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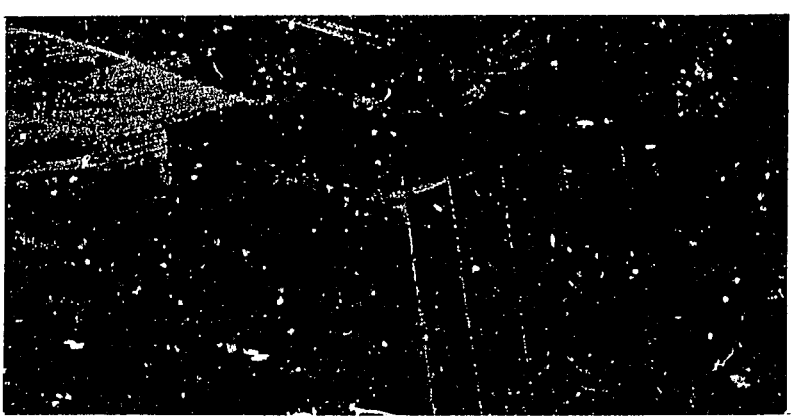
PN-AAA-113
ISN-36685

SMALL RUMINANT

COLLABORATIVE RESEARCH SUPPORT PROGRAM

TECHNICAL REPORT SERIES

NUMBER



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ISN: 36695

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MIXED CROP-ANIMAL SYSTEMS ON SMALL FARMS IN WESTERN KENYA

M. W. Sands, H. A. Fitzhugh,
R. E. McDowell, and S. Chema

Winrock International
Morrilton, Arkansas 72110

Cornell University
Ithaca, New York

Ministry of Livestock Development,
Kenya

December 1982

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PREFACE

This report is based on information from a survey of small farms in western Kenya during the period, October 1980 to November 1981. The objectives of the survey included characterization of small farm systems in western Kenya and development of a baseline against which to measure success of interventions to these systems. These interventions will primarily involve the introduction of a dual-purpose goat component.

The survey was an activity of the Small Ruminants Collaborative Research Support Program (SR-CRSP). Research activities of SR-CRSP in Kenya are conducted in collaboration with the Ministry of Livestock Development. Three SR-CRSP projects (Production Systems and Economics, Winrock International; Sociology, University of Missouri) participated in the survey.

Research conducted by M. W. Sands contributed to fulfillment of requirements for his Ph.D. degree in Animal Science at Cornell University.

Contributions of the following institutions and persons are gratefully acknowledged:

Program Administration Committee for SR-CRSP/Kenya: S. Chema (Chairman), Z. Owiro, P. Bartilol, E. Allonby, D. Kitivo and Y. Berger.

Ministry of Finance and Economic Planning, Central Bureau of Statistics (P. Singh, Director): J. Kekovole, P. Gachuki, V. Ongaya, and F. Mbiti; Field enumerators for survey: H. Kiguhi, P. Amuhinda, L. Ongecha, O. Evanns, E. Ochieng, and J. Onyodho.

SR-CRSP - Management Entity: Y. Berger, R. Naliaka, D. Robinson; Production Systems: D. Brown, K. Boor, R. Hart; Sociology: C. Suda, R. Campbell, M. Nolan; Economics: M. Job, J. De Boer.

Principal funding for this research was provided by Winrock International and the U.S. Agency for International Development through Grant No. AID/DSAN/XII-G-0049.

Special appreciation is expressed to the members of the farm families who participated in the survey and otherwise assisted with data collection. Without their patient cooperation this study would not have been possible.

1. INTRODUCTION

Recognition of the need to make most efficient possible use of basic agricultural resources - land, labor and capital - has stimulated an increased interest in the role of livestock in mixed systems, especially on small farms in developing countries (McDowell and Hildebrand, 1980; Fitzhugh et al., 1982). Do livestock represent a burden on the system, consuming resources that could be put to more productive use; or does the limited resource farmer utilize animals to improve and stabilize complex social and agricultural systems? The thesis of this investigation is that livestock ownership represents an adaptive strategy used by small scale farmers in western Kenya to increase their economic well being.

The widespread persistence of traditionally low productivity livestock production systems among small farmers has been attributed to many factors. Among these have been poor communication of available technology, lack of required inputs, and/or insufficient motivation of the farmer (Pagot, 1976). The lack of smallholder adoption of "improved production practices" may also be the result of inappropriate production alternatives being offered (Scoville, 1976; McDowell, 1978).

A small farm has been defined in many ways. Adams and Coward (1972) suggested that a small farmer is one who has "very little access to political power, productive services, productive assets and/or income streams in the society". The relatively low accessibility to one or more inputs and to infrastructural support systems forces the small farmer to modify his goals to include risk minimization as well as profit maximization (Wolgin, 1975; Johnson, 1971; Dillon and Scandizzo, 1978). Risk minimization will mean less dependence on the market for selling products and purchasing inputs. Thus, often diversification rather than specialization becomes more rational. In this context, the problems of improving the contribution of livestock to the small farm enterprise become complex. Livestock are rarely kept for a single purpose, such as meat or milk production. Generally they serve multiple purposes, including nonfood as well as food uses (McDowell, 1977).

Despite the importance of livestock, little effort has been directed toward improving the animal production on these small farms. The principal reason for their failure has been the attempted direct transfer of western ideas of animal production to the tropical small farms (McDowell, 1978). Thus, work has tended to concentrate on maximization of meat or milk production. What is not often recognized is that the small farmer is trying to satisfy several production objectives simultaneously. These often include weed control, fertilizer, meat, milk, capital savings, and enterprise diversity. Not only are the objectives often in conflict with each other, but progress towards maximization of any one of them will be slow. Thus, in order to make any improvements, an understanding of the farmer's desired objectives is essential.

The problem of increasing income, food production, and risk minimization on small farms must be approached from a base of the existing farming

system (McDowell and Hildebrand, 1980). This implies that agricultural scientists and development planners must fully understand the specific farming system as well as the farmer's production strategy and objectives. To accomplish this, direct contact and discussion between the specialist and the farmer must occur within the farmer's environment (Hildebrand, 1979; Kirkby et al., 1981). The specialist must accomplish the following sequential steps:

1) understand the basic farming system,
2) understand the knowledge base and constraints upon which the farmer bases his management decisions,
3) identify possible interventions to improve the overall well-being of the farm family, and
4) implement on-farm testing of the interventions in order to ensure that they are suitable to farmer's needs and to obtain suggestions from farmers for further improvements.

The survey on which this report is based was designed to accomplish steps 1 and 2 and to influence design of research to accomplish steps 3 and 4. The farming systems of interest are located in the Lake Victoria Basin of western Kenya. These systems share general characteristics in common with others in the humid tropics of central Africa and so this work has potential for broader application.

2. BACKGROUND

Kenya is agriculturally and ecologically very diverse. Annual precipitation ranges from 200-2500 mm (Bille and Heemstra, 1979), elevations range from sea level to 4800 meters. Ecosystems are equally varied; semiarid rangelands, humid coastal zones, alpine meadows, and perhaps most important, agriculturally productive highlands. The soils are extremely diverse. Of the total land area of 569,000 square kilometers, only about 7% can be described as good agricultural land in the sense that it has adequate rainfall, good soils, and is not too steep a slope. A further 20% could be classified as marginal agricultural land (Pratt et al., 1966; IADS, 1981).

