African Feed Resources and Ruminant Production from the Ecological and Socio-Economic Viewpoint

Ralph Richard von Kaufmann*

Abstract

Africa may be broadly characterized into five ecological zones ; Arid, semi-arid, sub-humid, humid and highland. Each zone has characteristic socio-economic systems which are reflected in the livestock husbandry. The socio-economic systems of the arid zones have to be highly mobile and able to cope with periodic catastrophic droughts but the people's traditional response of moving to wetter zones is increasingly curtailed. Livestock were dominat in the traditional systems of semi-arid zones but there is increasing reliance on subsistence cropping which is encroaching on vital dry season grazing and accelerating land degradation. The sub-humid zone is currently the least stressed but the accelerated activity of immigrant small and large farmers is moving ahead of the scientific or even ethno-scientific knowledge of sustainable systems. The socio-economy of the humid zone tends to be very sedentary and livestock husbandry tends to be secondary to cultivation and based on very low input strategies. The highlands are densely populated so land is at a premium. The farm families' inability to afford inputs necessary for good husbandry when faced with adversity can initiate a worsening poverty cycle. African agriculture is under stress but solutions can be found by research on components of the traditional systems.

Introduction

Modern technology that can boost agricultural production, such as fertilizers, machinery and irrigation, is not available to the vast majority of farmers and herders in sub-Saharan Africa. Thus the people are bound to follow the dictates of the climate, weather and soils. This is particularly true of smallholders, pastoralists and agro-pastoralists who own livestock which have to be looked after every day of the year. In consequence socio-economic systems have been developed which accord with the prevailing ecology. These systems have evolved over long periods and are still changing but they are not adapting fast enough to feed rapidly expanding populations. The average inhabitant of sub-Saharan Africa is worse off now than he was a decade ago in terms of food, and income.

Production has increased in the livestock sub-sector but this has been due to increasing livestock numbers and not to increasing productivity. This leads to disastrous competition between the immediate needs of the people and their livestock and the longer term requirements for sustainable animal agriculture. There is an Africa-wide need for improved livestock feeding but the way this can be achieved will vary according to the resources locally available and the socio-economic systems.

* International Livestock Centre for Africa (ILCA), P. O. Box 5689, Addis Ababa, Ethiopia.

