11.7	162.7	190.6	10.1	1.9
Benin	110.6	-	30.8	76.6	3.2	-
Botswana	24.6	-	24.6	-	-	-
Burundi	25.6	-	-	6.0	0.5	19.1
Cameroon	423.4	-	11.3	91.5	309.8	10.8
Centr. Afr. Rep.	623.0	-	30.5	287.8	304.7	-
Chad	1 259.2	871.4	311.0	76.6	-	-
Congo	341.5	-	-	11.3	330.2	-
Djibouti	-	-	-	-	-	-
Eq. Guinea	26.0	-	-	-	26.0	-
Ethiopia	99.0	2.2	12.1	39.6	-	45.1
Gabon	257.7	-	-	-	257.7	-
Gambia	10.0	-	10.0	-	-	-
Ghana	230.0	-	10.1	102.8	117.1	-
Guinea	245.6	-	5.9	197.6	42.3	-
Guinea Bissau	26.0	-	1.2	26.8	-	-
Ivory Coast	318.0	-	-	111.3	206.7	-
Kenya	96.2	46.1	33.6	4.0	-	12.5
Liberia	96.3	-	-	-	96.3	-
Madagascar	-	-	-	-	-	-
Malawi	61.1	-	-	61.1	-	-
Mali	229.3	-	178.1	51.2	-	-
Mauretania	-	-	-	-	-	-
Mozambique	570.3	23.7	245.7	273.3	27.6	-
Namibia	1.7	-	1.7	-	-	-
Niger	32.9	2.5	30.4	-	-	-
Nigeria	771.2	7.2	263.2	337.9	159.3	3.0
Rwanda	24.9	-	-	6.5	1.1	17.3
Senegal	88.5	-	84.7	3.6	-	-
Sierra Leone	71.6	-	-	8.3	63.3	-
Somalia	28.9	26.9	-	-	-	-
Sudan	287.5	-	59.4	225.7	-	2.4
Tanzania	640.6	36.3	205.6	374.8	-	23.9
Togo	54.2	-	2.1	37.7	14.4	-
Uganda	113.3	-	-	73.9	36.2	3.2
Upper Volta	211.6	-	150.0	61.6	-	-
Zaire	2 158.8	-	-	374.2	1 734.7	49.9
Zambia	300.0	-	109.6	185.2	-	5.2
Zimbabwe	70.1	8.1	62.0	-	-	-
Total	10 308.4	1 038.1	2 036.3	3 297.9	3 741.2	194.9

Note: As explained in the text the figures of tsetse infestation can be assumed to constitute a significant overestimate. The use of this table should therefore be limited to comparative assessments of infestation in the different ecological zones.

Source: Own estimates on the basis of Ford and Katondo (1973) and FAO (Higgins et al 1978).

Annex Table 8: Distribution of Human Agricultural Population in Tropical Africa by Ecological Zone by Country 1979
(1 000 Persons)

Ecologic. zone / Country	Total	Arid	Semi-arid	Sub-humid	Humid	High-lands
Angola	4 024	302	1 220	711	378	1 413
Benin	1 585	-	172	1 413	-	-
Botswana	646	530	116	-	-	-
Burundi	3 658	-	-	-	-	3 658
Cameroon	6 691	147	1 428	580	4 452	84
Centr. Afr. Rep.	1 903	-	166	927	810	-
Chad	3 729	1 313	1 923	493	-	-
Congo	524	-	-	73	451	-
Djibouti	116	118	-	-	-	-
Eq. Guinea	267	-	-	-	287	-
Ethiopia	25 320	1 421	10 994	1 240	633	11 032
Gabon	418	-	-	-	418	-
Gambia	460	-	460	-	-	-
Ghana	5 894	-	-	1 547	4 347	-
Guinea	3 941	-	55	2 782	1 104	-
Guinea Bissau	468	-	238	228	-	-
Ivory Coast	6 171	-	-	4 616	1 555	-
Kenya	12 318	2 888	374	-	-	9 056
Liberia	1 268	-	-	-	1 268	-
Madagascar	7 148	579	751	3 020	2 246	552
Malawi	5 029	-	-	5 029	-	-
Mali	5 653	527	4 606	520	-	-
Mauretania	1 323	1 005	318	-	-	-
Mozambique	6 671	407	3 689	2 348	227	-
Namibia	482	85	353	-	-	44
Niger	4 556	3 070	1 486	-	-	-
Nigeria	40 420	293	17 043	-	11 955	11 129
Rwanda	4 183	-	-	-	-	4 183
Senegal	4 135	555	3 572	8	-	-
Sierra Leone	2 224	-	-	623	1 601	-
Somalia	2 852	2 819	-	-	-	33
Sudan	13 828	7 231	3 084	3 250	263	-
Tanzania	14 179	567	5 258	4 759	-	3 595
Togo	1 793	-	-	1 560	233	-
Uganda	10 421	-	135	4 304	3 564	22 943
Upper Volta	5 519	57	4 681	781	-	-
Zaire	20 582	-	-	3 462	15 419	1 701
Zambia	3 678	-	1 497	2 037	-	-
Zimbabwe	4 233	941	2 116	1 176	-	-
Total	238 308	24 853	65 735	59 442	50 307	37 971

Note: Rough estimates only.