The leading export crops are coffee, tea, sisal, pyrethrum, and horticultural products. Other cash crops include cashew nuts and wattle bark. The primary food crop is maize which is usually eaten as a boiled paste (ugali) with various relishes. Maize is also eaten green, either roasted or boiled with beans and potatoes (irio). Other major food crops include wheat, rice, potatoes, and pulses. Other crops such as cassava, sweet potatoes, and bananas are important locally (Heyer et al., 1976).

In 1979, the livestock sector in Kenya contributed about 262.4 million Kenya Pounds[1] to the total gross Domestic Product (Kenya, 1980e). Table 2.1 shows the estimated production of various livestock products. On-farm consumption utilized approximately 44% of the livestock production. This consumption is most important with milk where only about 40% of the milk produced nationally enters the formal market.

2.1. Kakamega District

The work reported was conducted in the highlands of western Kenya (Figure 2.1). Kakamega District in Western Province is considered to be agriculturally a high potential zone (Pratt et al., 1966). Annual rainfall was calculated from data collected over the previous thirty years by the Kenyan meteorological department. Annual means for the Kakamega, Kaimosi, and Vihiga stations were 2015, 2051, and 1834 mm, respectively (Figure 2.2). Altitude ranges from 1400 to 1850 meters. The daily maximum temperature is between 22-27°C while the daily minimum is 10-1[illegible]°C. While relative humidity is very high every morning (90%) it quickly falls off to 45% in midafternoon during the dry season.

Nyandat (1977) reported that Kakamega soils are primarily humic nitrosols or ultisols in the U.S. classification (Sanchez, 1976). They have

[1] A Kenya Pound is worth 20 Kenya shillings or U.S. $2.60.

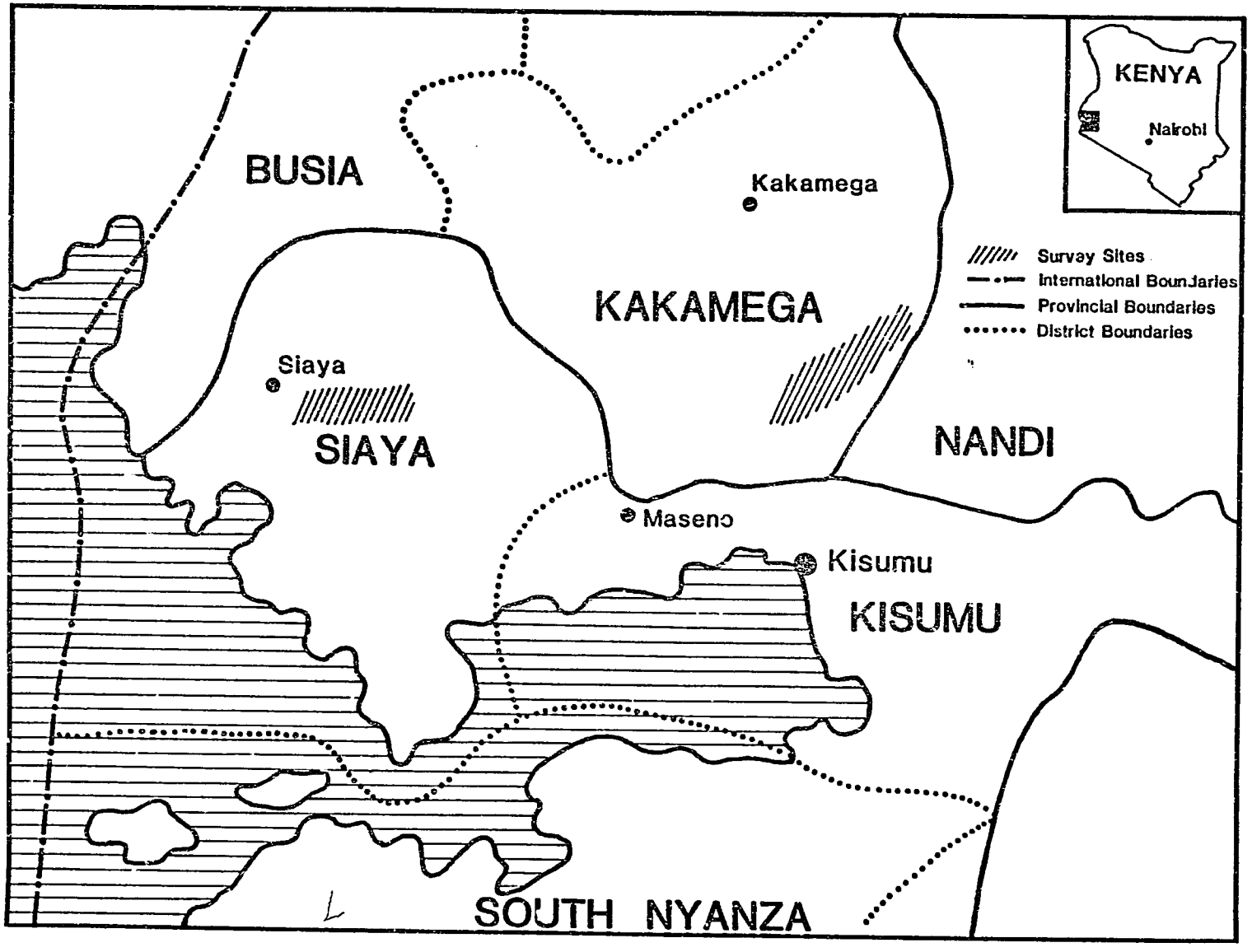


Figure 2.1 Map of western Kenya.

Table 2.1. Estimated Gross Production and Value of Livestock Products, 1979.

Commodity	Total Production	Percent Consumed On-farm	Average Price (Ksh)	Total Production Value (million Ksh)
Milk[a]	1149 x 10^6 liters	60	1.32/liter	75.8
Beef	214,700 mt[b] CDW[c]	25	8.00/kg CDW	85.9
Sheep & Goat Meat	49,405 mt CDW	50	11.00/kg CDW	27.1
Chicken Meat	16,716 mt CDW	50	14.96/kg CDW	12.5
Eggs	439 x 10^6	42	0.68/egg	14.9
Hides & Skins	5 x 10^6	20	8.00/piece	2.0
Pork	4,000 mt CDW	5	12.00/kg CDW	2.4
Wool	1,200 mt	0	13.00/kg	0.8
Honey	10,541 mt	40	20.00/kg	11.0
Other				30.0
Gross Total		43.5		262.4

[a] Includes milk from cattle, camels, goats
[b] Metric tons
[c] Cold dressed weight

Source: Kenya, 1980e

reasonable levels of fertility and structure, but show a positive response to nitrogen and phosphorus. The more common natural grasses are Cynodon, Hyparrhenia, Digitaria, Pennisetum, Brachiaria, Loudetia, and Sporobolus (Chudleigh, 1974).

Total land area of Kakamega is 3520 km^2 of which approximately 82% is registered by smallholders (Kenya, 1980b). Average holding size is 2 to 2.5 ha (Chudleigh, 1974); however, holdings in the more densely populated divisions are smaller. Hay and Heyer (1972) reported that 83% of the farmers had less than 2.05 hectares in Vihiga Division.

The dominant tribe in the rural area is the Abaluhya. The 1979 census estimated that the District population was about 1,033,000. The land pressure is 294 people/km^2. In some parts of the District pressure is as high as 880 people/km^2 (Lihanda, 1978).

The most important food crops are maize and beans, usually intercropped. Other food crops include sorghum, millet, cassava, sweet potatoes, bananas, and vegetables. The principal cash crops of the area are trees, tea, and coffee.