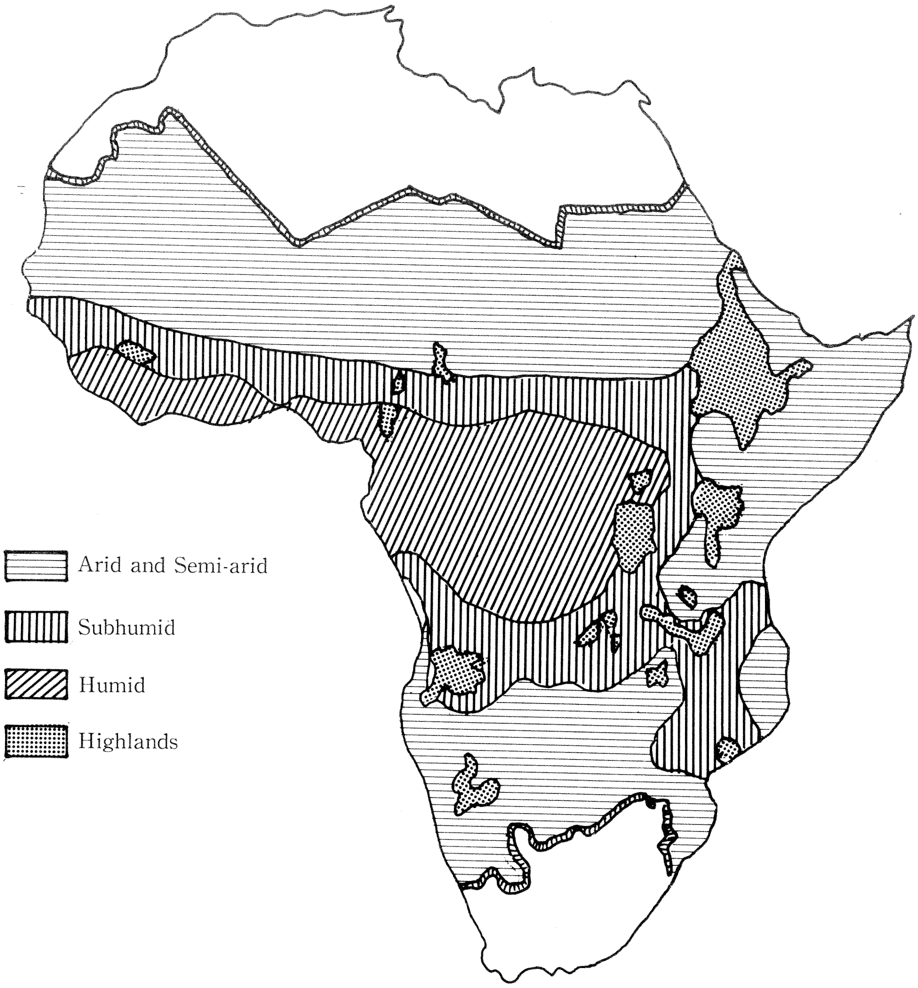

Fig. 1 Agro-ecological zones of sub-Saharan Africa.

Table 1 Rainfall and grass production over 4 years at Niono, Mali

Year	Rainfall (mm)	Grass cover %		Herbaceous biomass (t DM/ha)	
		x̄	s.d.	x̄	s.d.
1981	411	73	28	1.6	0.7
1982	478	64	24	1.3	0.7
1983	195	63	34	0.5	0.4
1984	334	59	30	1.0	1.1

Source : ILCA data.

Table 2 Human and livestock populations of ecological zones of sub-Saharan Africa

Zone	Land area (million km²)	Humans	Cattle	Sheep	Goats
		(millions)			
Zone 1	12	91 (8)	77 (6)	62 (5)	81 (6)
Zone 2	5	66 (13)	45 (9)	25 (5)	33 (7)
Zone 3	4	50 (12)	9 (2)	8 (2)	12 (3)
Zone 4	1	38 (38)	29 (29)	24 (24)	12 (12)
Total	22	239	148	108	125

Source : Jahnke, 1982.

The agro-ecological zones of sub-Saharan Africa

The differing agro-ecological environments found in sub-Saharan Africa can be aggregated into zones with broadly similar characteristics (Fig. 1):

1 Warm, arid and semi-arid tropics
2 Warm, sub-humid tropics
3 Warm, humid tropics
4 Cool tropics, highlands

Zone 1, the warm, arid and semi-arid tropics, is alternatively classified into two zones; arid and semi-arid thus making 5 zones in sub-Saharan Africa but more recent literature associated with the FAO Geographic Information System (GIS) combines the two. Thus zone 1 extends from the edges of the deserts, where there is virtually no rain, to regions receiving up to 900 mm of rainfall and having 180 growing days a year.

The amount of rainfall received each year in this zone varies widely across the zone as a whole and even more from place to place. This has a direct effect on range biomass production which can vary by threefold or more as illustrated by herbaceous biomass production at Niono in Mali (Table 1). To respond to this the herd owners have to be able to move their herds frequently and over long distances. Thus the pastoralists have developed socio-economic systems which enable them to cope with the rigours and disciplines of nomadic or transhumant movement and the sharing of grazing areas between groups of herders (Swift, 1979). However, since they are not able to influence the productivity of the range land many pastoral societies are resorting to planting crops in an effort to meet the needs of expanding populations. This encourages sedentarization, tends to use the best grazing land for crops and concentrates the livestock in fixed locations. These trends are not compatible with sustained production using traditional practices. For example, attempts to spread the grazing pressure by sinking more boreholes have, at best, provided only short-term benefits because whereas the range lands in these areas were accessible when there was surface water they are now used year round. They have not only encouraged permanent residence by pastoralists but occasionally by cultivators as well.