Source: Based on FAO background material to AT 2000 and FAO (Production Yearbook 1979)

Annex Table 7: Distribution of Cattle in Tropical Africa by Ecological Zone by Country 1979 (1 000 Head)

Country \ Ecologic. zone	Total	Arid	Semi-arid	Sub-humid	Humid	Highlands
Angola	3 120	624	874	842	62	718
Benin	800	-	288	512	-	-
Botswana	3 300	2 708	594	-	-	-
Burundi	836	-	-	-	-	838
Cameroon	3 027	82	920	1 771	188	66
Centr. Afr. Rep.	870	-	141	154	375	-
Chad	4 070	2 078	1 913	81	-	-
Congo	71	-	-	9	62	-
Djibouti	32	32	-	-	-	-
Eq. Guinea	4	-	-	-	4	-
Ethiopia	25 900	3 826	3 626	3 628	1 554	13 468
Gabon	3	-	-	-	3	-
Gambia	280	-	280	-	-	-
Ghana	930	-	-	372	558	-
Guinea	1 700	-	51	-	1 530	119
Guinea Bissau	264	-	88	176	-	-
Ivory Coast	650	-	-	585	65	-
Kenya	10 470	3 036	523	-	-	6 911
Liberia	38	-	-	-	38	-
Madagascar	8 744	1 513	3 148	1 906	1 887	490
Malawi	790	-	-	790	-	-
Mali	4 459	2 229	2 140	90	-	-
Mauretania	1 600	1 312	288	-	-	-
Mozambique	1 380	489	483	359	69	-
Namibia	3 000	1 455	1 275	-	-	270
Niger	2 995	2 450	545	-	-	-
Nigeria	12 000	240	8 700	1 795	857	408
Rwanda	640	-	-	-	-	640
Senegal	2 806	589	2 217	-	-	-
Sierra Leone	270	-	-	178	92	-
Somalia	3 800	3 420	-	-	-	380
Sudan	17 300	3 394	6 788	6 789	329	-
Tanzania	15 300	841	4 973	6 426	-	3 060
Togo	250	-	5	-	225	20
Uganda	5 387	-	510	2 979	510	1 388
Upper Volta	2 700	68	2 133	499	-	-
Zaire	1 144	-	-	275	606	263
Zambia	1 800	-	1 251	544	-	5
Zimbabwe	5 000	1 300	1 700	2 000	-	-
Total	147 510	31 462	45 454	32 758	8 814	29 022

Note: Rough estimates only.

Source: Own estimations after World Atlas of Agriculture (1976), OAU/STRC 1976 and other sources; totals from FAO (Production Yearbook 1979) country figures.

Annex Table 8: Distribution of Sheep in Tropical Africa by Ecological Zone by Country 1979
(1 000 Head)

Ecologic. zone / Country	Total	Arid	Semi-arid	Sub-humid	Humid	High-lands
Angola	220	44	53	48	18	57
Benin	950	-	380	570	-	-
Botswana	450	369	81	-	-	-
Burundi	336	-	-	-	-	336
Cameroon	2 211	12	852	1 136	183	28
Centr. Afr. Rep.	80	-	17	18	45	-
Chad	2 278	934	1 253	91	-	-
Congo	66	-	-	8	58	-
Djibouti	310	310	-	-	-	-
Eq. Guinea	34	-	-	-	34	-
Ethiopia	23 234	2 323	3 718	1 859	1 162	14 172
Gabon	100	-	-	-	100	-
Gambia	95	-	95	-	-	-
Ghana	1 650	-	-	660	990	-
Guinea	430	-	4	340	86	-
Guinea Bissau	73	-	24	49	-	-
Ivory Coast	1 150	-	-	276	874	-
Kenya	4 000	1 240	120	-	-	2 640
Liberia	190	-	-	-	190	-
Madagascar	658	434	118	53	-	53
Malawi	140	-	-	140	-	-
Mali	6 067	4 247	1 820	-	-	-
Mauretania	5 200	4 940	260	-	-	-
Mozambique	105	36	37	27	5	-
Namibia	5 150	3 625	577	-	-	948
Niger	2 500	2 375	125	-	-	-
Nigeria	8 500	170	2 380	2 459	3 476	15
Rwanda	257	-	-	-	-	257
Senegal	1 884	471	1 394	19	-	-
Sierra Leone	60	-	-	40	20	-
Somalia	10 000	8 200	-	-	-	1 800
Sudan	17 200	6 750	6 749	3 375	326	-
Tanzania	3 000	285	1 035	990	-	690
Togo	835	-	17	785	33	-
Uganda	1 068	-	101	593	102	272
Upper Volta	1 800	72	1 440	288	-	-
Zaire	779	-	-	171	475	133
Zambia	51	-	36	15	-	-
Zimbabwe	754	226	385	143	-	-
Total	103 865	37 063	23 071	14 153	8 177	21 401