Livestock are numerous and important to the small farmer. Table 2.2 shows estimates of the District livestock population based on a live-

Figure 2.2. Mean monthly rainfall at three (3) sites in Kakamega District.

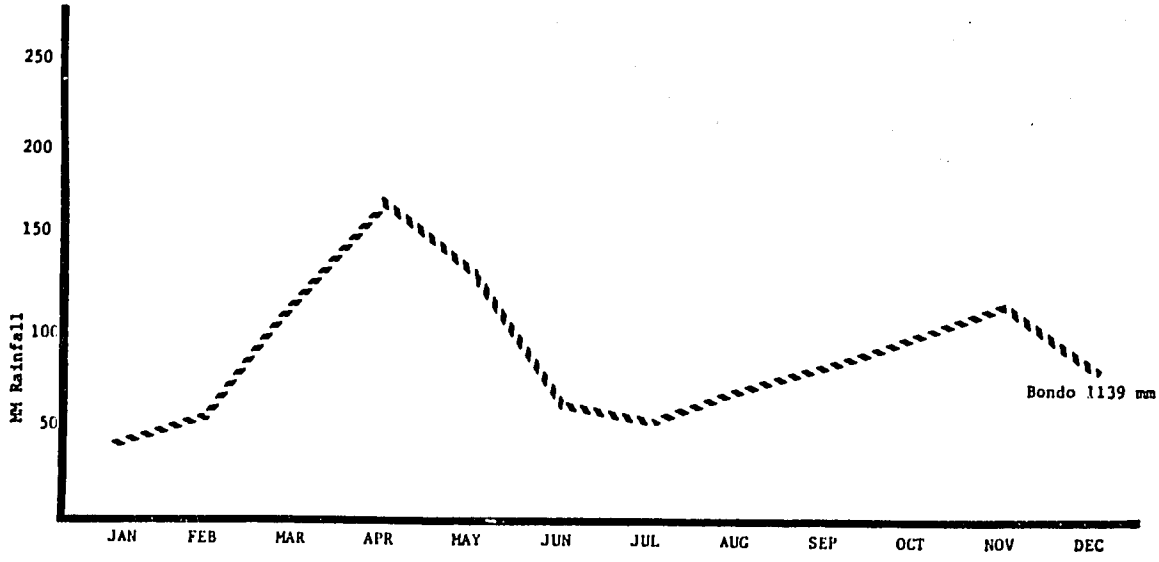


Figure 2.3 Mean monthly rainfall at one site in Siaya District.

stock census taken by members of the Ministry of Livestock Development in October 1980 (Kenya, 1980d). Only cattle are milked. Sheep and goats are sold for meat when a cash need arises. Pigs are rare; only 3,845 were reported in the 1980 livestock census for Kakamega. Poultry are common. Ministry officials estimated the Kakamega population at 462,000 birds (Kenya, 1979). They are principally native types of chickens but some imported breeds of layers and broilers as well as turkeys and ducks are also found (Kenya, 1979).

Table 2.2. Estimated Livestock Populations in Kakamega and Siaya Districts.

Species	Kakamega[a]	Siaya[b]
Crossbred cattle	29,720	1,140
Zebu cattle	318,940	198,800
Native hair sheep	44,350	101,700
East African goats	43,850	115,700
Swine	3,845	585

[a] Livestock Census Oct. 1980, Ministry of Livestock Development
[b] Annual Report 1979, Siaya District, Ministry of Agriculture

2.2. Siaya District

Siaya District in Nyanza Province is considered an agriculturally medium potential zone (Pratt et al., 1966). Annual rainfall calculated from the previous thirty years is 1139 mm (Figure 2.3). Rainfall usually occurs in intense showers in the late afternoon. Altitude ranges from 1140 to 1500 meters. The maximum midafternoon temperatures are 24-28°C while daily minimum temperatures are between 11-15°C. Relative humidity ranges from 90% at dawn to 40% in the midafternoon during the dry season. The natural vegetation is dominated by invasive shrubs (e.g., *Albizia coriana* and *Lantana camara*) and poor quality grasses including *Hyparrhenia*, *Cymbopogon*, *Aristida*, *Brachiaria*, and *Digitaria*.

Nyandat (1977) stated that the major soils of the Siaya area are Orthic and Plinthic Ferrasols or Ustox and Orthox Oxisols in the U.S. classification (Sanchez, 1976).

Siaya has a total land area of 2523 km^2 with 57% registered by smallholders and 43% scheduled for future smallholder registration (Kenya, 1980b). CIMMYT (1977) estimated cropped land per family was between 2 and 3.5 ha. Holding size differed by agro-ecological zones. For the zone Tea West of the Rift, the primary classification for Siaya, 58% of the farmers had holdings less than 1 hectare, 28% had holdings of between 1 and 3 hectares. This left only 13% with holdings larger than 3 hectares.

The Luo tribe inhabits all the rural area of Siaya. The 1979 census gave the population as 470,000. The land pressure was estimated at 186 people/km^2.

As for most of Kakamega, farmers in Siaya attempt two croppings per year. However, the long rains (March-May) are more reliable than the short rains (Sept.-Nov.). The principal food crops are maize and beans intercropped. Sorghum, millet, cassava, sweet potatoes, and grains are also important. Cash crops, not found on many small farms, are cotton, trees, and sugarcane. The Luo were traditionally herders and still have large numbers of livestock. Livestock numbers estimated by the District Agriculture Office are shown in Table 2.2. Poultry (chickens and ducks) are also common and found on most farms. Swine are extremely rare.

3. SMALLHOLDER SURVEY

The first step in the design of interventions to an agro-ecosystem is to develop an understanding of that system. To this end, collaboration between the various projects in the Kenya SR-CRSP supported a series of surveys to characterize many of the enterprises and their interactions on the small farm in western Kenya. Individual survey materials were developed by three projects. The Economics Project (Winrock International) focused primarily on labor utilization, farm budgets, and marketing. People's attitudes about livestock and consumption of animal products were investigated by the Sociology Project (Univ. Missouri).

The overall characterization of the farming systems was the responsibility of the Production Systems Project (Winrock International). The first year's survey, reported in this chapter, also provides a baseline, against which the success of future interventions to these smallholder systems can be measured.

3.1. Methodology

3.1.1. Surveys

Sample Frame. The sample used for the Production Systems Survey was drawn from a much larger national sample frame used by the Central Bureau of Statistics of the Ministry of Finance and Economic Planning. The original sample frame was designed for use in the first four rounds of the Integrated Rural Survey (Kenya, 1977). The original sample was a two-stage stratified sample. The primary sampling unit was the sublocation, the basic administrative unit in the country. Prior to sampling all sublocations were classified into agro-ecological zones by the Ministry of Agriculture. Agro-ecological zones in Western and Nyanza Provinces were 1) Tea West of Rift Valley, 2) Coffee West of Rift Valley, and 3) Upper Cotton West of Rift Valley. Tea and coffee zones overlap substantially with zones 1 and 2 of Pratt et al. (1966). Upper Cotton West of Rift Valley is comparable to zone 3 of Pratt et al. (1966).

In selecting the final list of sublocations, an equal number were drawn from each of the six Provinces with a significant portion of smallholder agriculture. Locations within agro-ecological zones were divided in "chunks" according to the 1969 population census. Two "chunks" were then selected at random within each location. A field team would count and identify households and group them into "clusters" of approximately 200 households. Two clusters were randomly picked from each chunk and twenty households per cluster chosen for actual enumeration.