Zone 2, the warm sub-humid tropics, lies between zone 1 and zone 3. It is characterized by having 900 mm to 1500 mm of rainfall and 180 to 270 growing days a year. Despite the zone's reliable rainfall and long growing season, it is relatively lightly populated with both people and livestock (Table 2). This is attributable to the presence of the tsetse fly which transmits the disease trypanosomiasis (sleeping sickness) to humans and livestock, and to the poor quality of the soils. The soils are deficient in almost every desirable quality. They are dense, prone to surface capping, have a hard under-layer leading to poor infiltration and perched water tables. They are low in nitrogen, phosphorus and carbon and have low cation

Table 3 Production parameters for traditionally managed Bunaji cattle in the sub-humid zone of Nigeria

	Traditional[Z] management	Improved[Y] management
Age at first calving	60	31 months
Calving interval	757	432 days
Birth weight	19	24 kg
180 day weight	60	101 kg
365 day weight	104	150 kg
Adult cow weight	268	340 kg
Calf mortality to 365 days	22	7 %
Adult mortality	6	4 %
Milk production	0.76	4 l/cow/day

Source : [Z] Otchere, 1986.
[Y] Various sources.

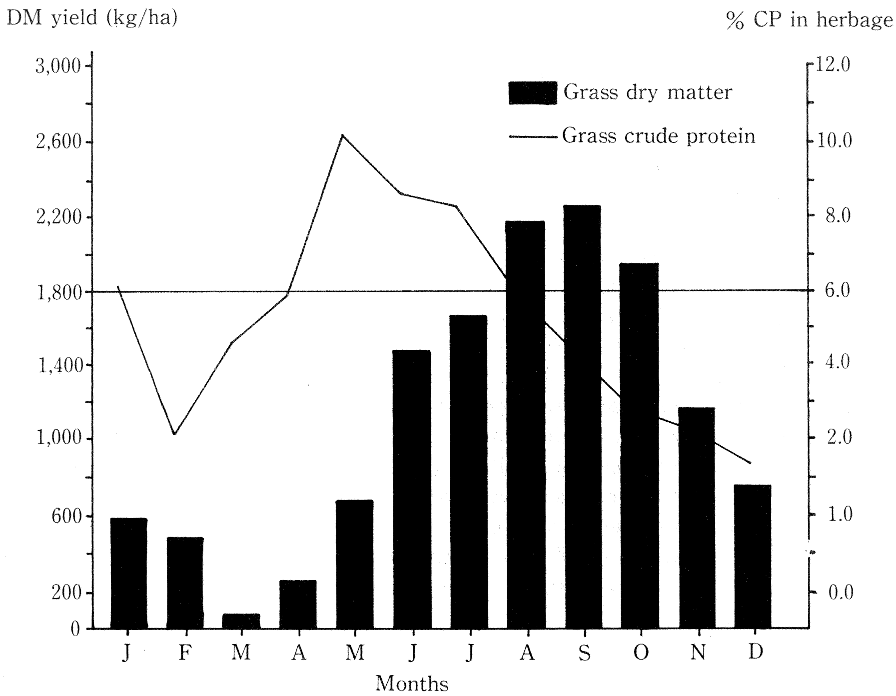

Fig. 2 Productivity of natural herbage at Kachia in the sub-humid zone of Nigeria.
Source : Mohamed Saleem, 1986.

exchange capacities. As a result crop yields are low.

Despite the drawbacks of the zone, increasing population pressures in the other zones are encouraging farmers and herd owners to migrate to the zone, leading to major ecological changes (Bourn *et al.*, 1986). In West Africa, cattle- and sheep-owning agro-pastoralists have settled amongst crop farmers in zone 2. The two communities interact - the agro-pastoralists may, for example, herd cattle for the farmers - but the communities are ethnically and culturally distinct. In other parts, farmers are tending to keep more cattle themselves and, particularly in East Africa, smallholder dairying is increasingly popular.

The situation is one of great fluidity and uncertainty. The inhabitants in many instances have little experience of the zone to help them develop sustainable systems. The practice of leaving soils fallow after cropping is increasingly less feasible in the more densely populated areas. The lack of any title to grazing land inhibits the herd owners from investing in land improvement.

Although herbage yields are higher in zone 2 than in zone 1 ruminant livestock productivity in the zone is still very low. This can be judged by a comparison of production parameters derived under traditional management with on-station results for the same breed (Table 3). This is due to the poor quality and variable supply of the feed on offer. Because of the low soil nitrogen and rapid plant growth at the heading stage the plant material has less than the critical 6% crude protein content, required for livestock growth and development, for most of the year (Fig. 2). Unlike zone 1 there is usually plenty of bulk material in the dry season, when crop residues and field weeds are available. However, shortages of feed during the wet season are becoming more common as cropping increases. There are also other adverse trends, such as increased stubble burning by farmers and increased planting of maize, which is early maturing and has little feed value by the time animals can enter the fields, in place of sorghum which has green flag leaves and immature panicles on offer at the time of crop-residue grazing.