Note: Rough estimates only.

Source: Own estimates after World Atlas of Agriculture (1976) and other sources; totals from FAO (Production Yearbook 1979) country figures.

Annex Table 9: Distribution of Goats in Tropical Africa by Ecological Zone by Country 1979 (1 000 Head)

Country / Ecologic. zone	Total	Arid	Semi-arid	Sub-humid	Humid	High-lands
Angola	930	186	223	205	74	242
Benin	950	-	304	646	-	-
Botswana	1 200	984	216	-	-	-
Burundi	565	-	-	-	-	565
Cameroon	1 720	39	1 446	196	32	5
Centr. Afr. Rep.	760	-	184	179	437	-
Chad	2 276	934	1 253	91	-	-
Congo	119	-	-	15	104	-
Djibouti	520	520	-	-	-	-
Eq. Guinea	8	-	-	-	8	-
Ethiopia	17 120	6 506	3 766	856	513	5 479
Gabon	90	-	-	-	90	-
Gambia	92	-	92	-	-	-
Ghana	2 000	-	-	800	1 200	-
Guinea	395	-	4	312	79	-
Guinea Bissau	183	-	61	122	-	-
Ivory Coast	1 200	-	-	384	816	-
Kenya	4 500	2 385	315	-	-	1 800
Liberia	190	-	-	-	190	-
Madagascar	1 583	1 171	412	-	-	-
Malawi	860	-	-	860	-	-
Mali	5 757	4 030	1 727	-	-	-
Mauretania	3 250	3 067	183	-	-	-
Mozambique	330	112	115	86	17	-
Namibia	2 150	946	1 019	-	-	185
Niger	6 400	6 080	320	-	-	-
Nigeria	24 500	245	10 780	7 820	5 621	34
Rwanda	786	-	-	-	-	786
Senegal	1 000	250	740	10	-	-
Sierra Leone	175	-	-	116	59	-
Somalia	16 000	15 040	-	-	-	960
Sudan	12 200	4 787	4 787	2 394	232	-
Tanzania	4 700	259	1 668	1 880	-	893
Togo	748	-	15	688	45	-
Uganda	2 144	-	204	1 190	204	546
Upper Volta	2 700	108	2 160	432	-	-
Zaire	2 783	-	-	501	1 865	417
Zambia	300	-	208	91	-	1
Zimbabwe	2 061	618	1 051	392	-	-
Total	125 287	46 287	33 215	20 266	11 586	11 933

Note: Rough estimates only.

Source: As in Annex Table 8.

Annex Table 10: Distribution of Ruminant Livestock Units in Tropical Africa by Ecological Zone by Country 1979 (1 000 TLU)