For the purpose of the Production Systems Survey, two clusters in both Siaya and Kakamega Districts were chosen (Figure 2.1). Maps of the clusters were updated or redrawn to include all present households and any significant landmarks. Using these maps, twenty households were selected at random for enumeration in each cluster.

The household was chosen as the sampling unit. Because of polygamy, widespread male migration and multiple generations living together, there was often some confusion as to proper delineation. In the context of this survey, a household was defined as follows:

> A person or a group of persons generally bound by ties of kinship, normally reside together within a single compound and who share a community of life such that they are answerable to the same head and have a common source of food.

Enumerators were given three questions to ask if they had any doubt about the household.

1) Do these people normally reside together within a single compound?
2) Are they answerable to the same head? In other words, is there one particular person who may be present or absent to whom all the household members look upon as having the final decision-making authority?
3) Do they have a common source of food? Are they all dependent on a common holding for food?

To insure an enumerator was dealing with a single household the answers to all 3 questions had to be "Yes".

Enumerators. Enumerators were selected from applications of persons having at least completed Form II in secondary school. As farmers conversed primarily in tribal dialects, it was important for enumerators to originate from localities within the survey areas. One enumerator was hired for each cluster of 20 farms.

Prior to initiation of the surveys, all enumerators participated in a two-week training course. The course included a general discussion of sampling, a detailed discussion of survey questions, and one week of practice interviews on surrounding farms. In addition, enumerators were trained in general livestock husbandry and condition scoring.

All enumerators were required to find living accommodations adjacent to or in their respective clusters. This allowed them to develop an informal but important information gathering network.

Baseline Survey. A baseline survey to collect various single point data was the first instrument completed. Because of its length (Sands, 1983), it was split into two modules, administered 14 days apart. Data collected in the first module included detailed demographic information on the household, a description of land and crops, numbers and uses of structures, and capital resources. In the second module, data on individual livestock included species, age, sex, previous parturitions, value, and a condition code. This initial survey also set a base level from which to initiate the cyclical monitoring survey.

Cyclical Monitoring. The monitoring survey was designed to record the seasonal changes in the farming activities, quantity and quality of feed supplies, and the condition of the animals (Sands, 1983). Farms were visited at 28-day intervals.

In addition to data on changes in household demography, land and capital resources, and status of field crops, more specific information on livestock was collected. This included births, deaths, and other changes in herd composition. Feeding practices and milk production over the previous 7 days were also recorded.

Animal condition scores adapted from Wellington (1981) were recorded every visit for cattle, sheep and goats. Animals were observed and assigned a score from 1 to 5. Condition score 1 was for emaciated animals while score 5 was for fat, well-muscled animals. Graphic representations of 3 of the scores for cattle are shown in Figure 3.1.

The limitations of condition codes are acknowledged (Evans, 1978); however, cattle scores were used effectively in Botswana and other sites at far lower costs than monthly weighings.

Animal weights were taken at 3-month intervals. Sheep, goats, and calves were weighed directly. Heart girth measurements on mature cattle were used to estimate weight using formulas reported by Semenye (1979). Coefficients for formulas differed for different heart girth measurements (Table 3.1).

Table 3.1. Conversion of Heart Girth (cm) to Live Weight (kg).

Heart Girth (cm)	K	Intercept
Under 110	1.05	- 44.58
111 - 140	2.65	-168.70
141 - 150	3.10	-215.47
151 - 170	3.66	-280.73
Over 170	4.90	-466.18

Source: Semenye, 1979

The survey year was divided into four-week lunar cycles. It was felt that 28-day cycles had certain advantages over more conventional calendar months (Kenya, 1977). These included:

1) Cycles were equal in length.
2) Cycles always started on a Monday.
3) Enumerators had a simple workplan for household visits that was consistent over all cycles.
4) Possible biases resulting from consistent visits to a specific household at the beginning or end of the month were reduced.

Enumerators visited one farm per day. As farmers were not always available on the specified day, enumerators had to compensate by visiting the next specified household and returning the next day to the missed farm.

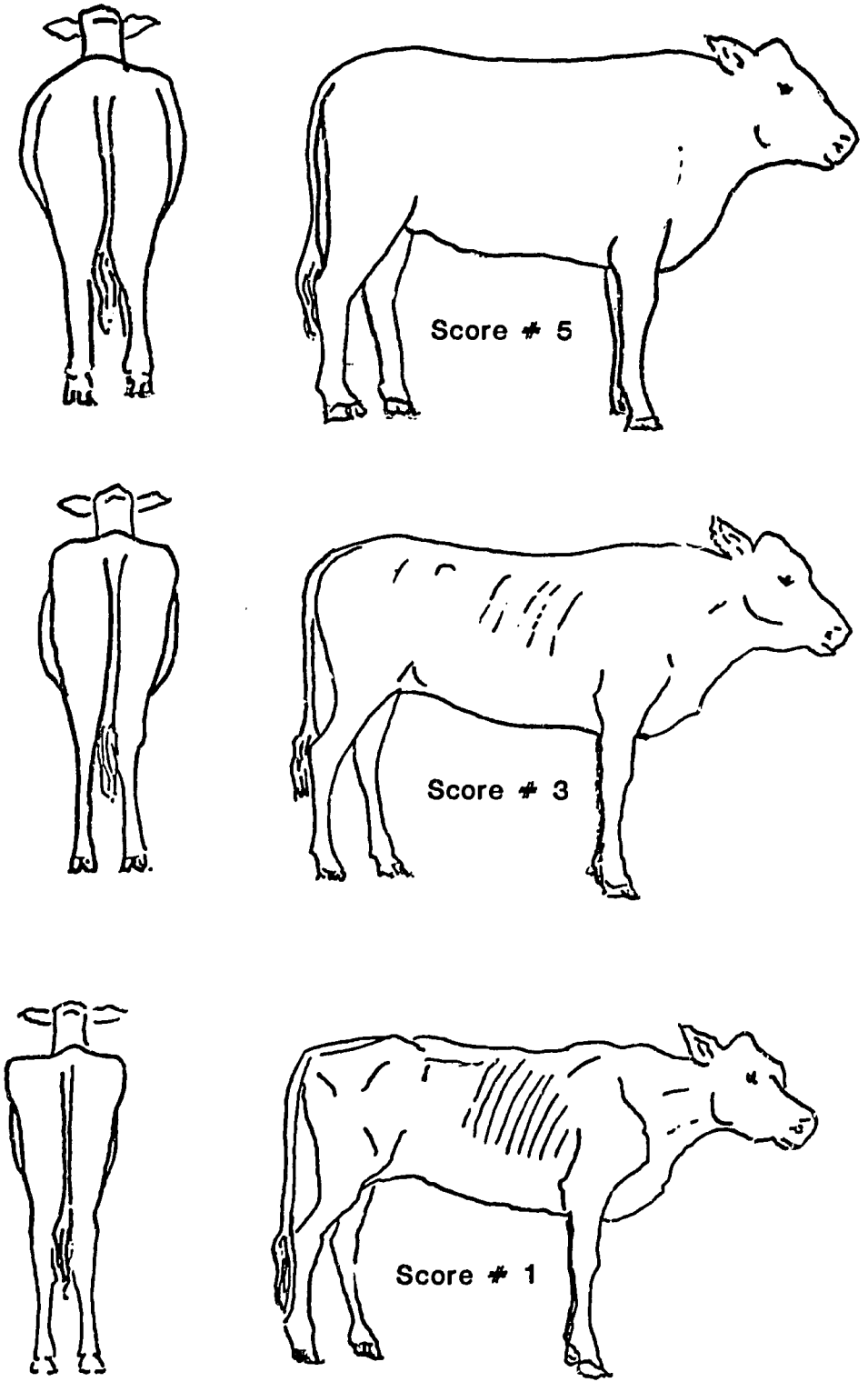


Figure 3.1 Scores for 3 Cattle Conditions.