Zone 3, the warm humid tropics, receives between 1500 mm and 2000 mm of rainfall and has 270 to 365 growing days a year. The warmth and humidity promote prodigious plant growth but are also conducive to many livestock diseases. Thus, despite the abundance of feed, livestock do not feature very prominently in the farming systems. The cattle, sheep and

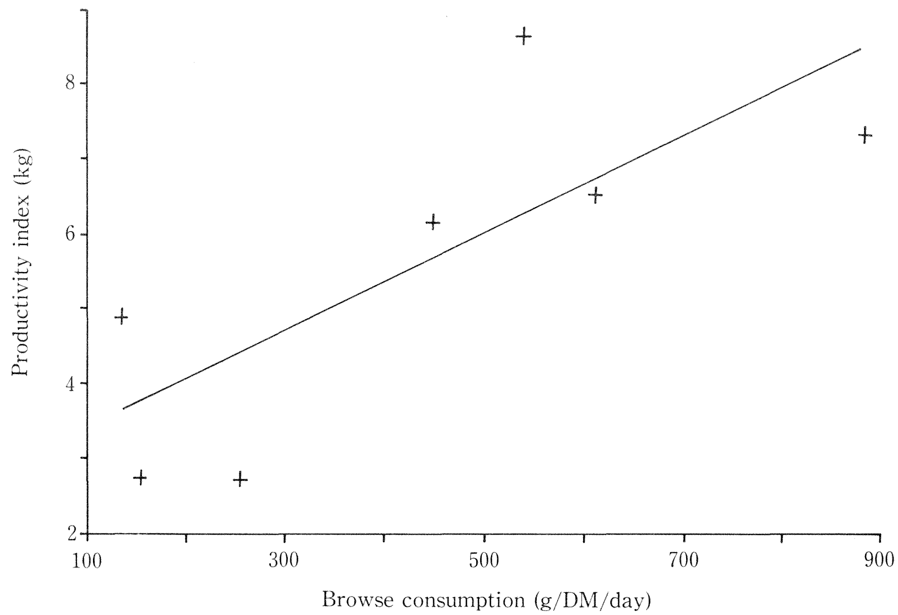

Fig. 3 Effects of browse consumption on the productivity index of West African Dwarf does in Nigeria.
Source : Reynolds, 1989.

Table 4 Average farm sizes (ha) and land use at three sites in the Ethiopian Highlands

Location	Dogollo (ha)		Ginchi (ha)		Inewari (ha)	
Land class	x̄	s.d.	x̄	s.d.	x̄	s.d.
Cultivated	1.70	0.90	2.60	1.20	1.90	0.60
Fallow	0.01	0.04	0.03	0.01	0.01	0.03
Pasture land[z]	0.18	0.15	0.50	0.40	0.12	0.17
Total	1.89	1.00	3.13	1.20	2.03	0.60
ha/family member	0.39		0.56		0.36	

[z] Does not include communal grazing
Source : Getachew Asamenew, personal communication.

goats that are found in the zone tend to belong to breeds that are tolerant of trypanosomiasis and dermatophilosis, two major diseases in the zone.

Under the prevailing husbandry systems the owners invest very little cash or labour and in consequence livestock productivity is very low. The results of feed supplementation trials demonstrate that this could again be improved by better nutrition (Fig. 3). The apparent lack of interest of livestock owners in the productivity of their livestock may be taken as an indication that livestock keeping is not profitable and not important in the socio-economies of the people. In fact the opposite is the case. Small ruminants are the most important source of meat for rural families. The fact that the animals survive by scavenging means that nearly all the output is profit. This makes it difficult to introduce interventions that require investment of capital or labour.

Zone 4, the cool tropics, appears as islands in the map (Fig. 1), wherever highlands (above 1500 m above sea level) occur. These are predominantly in East Africa, with almost 50% in Ethiopia. The rainfall in the highlands varies from 700 mm to 1500 mm and the length of the growing period varies from 150 to 240 days. The primary agriculturally important difference from the other zones is the low ambient temperature which averages below 20℃.