Country / Ecologic. zone	Total	Arid	Semi-arid	Sub-humid	Humid	High-lands
Angola	2 299	460	639	615	53	532
Benin	750	-	270	480	-	-
Botswana	2 475	2 030	445	-	-	-
Burundi	677	-	-	-	-	677
Cameroon	2 512	63	874	1 372	153	50
Centr. Afr. Rep.	555	-	117	128	310	-
Chad	3 715	2 050	1 590	75	-	-
Congo	69	-	-	9	60	-
Djibouti	130	130	-	-	-	-
Eq. Guinea	7	-	-	-	7	-
Ethiopia	23 131	4 387	3 287	2 810	1 255	11 392
Gabon	21	-	-	-	21	-
Gambia	215	-	215	-	-	-
Ghana	1 016	-	-	406	610	-
Guinea	1 273	-	37	65	1 088	83
Guinea Bissau	210	-	70	140	-	-
Ivory Coast	690	-	-	476	214	-
Kenya	8 729	3 038	410	-	-	5 281
Liberia	65	-	-	-	65	-
Madagascar	6 345	1 220	2 256	1 340	1 181	348
Malawi	653	-	-	653	-	-
Mali	4 512	2 596	1 853	63	-	-
Mauretania	2 685	2 441	244	-	-	-
Mozambique	1 010	343	353	263	51	-
Namibia	2 830	1 476	1 052	-	-	302
Niger	3 317	2 891	426	-	-	-
Nigeria	11 715	227	7 403	2 284	1 510	291
Rwanda	553	-	-	-	-	553
Senegal	2 256	469	1 787	-	-	-
Sierra Leone	213	-	-	140	73	-
Somalia	10 660	10 118	-	-	-	542
Sudan	17 550	6 030	5 905	5 329	286	-
Tanzania	11 480	843	3 751	4 785	-	2 300
Togo	334	-	7	147	166	14
Uganda	4 078	-	388	2 264	388	1 038
Upper Volta	2 345	71	1 853	421	-	-
Zaire	1 157	-	-	260	658	239
Zambia	1 295	-	900	391	-	4
Zimbabwe	3 781	994	1 334	1 453	-	-
Total	137 308	41 697	37 446	28 370	8 149	23 646

Note: Rough estimates only.

Source: Annex Tables 1, 7, 8 and 9.

Annex Table 11: GDP, GDP Per Caput and Sector Contributions by Agriculture and Livestock in Tropical Africa by Country 1980 (1975 Prices)

Country	GDP[a] million $	Population[b] 1 000	GDP per caput $	Share of agriculture[c] in GDP %	Share of livestock in agric. GDP[d] %	Livestock GDP million $
Angola	3 102	7 078	438	36.0	18.6	208
Benin	619	3 530	175	37.8	11.7	27
Botswana	n. av.	n. av.	n. av.	n. av.	n. av.	n. av.
Burundi	461	4 512	102	60.8	6.0	17
Cameroon	2 602	8 444	308	31.4	9.9	81
Centr. Afr. Rep.	456	2 221	205	37.7	7.8	13
Chad	565	4 473	126	48.8	38.7	107
Congo	905	1 537	589	9.5	3.5	3
Djibouti	n. av.	n. av.	n. av.	n. av.	n. av.	n. av.
Eq. Guinea	n. av.	n. av.	n. av.	n. av.	n. av.	n. av.
Ethiopia	3 079	32 601	94	45.1	33.0	458
Gabon	3 402	551	6.174	7.6	2.2	6
Gambia	111	803	184	38.7	16.1	7
Ghana	5 500	11 679	471	38.3	4.0	84
Guinea	1 180	5 014	235	38.6	11.2	51
Guinea Bissau	n. av.	n. av.	n. av.	n. av.	n. av.	n. av.
Ivory Coast	6 068	7 973	761	21.8	2.3	30
Kenya	4 127	16 402	251	27.5	34.8	395
Liberia	897	1 863	481	26.1	5.5	13
Madagascar	2 119	11 537	184	34.5	20.7	151
Malawi	940	8 628	109	37.4	7.2	25
Mali	693	6 646	104	36.8	36.3	93
Mauretania	417	1 634	255	35.2	86.3	127
Mozambique	2 956	13 811	214	40.5	14.1	169
Namibia	n. av.	n. av.	n. av.	n. av.	n. av.	n. av.
Niger	678	5 305	128	56.8	29.8	115
Nigeria	35 941	77 082	466	24.4	11.0	965
Rwanda	514	4 797	107	53.0	5.0	14
Senegal	2 479	5 661	438	21.6	21.3	114
Sierra Leone	560	3 474	161	45.2	6.2	157
Somalia	420	3 645	115	26.1	81.8	97
Sudan	5 516	18 371	300	36.2	36.3	765
Tanzania	2 622	17 934	157	40.1	24.5	277
Togo	686	2 699	254	23.9	10.3	17
Uganda	2 635	13 201	215	46.2	14.3	195
Upper Volta	726	6 908	105	41.8	27.3	83
Zaire	2 409	28 291	85	21.5	4.0	21
Zambia	2 046	7 764	264	13.3	30.3	82
Zimbabwe	3 019	10 310	293	20.8	35.7	224
Total/average	100 650	356 179	263	29.0	17.4	5 191

a) From FAO background material to AT 2000; 1975 figures based on national accounting procedures.

b) Estimates as used by FAO (AT 2000); the 1980 estimates are consistent with the population figures in FAO (Production Yearbook 1979).

c) Based on FAO (AT 2000) projections from 1975 and corrected for the use of international prices therein; agriculture includes livestock.

d) Share of livestock in total agriculture as in FAO projections from 1975, i. e. based on international prices.

Source: See footnotes.

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254