Livestock Market Survey. Livestock are sold principally in open air weekly markets. The major livestock markets for the surveyed areas are listed in Table 3.2.

Table 3.2. Major Livestock Markets for SR-CRSP Surveyed Farmers.

Market	Livestock Market Days
Ngiya	Tuesday
Luanda	Thursday
Cheptulu	Tuesday
Mudete	Thursday
Serem	Saturday
Mbale	Saturday

Four markets (Cheptulu, Mbale, Ngiya, Luanda) were surveyed to estimate value of species by age and sex. Enumerators observed sales and recorded information on sex, age, condition code, and price. Additionally, the seller's reason for selling the animal was recorded.

Total numbers of each species sold at the market were obtained from the County Council records. However, farmers often sold animals outside the actual market to avoid the County Council cess. Undercounting of actual sales probably ranged from 10-15% for cattle and 15-25% for sheep and goats.

Livestock Management Survey. A module characterizing livestock management practices (Sands, 1983) was administered in the spring of 1981. Specific practices in feeding, watering, breeding, health care, and milking were examined.

Household Food Consumption Survey. In April and June surveys of household food consumption were conducted. Respondents were asked about total consumption of food items over the previous 7 days. No written records were kept by farm families so information was based solely on recall. Weight, value, and whether or not purchased were recorded for all food items.

3.1.2. Farm Classification

District. Farms were classified by several criteria. Because of the small sample size (80 farms) and large variations, cross classification analyses were limited.

The first classification was by District: Siaya or Kakamega. Various factors inherent in this classification were rainfall, altitude, general soil type, and tribe. Forty farms were in each District.

Farm Size. Total farm area was used to classify farms into one of five size groups. Table 3.3 shows the distribution of farms in the various size classifications.

Table 3.3. Classification of Farms By Size.

Farm Size Class	Number of Farms			Sample Percent
	Siaya	Kakamaga	Total	
Under 0.5 ha	13	12	25	31
0.5 - 1.0	1	14	25	31
1.0 - 1.5	7	6	13	16
1.5 - 2.0	3	4	10	13
Over 2 ha	6	4	10	13
Total	40	40	80	100

Type of Livestock. The presence or absence of ruminant livestock during the baseline survey in Oct.-Nov. 1980 was a separate classification. Forty-eight farms (61%) had ruminants and 32 farms did not have ruminants at the beginning of the cyclical monitoring survey (Table 3.4).

Table 3.4. Classification of Farms by Type of Crops and Livestock Holdings

District	With Cash Crops	Without Cash Crops	With Ruminants	Without Ruminants	Total Farms
Siaya	4	36	24	16	40
Kakamega	18	22	24	16	40
Total	22	58	48	32	80

Type of Farm Production. An attempt was made to classify farms on the basis of their involvement with cash crops. Subsistence farms were farms that had no cash crops (tea, coffee, woodlot) and produced only enough maize for family maintenance needs (190 kg/person). Cash farms either had specific cash crops (ratio of land in cash crops to total land <.001) or produced more maize than required for home consumption. The majority of farms (72.5%) were subsistence operations (Table 3.4). An additional cross-classification of type of farm production and presence of ruminants on the farm is shown in Table 3.5.

Table 3.5. Classification of Farms by Presence of Ruminants and Type of Crops.

	With Ruminants	Without Ruminants	Total
With Cash Crops	13	9	22
Without Cash Crops	35	23	58
Total	48	32	80

3.1.3. Forage Analysis

Sampling and Handling. Samples of the major feeds consumed by livestock on the smallholder farms were sampled at intervals over the year. Crop residues sampled were maize residues (thinnings and stover), sorghum residues (thinnings and stover), sweet potato vines and banana leaves. Napier grass (*Pennisetum purpureum*), *Cymbopogon afronardus*, *Cynodon dactylon* and a roadside mix (*C. dactylon* and *Digitaria scalarum*) were the grasses sampled. *Tylosema fassoglensis* was a local legume sampled. *Sida cunefolia* was a low growing browse common in Siaya. In addition, samples of various available concentrates were sampled. These included ugali (maize flour), dairy meal, layers meal, and wheat bran. All samples were dried in paper bags and ground to pass through a 1 mm screen. Samples were packed and returned to Cornell University for laboratory analysis.

Laboratory Analysis. Nitrogen was determined using a boric acid modification of the Kjeldahl procedure (Pierce and Haenisch, 1940) and expressed as crude protein by multiplying by 6.25. Neutral detergent residue (NDR), acid detergent residue (ADR), cellulose, hemicellulose, sulfuric acid lignin and silica were determined according to procedures described by Goering and Van Soest (1970). Sodium sulfite was eliminated from the neutral detergent procedure. In vitro determinations of organic matter (TDOM) and cell wall (TDCW) digestibilities were made using the modified Tilley-Terry method (Goering and Van Soest, 1970). Digestible energy values were estimated by the equation:

$$DE(Mcal/kg)OM) = (\%TDOM - 9.9)(.04620)$$

In the above equation the correction for metabolic fecal organic matter (9.9) was developed from data on goats fed tropical forages (McCammon-Feldman, 1980).

Summative equations (Goering and Van Soest, 1970) were used to predict cell wall and organic matter digestibilities from chemical compositions. The equations used were:

Predicted Digestible Cell Wall

$$(PDCW) = 147.3 - (78.9(\log_{10}((Lig/ALR)100)))$$

Predicted Digestible Organic Matter

$$(PDOM) = ((100 - NDR).98 + NDR(PDCW))/((100 - Ash)100)$$

Dry matter intake was predicted on the basis of the cell wall content (NDR) of the plant (Goering and Van Soest, 1970). This regression

$$\text{Intake } (g/kg.^{75}) = 110.4 - \frac{1716}{(100 - NDR)}$$

equation was developed using data from sheep on low quality diets that did not allow for much selection. As the variation in quality of feed presented increases, this equation will progressively underestimate an animals' intake. For confinement feeding of more uniform feeds, such as Napier grass, this equation should yield reasonable predictions. However, intake based on chemical composition estimates should be used with extreme caution, particularly in the tropics.

3.2. Results

3.2.1. Land Holdings

The land holdings of farms in the two districts are shown in Table 3.6. Siaya farms were slightly larger (1.09 ha) than in Kakamega (0.98). The scarcity of land is emphasized by the fact that 62% of the farms had land holdings less than one ha. No significant differences in holding size were seen when farms were classified by presence of livestock or type of farm (Appendix Tables 1 and 2). As expected, cash crop farms had larger land resources (1.63 ha) than subsistence farms (0.81 ha). Similarly farms with livestock tended to have slightly larger holdings (1.08 ha vs .97 ha). Because of recent land consolidation and registration efforts in both Districts almost all farms were single units. Less than 10% of the farms consisted of more than 1 parcel. In Siaya, a few farmers continued to cultivate a portion of their parents' holding.

Table 3.6. Land Holdings of Surveyed Farms by Farm Size and District.