The low temperatures permit the production of a different range of crops and the use of temperate-zone livestock, which are potentially more productive than the indigenous breeds. The zone is also a preferred area for human settlement so the population pressure is extremely high and the socio-economic systems are adapted to intensive land use (Table 4). The rainfall is bimodal and the rainy seasons are short, so timely cultivation is very important. Draught animal power has been used in many of these areas for a long time but the technology used has remained virtually unchanged. Increasing cultivation and stocking rates on the communal grazing has put a premium on conservation and utilization of crop residues. Again the prospect of the people is bleak unless there is a dramatic increase in productivity because there is no more room for expansion. The poverty of the people makes them very risk averse and in constant danger of entering a downward spiral in which they are forced, by immediate needs for survival, to do things that lead to land degradation and accelerating poverty.

Appropriate responses

The nature of the appropriate responses to overcoming the livestock feed constraints in each of the zones will be determined by a combination of socio-economic and ecological factors.

Zone 1, The most pressing goal of the majority of pastoralists is survival (Dyson-Hudson, 1977). This implies that increasing productivity, which tends to increase the fluctuations in production, will not be a first priority because it is in conflict with minimizing risk. Thus the pastoralists in this zone are more likely to respond to indirect measures that will encourage offtake of livestock and thus increase the feed per head for the remaining animals. Such measures include improved markets and infrastructure, the identification of appropriate alternative investments such as water tanks and the growing of grain legumes (Coppock, personal communication.) The lack of adoption of improved husbandry techniques such as rotational grazing and feed supplementation, other than veterinary measures which are evidently risk-reducing, supports this hypothesis.

Zone 2, Livestock owners can grow forages to improve livestock productivity but this must not exacerbate the prevailing labour constraints. In the case of both the smallholders and the agro-pastoralists the most likely path will, therefore, be through exploiting crop-livestock interactions. Forage legumes, which can improve soils by way of increased nitrogen and organic-matter contents and improved soil physical properties may be introduced into the cropping systems to increase yields and returns to labour (Tarawali *et al.*, 1987). Once introduced the legumes will be available as food for livestock.

Zone 3, Attempts to increase livestock productivity through improved feeding have centred on maximizing returns to labour by way of using household scraps and crop by-products. However, the amounts of feed that will be needed for a profitable production system, and limits on labour availability, dictate that feedstuffs are going to have to be grown close to where livestock are kept. Alley farming is an attractive proposition in intensively farmed areas where soil fertility is low. Browse legumes grown in alleys can be used for mulch, thereby restoring soil organic matter, and for restoring soil surface mineral levels with minerals brought up from lower soil horizons. Some of the browse can be fed to livestock. Alternatively leguminous browses may be grown in conjunction with grasses such as Napier (*Pennisetum purpureum*) to provide a complete diet.

Zone 4, It is extremely difficult to devise strategies for increased feed production because the land is already intensively farmed. Thus the available feed must be better used by treating it to make it more nutritious, by feeding it to the most responsive animals or by increasing the utility of the animals that consume the feed. The various methods of treating crop residues are well documented in the literature (ARNAB, 1989). However, none have been widely adopted probably because they all require some investment in labour or capital, both of which are in short supply, or require some input that is not readily available.

ILCA, in partnership with national agricultural systems (NARS) and other institutions, has been researching the problem from other angles. A harnessing system that enables a single ox to work with 70% of the efficiency of a pair of oxen has been developed. Thus two single oxen are 40% more productive than a pair working together. Nevertheless this has not been sufficient to encourage the farmers to break away from the traditional systems involving sharing for those that do not have two oxen. Another alternative being tested is to use large-framed dairy cows for traction. If this proves successful farmers will be able to dispense with oxen that are used for only brief periods in the year and keep more cows. ILCA is also trying to increase the use that is made of the oxen by developing appropriate implements. ILCA has developed a broadbed maker that can improve drainage of otherwise waterlogged vertisols, thereby allowing early planting. The broadbed maker is now being tested by farmers and work continues on a seeder and cultivator attachment for the broadbed maker. If the broadbed maker is adopted and used to enable early planting it will open up the possibility of double cropping which will increase the amount of crop residues and by-products produced each year. It also raises the possibility that the farmers could grow forage crops once their immediate subsistence needs are assured (ILCA, 1990).

Conclusions

The livestock owners of each zone have adapted to their environment so as to secure their own survival and that of their livestock. But all the livestock production systems in sub-Saharan Africa are under increasing pressure. Sub-Saharan Africa already has disproportionately large numbers of the world's poorest people. However, there are possibilities for increased livestock productivity in each zone but more research is needed to develop the concepts into practical extension packages.

The major challenge lying ahead is to increase the productivity of livestock so as to provide Africans with an improved standard of living while protecting the continent natural resource base from degradation. ILCA's research is purposely directed to meet the challenge.

References

1) ARNAB, (1989) : Overcoming constraints to the efficient utilisation of agricultural by-products as animal feed. *In* : Proceedings of Fourth Annual Workshop, Institute of Animal Research, Mankon Station, Bamenda, Cameroun, 20-27 October 1987. African Research Network for Agricultural By-products. Addis Ababa, Ethiopia. 474 pp.

2) Bourn D., Milligan, K. and Wint, W. (1986) : Tsetse, trypanosomiasis and cattle in a changing environment. *In* : Livestock systems research in Nigeria's sub-humid zone. Proceedings of second ILCA/NAPRI symposium, Kaduna, Nigeria, 29 October-2 November 1984. International Livestock Centre for Africa, Addis Ababa, Ethiopia. Edited by : Kaufmann, R. von, Chater, S. and Blench, R. pp. 85-109.

3) Dyson-Hudson, R. (1977) : An ecosystems approach to East African livestock production systems. *In* : East African pastoralism : anthropological perspectives and development needs. International Livestock Centre for Africa, Addis Ababa, Ethiopia. Edited by : Westley, S. B. and Maloba, G.

4) ILCA and IAR, (1990) : Joint vertisol project 1989 Report. International Livestock Centre for Afica, Institute for Agricultural Research and Alemaya University, Addis Ababa, Ethiopia. 72 pp.

5) Jahnke, H. E. (1982) : Livestock production systems and livestock development in Africa. Keiler Wissenschaftsveralg Vauk, Kiel. 253 pp.

6) Mohamed-Saleem, M. A. (1986) : The ecology, vegetation and land use of sub-humid Nigeria. *In* : Livestock systems research in Nigeria's sub-humid zone. Proceedings of second ILCA/NAPRI symposium, Kaduna, Nigeria, 29 October-2 November 1984. International Livestock Centre for Africa, Addis Ababa, Ethiopia. Edited by : Kaufmann, R. von, Chater, S. and Blench, R. pp. 59-84.

7) Otchere, E. O. (1986) : Traditional cattle production in the sub-humid zone of Nigeria. *In* : Livestock systems research in Nigeria's sub-humid zone. Proceedings of second ILCA/NAPRI symposium, Kaduna, Nigeria, 29 October-2 November 1984. International Livestock Centre for Africa, Addis Ababa, Ethiopia. Edited by : Kaufmann, R. von, Chater, S. and Blench, R.

8) Reynolds, L. (1989) : Effects of browse supplementation on the productivity of West African Dwarf goats. *In* : African small ruminant research and development. International Livestock Centre for Africa, Addis Ababa, Ethiopia. Edited by : Wilson, R. T. and Azeb, M. pp. 237-250.

9) Swift. J. and Cisse, S. (1979) : Les pasteurs des savanes d'Afrique Occidentale. International African Seminar of the International African Institute, Zaria, Nigeria, 16-21 July 1979. CIPEA Mali Document de Programme, no. AZ 32. 67 pp.

10) Tarawali, G., Mohamed-Saleem, M. A., and Kaufmann, R. von, (1987) : Comparison of labour requirements for cropping maize on land previously used for Stylosanthes fodder

banks and on adjacent fallows in the sub-humid zone of Nigeria. ILCA Bulletin, no. 26, 36-39.

Discussion

Haryanto, B. (Indonesia) : The first calving age in Africa is 60 months while in the case of improved management the first calving age is only 31 months. Could you comment on this aspect?

Answer : The age for the first calving of tropical cattle depends generally on two factors, the genetic background and the nutritional level. The time required for the first calving can be shortened through the improvement of the nutritional level or through genetic improvement for earlier sexual maturity.