Farm Class(ha)	Farm Size $\bar{x}$	S.D.
< 0.5	0.28	0.14
0.5 - 1.0	0.74	0.16
1.0 - 1.5	1.29	0.13
1.5 - 2.0	1.79	0.12
> 2.0	2.82	0.73
Siaya	1.09	0.89
Kakamega	0.98	0.84

The large variation in land pressure is demonstrated in Table 3.7. Siaya averaged 9.9 people/ha while Kakamega had 15.36/ha. The importance of farm size is evident with the dramatic decrease in people/ha from the smallest farms (29.29) to the larger farms (3.05). Presence of livestock had no significant effect, but cash crop farms (8.4) had only half the people/ha of subsistence farms (15.5). Similar trends were seen in all classes for workers and dependents per unit of land.

Table 3.7. Land Pressure by Farm Size and District.

Farm Class (ha)	Total		Workers		Dependents	
	Per farm	Per	Per farm[a]	Per ha	Per farm[b]	Per ha
< 0.5	4.88	29.29	1.32	8.17	3.56	21.12
0.5 - 1.0	5.96	8.59	1.12	1.69	4.84	6.90
1.0 - 1.5	7.69	5.92	1.77	1.83	5.92	4.57
1.5 - 2.0	7.43	4.13	2.57	1.43	4.86	2.70
> 2.0	8.10	3.05	2.20	0.84	5.90	2.21
Siaya	4.65	9.90	1.05	2.30	3.60	7.60
Kakamega	7.95	15.36	2.05	4.27	5.90	11.09

[a] Workers are between 16 and 40 years old.
[b] Dependents are under 16 or over 40 years old.

Table 3.8. Family Demography by Farm Size and District (members).

Farm Class (ha)	Male	Female	< 16 years	16-40 years	>40 years	Total
< 0.5	2.36	2.52	2.68	1.32	0.88	4.88
0.5 - 1.0	2.68	3.32	3.32	1.12	1.52	5.96
1.0 - 1.5	4.00	3.69	4.77	1.77	1.15	7.69
1.5 - 2.0	2.29	4.68	3.57	2.57	1.29	7.43
> 2.0	4.40	3.70	3.90	2.20	2.00	8.10
Siaya	2.25	2.42	2.25	1.05	1.35	4.65
Kakamega	3.70	4.20	4.65	2.05	1.25	7.95

3.2.2. Household Demography

Family Size and Composition. The size and distribution of the household is shown in Table 3.8. Family size in Siaya (4.65) was smaller than in Kakamega (7.95). As expected the number of family members residing on the farm increased from 4.88 members on the smallest farms to 8.10 on farms over 2 ha. Very little difference in family size was seen on farms classified by presence of livestock. Cash farms tended to have larger families (7.91) than did subsistence farms (5.69).

The expected continued population growth in the area is shown by the fact that between 48-58% of the family members were less than 16 years old. The most economically active age group (16-40 years) was 22 to 28% of the farm family. Although youths could help in agricultural work, they were not available consistently because of school attendance.

Combining members under 16 and over 40 as dependents (Table 3.7) the ratio of dependents per worker was 2.88 for Kakamega and 3.43 in Siaya. A worker on a cash farm supported 2.55 dependents while a subsistence worker had 3.41.

Head of Household. Table 3.9 contains some characteristics of the head of the household. Heads of household were 40 to 55 years old. Of particular interest was the number of female heads of household (42-45%). A higher proportion of male heads of household in families having livestock (53.1% vs 29.0%) was expected because raising livestock in this part of Kenya is traditionally a male activity. While some female heads of household were widowed, most were married, but the husband had left to seek wage employment. Usually, he had gone to anurban area (i.e., Nakuru, Mombassa, Nairobi). He would return occasionally and hopefully send money back. Because of his long term absences, the day-to-day agricultural management decisions were made by the woman. She decided what, when, and how to plant; what to sell. These included decisions about livestock as well as crops. The importance of the female heads of households should be considered when interventions and extension activities are designed.

The level of education farmers have is extremely important in designing extension activities. Most heads of households had completed 2 years of education, but a portion had no formal education, especially in Siaya.

The first language of all farmers was their native dialect, either Dholuo, or Luhya. About 75% of the farmers spoke a second language. This was usually Kiswahili, and less often English or another tribal language. Thus extension activities should be conducted in local tribal dialects or possibly Kiswahili.

Family Education. The number of children remaining on the farm in Kakamega averaged 4.57 children and 2.17 in Siaya. This was principally

Table 3.9. Characteristics of the Head of Household by Farm Size and District.

Farm Class (ha)	Percentage of Male Heads	Age (Yrs)	Formal Education (Yrs)	Number of Children	Languages Spoken
< 0.5	36.0	47	1.7	3.00	1.8
0.5 - 1.0	44.0	51	1.3	2.96	1.5
1.0 - 1.5	46.2	51	1.5	4.23	1.9
1.5 - 2.0	42.9	53	1.7	3.43	2.4
> 2.0	60.0	56	1.9	4.20	1.9
Siaya	45.0	52	1.2	2.17	1.4
Kakamega	42.5	49	2.0	4.57	2.2

Table 3.10. Children in School by Farm Size and District.

Farm Class (ha)	Total	Males	Females	Primary School	Secondary School
< 0.5	1.52	.86	.66	1.36	0.16
0.5 - 1.0	2.16	1.16	1.00	2.00	0.16
1.0 - 1.5	3.15	1.62	1.54	3.00	0.15
1.5 - 2.0	2.86	1.14	1.71	2.14	0.71
> 2.0	3.50	2.30	1.20	2.90	0.60
Siaya	1.63	1.03	.60	1.61	0.02
Kakamega	3.02	1.52	1.42	2.55	0.47

a function of higher outmigration rates and not larger original family size. Likewise, subsistence farms had experienced more outmigration and had fewer children remaining (3.07) than did cash farms (4.18).

The Kenyan government has placed emphasis on education and literacy. A large percentage of the children on the surveyed farms were attending school (Table 3.10). Larger farms had more children at school. Similarly, cash farms supported 3.55 students versus 1.90 students from subsistence farms. As school fees can be quite large (500-1500 Ksh.), farms with more resources had more children in school. This was particularly true in the secondary schools and accounted in part for the lower numbers of students attending secondary schools.

3.2.3. Capital Resources

The poverty of Kenyan farm families is apparent when looking at the capital resources. Essentially all farm operations were carried out with either a "jembe," a large, heavy hoe, or a "panga," the African machete. Farms typically had 2-4 jembes and 1-2 pangas. These were supplemented by a bucket, several baskets, and perhaps a shovel or axe. The value of the panga and jembes and total value of the agricultural implements are in Table 3.11. Because of large intraclass variation, there were no significant differences between farm classes.

Table 3.11. Capital Inventory on Farms by Size and District.

Farm Class (ha)	Number of Residences	Value (Ksh)	
		Pangas and Jembes	Total Implements
< 0.5	1.80	58.36	150.40
0.5 - 1.0	2.56	59.32	129.08
1.0 - 1.5	2.54	58.46	139.85
1.5 - 2.0	2.14	65.14	189.71
> 2.0	3.20	79.50	230.40
Siaya	2.17	45.32	134.07
Kakamega	2.55	78.50	176.85

The number of residences were recorded (Table 3.11) as a measure of relative wealth. Houses were typically made with mud plastered over a frame of poles for walls and thatch roof, but corrugated tin sheets have become more common as a roofing material. A small number of houses in Kakamega were also built from locally made cement blocks.

At night livestock were kept in an open pen constructed from brush and poles (boma). Small stock and poultry were often kept in a corner of the owner's hut. Other capital investments for the livestock subsystem were assorted ropes and possibly a gourd or bucket for milking.

3.2.4. Cropping Activities

Cropping Strategy. The majority of surveyed farms were in the subsistence class with a primary objective of producing sufficient food to meet family requirements. Maize, sorghum, cassava, beans, cowpeas, vegetables, bananas, and sweet potatoes were grown, most of them season after season to meet these objectives. To insure self-sufficiency in food, most farmers used two cropping seasons. Only in Kaimosi where higher elevations compelled late maturing (180-270 days) maize did farmers not consistently plant a second crop to meet the food needs from early May to December and December to May, respectively. Level of production often did not meet the objectives and maize deficits were experienced. Historically, the period February to June is often characterized by marked food shortages (Moock, 1973; Gerhart, 1975; Lihanda, 1978; CIMMYT, 1977). Other crops were often grown with maize to reduce risk of food shortages.

Market objectives were of secondary importance to farmers. Provincial data indicated that over 80% of the maize produced in Siaya and Kakamega was consumed in the household (Kenya, 1977). Some maize and beans were sold at harvest out of a desperate need for cash. When farmers had to repurchase maize in the dry season, the price had increased as much as 300%. In addition to surplus maize and beans, cash crops were coffee and tea in Kakamega and "Siala" trees (*Markhamia platycalyx*) grown for building poles in both Kakamega and Siaya (Table 3.12). Sugarcane was also found on 12.5% of the Kakamega farms, however, this crop had not proven profitable and planted areas were being reduced sharply.

Table 3.12. Percentage of Farms Growing Various Cash Crops.

District	Coffee	Tea	Sugarcane	Tree
Siaya	--	--	--	3
Kakamega	15	10	13	40

Long Rains Season. The long rains start in March and continue into June. Farmers in western Kenya perceived the long rains as the beginning of the agricultural year. Management decisions made at planting time limited the range of choices during the subsequent short rains.

Typically 60 to 70% of the total land area was planted to food crops during the 1981 long rains (Table 3.13). This percentage was consistent (65-69%) over all classes although one would expect that as farm size decreased a greater proportion would be devoted to food production. North of these sites in the Mayenga and Shitoli Divisions of Kakamega, Rukandema (1978) found that on larger farms 21% of the land was cropped while 67% was cropped on smaller farms. However, his large farms averaged 3.6 ha and the small only 0.6 ha.

The most popular food crop was maize grown either as a sole crop or intercropped with beans. Intercropped maize and beans were grown on 73-88% of the farms during the 1981 long rains (Table 3.14). Monoculture maize (73%) and cassava (63%) were important crops in Siaya, while only

Table 3.13. Various Land Uses During the Long Rains by Size and District.

Farm Class (ha)	Food Crops Ratio N	Food Crops Ratio x̄	Cash Crops Ratio N	Cash Crops Ratio x̄	Grazing Land Ratio N	Grazing Land Ratio x̄
< 0.5	25	0.68	5	0.24	24	0.28
0.5 - 1.0	25	0.69	4	0.24	24	0.29
1.0 - 1.5	13	0.67	2	0.19	13	0.30
1.5 - 2.0	7	0.65	5	0.08	7	0.30
> 2.0	10	0.68	4	0.17	10	0.25
Siaya	40	0.70	2	0.10	39	0.30
Kakamega	40	0.64	18	0.19	39	0.26

Table 3.14. Percentage of Farms with Various Crops During Long Rains 1981 by Size and District.

Farm Class (ha)	Maize	Maize/Beans	Cassava	Cassava/Maize	Other Cereals	Sweet Potatoes	Fallow	Trees
< 0.5	56	64	36	8	12	8	48	20
0.5 - 1.0	36	100	32	8	24	20	40	16
1.0 - 1.5	54	77	62	0	38	31	54	15
1.5 - 2.0	86	57	71	26	14	29	86	43
> 2.0	60	90	40	10	20	30	60	30
Siaya	73	73	63	10	38	13	53	3
Kakamega	33	88	23	8	5	28	50	40

33% and 23% of the Kakamega farms grew these crops. Kakamega farmers planted 46% of their land to maize and beans and 32% in Siaya. In Siaya, cassava was also extremely important as 70% of the farmers had 28% of their land in cassava or a cassava and maize intercrop. Areas in other minor crops are shown in Appendix Table 3.

All except 2 farms had land available for grazing either as fallow land or land around the household compound. This was typically 25 to 30% of the total farm. Farm class differences were unimportant (Table 3.13). This land was often on steep slopes or other land not well suited for arable agriculture. Often, the only alternatives were trees, tea, or coffee. Grazing land was not managed per se. There were no inputs of improved forage varieties or fertilizers; however, in Kakamega, some reasonably high quality native forages were found (e.g., *Cynodon spp*, *Glycine spp*, *Trifolium spp*, and *Tylosema spp*).

Short Rains Season. The short rains typically begin in September. Most farmers tried to supplement their long rains crops by planting at least some portion of their shamba during the rains (Table 3.15). This was particularly true at the lower elevations of Kakamega District and higher rainfall areas of Siaya. Above 1650m farmers were not able to consistently get a short-rain crop because of the need to use a long maturing maize (180-270 days) during the long rains. In Kakamega, farmers had 33% of their land in food crops during the short rains, principally maize, maize-beans, maize-sorghum, or sorghum. Kakamega farmers grew 3.0 types of food crops during the short rains. Siaya farmers had 54% of their land in food crops during the short rains. Cassava maturing from a long rains maize and cassava intercrop was the major component of the short rains cropping activities (26% of total farm). Siaya farmers grew 2.4 types of food crops during the short rains.

Table 3.15. Cropping Activities During Short Rains (1980).

Farm Class (ha)	Maize		Maize/beans		Cassava		All Food		Fallow		Grazing	
	N[a]	$\bar{x}$[b]	N	$\bar{x}$	N	$\bar{x}$	N	$\bar{x}$	N	$\bar{x}$	N	$\bar{x}$
< 0.5	14	.46	5	.27	8	.23	21	.54	7	.30	22	.40
0.5-1.0	13	.24	9	.26	8	.31	24	.42	19	.28	25	.46
1.0-1.5	9	.12	5	.24	7	.20	13	.35	12	.51	13	.61
1.5-2.0	6	.19	2	.32	5	.20	7	.47	7	.35	7	.41
> 2.0	8	.12	5	.15	5	.17	9	.34	10	.45	10	.58
Siaya	32	.29	9	.31	28	.26	38	.54	30	.28	37	.45
Kakamega	18	.20	17	.21	5	.03	36	.33	35	.43	40	.51

[a] N is number of farms growing crop.

[b] $\bar{x}$ is mean ratio of crop to farm area for N farms.

The reduced food security on small farms is illustrated by the percentage of land in food crops. While during the long rains no trends were evident in food crops area, during the short rains smaller farms tended to have larger percentages of land in food crops and smaller percentages in fallow and grazing land.

Crop Inputs. Purchased maize seed was practically the only purchased input used for cropping. Table 3.16 lists several of the more commonly used maize varieties in the area. Local white varieties came from S. Africa in the early 1900s and were descendants of the Tuxpeno varieties (Gerhart, 1975). During the short rains season these were the varieties used. Prices for seed in the market ranged from 2-4 Ksh/kg. Hybrid seed was purchased quite extensively in Kakamega (90% farmers) for use during the long rains. The most common hybrids in Kakamega were H 613C and H 614C. In Siaya only 40% of the farmers purchased even small amounts of hybrid seed (H 511 or H 512) at a cost of 5.50 Ksh/kg.

Table 3.16. Common Maize Varieties Used in Western Kenya.

Variety	Year of First Release	Remarks[a]
Maduema Makula Rachar (Ndere)	early 1900s	- Kenya Flat White Complex - 120-150 days
Nyamula	late 1800s	- yellow - 120 days
H 511	1967	- 150-180 days - 40 bags/ha - 1000-1700 m
H 512	1970	- 150-180 days - 45 bags/ha - 1200-1800 m
H 611C	1971	- 180-270 days - 62 bags/ha - 1800-2400 m
H 613C	1972	- 180-270 days - 75 bags/ha - 1500-2100 m
H 614C	1976	- 180-270 days - 75 bags/ha - 1500-2100 m

[a] As reported by Kitale NARS

Local varieties of seed were used for all other crops. The only improved sorghum variety available was Serena. Local white varieties included Kumba and Ingumba. Red/brown types valued for their bird resistance included Kisudi, Ohunjo and Oloro. Cassava varieties planted from mature stems included Khamisi, Rateng, and Dusuma. Only Dusuma was consumed fresh. Other varieties were chipped and dried before consumption. Rose Coco was the most important variety of bean (Phaseolus vulgaris) grown. At least six other varieties were seen in markets and on farms. Bean seed prices were 5-6 Ksh/kg.

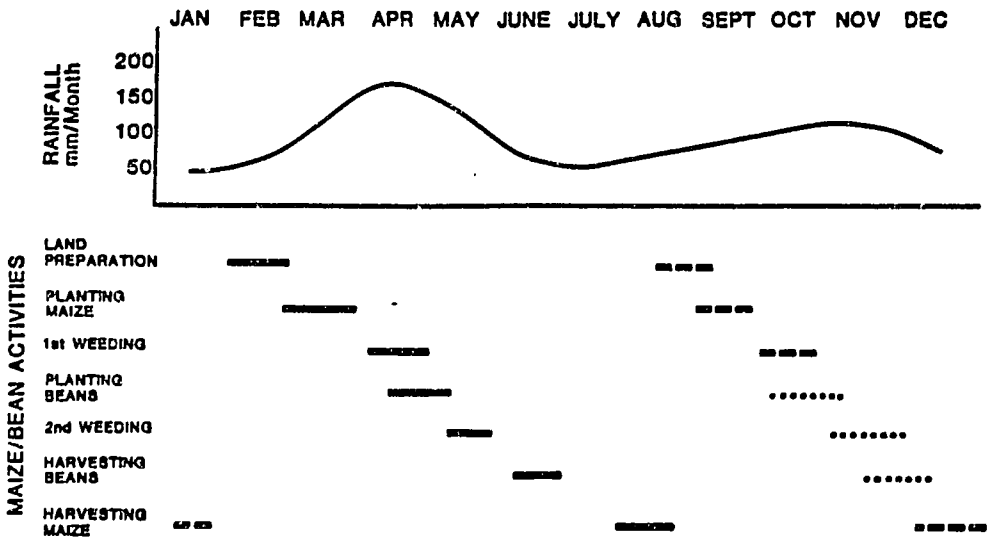
Labor was the major input. Job (1983) investigated labor use on the surveyed farms (Table 3.17). Each hectare of land in maize and beans required approximately 200 man days of labor per season. Similarly, a hectare of maize alone required around 240 man days per season. Differences in labor inputs between Districts were related to environmental conditions. The soil in Siaya at the time of digging (Figure 3.2) was generally drier and harder than in Kakamega. The fallow area after harvest in Kakamega generally produced a weed crop that maintained soil friability whereas the more exposed soils of Siaya required more labor for soil preparation (101 vs 64 man days/ha). Higher plant populations per hectare of both maize and beans in Kakamega increased labor requirements for planting over that in Siaya. However, the more open canopy from lower crop plant populations in Siaya allowed more weed growth increasing labor expended in weeding (84 vs 57 days/ha).

Estimated labor requirements were similar to those reported by Rukandema (1978) for Kakamega District. Digging required the most labor, followed by required two weedings. None of the farmers used oxen for plowing; Rukandema (1978) found a positive effect on maize yield from oxen use in a nearby area. Farmers generally felt that plot sizes were too small to justify the expense of owning (500 Ksh/yoke and plow) or hiring the oxen and plow (250-300 Ksh/ha). Because weeding required high inputs of labor, use of oxen to reduce length of planting period might only exacerbate the labor problem at weeding time. Labor was hired for digging on several farms. In general the cost was higher (400-450 Ksh/ha) than for oxen but people could be hired more easily and often payment was in harvested crops or in reciprocal labor instead of cash.

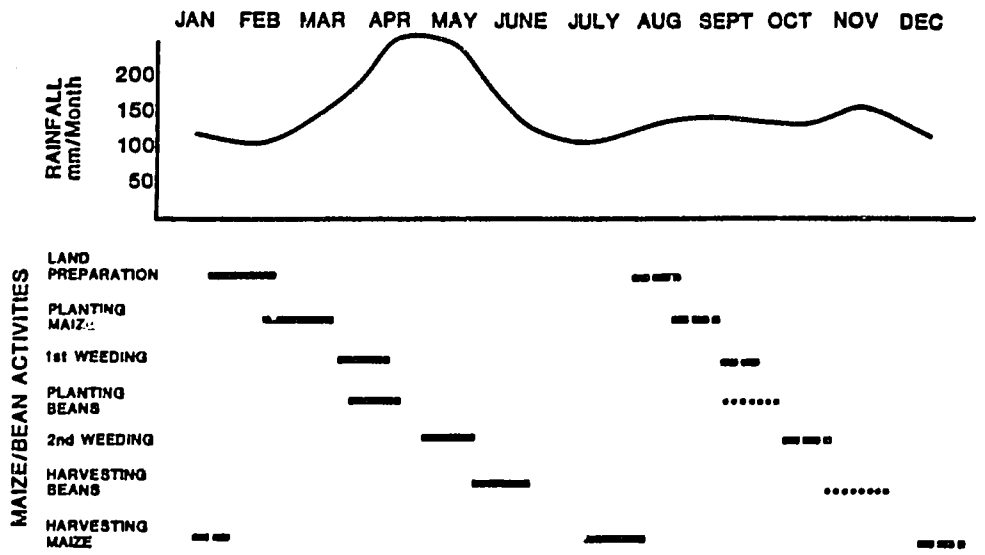
Table 3.17. Labor Input for Long Rains Maize/Beans on Surveyed Farms in Western Kenya (Man Days/Hectare).

Activity	Siaya	Kakamega	Mean
Digging	101	64	79
Planting	12	22	17
Weeding	84	57	67
Harvest Beans	15	10	12
Harvest Maize	27	20	22
Seasonal Total	239	173	197

Source: Adapted from Job (1983)



Mean Monthly Rainfall and Maize/Bean Cropping Activities in Siaya District



Mean Monthly Rainfall and Maize/Bean Cropping Activities in Kakamega District

Figure 3.2 Seasonal labor use in maize and bean intercrops in western Kenya.

The importance of female labor in cropping activities is apparent from Table 3.18. These figures were considerably higher for farms that had experienced considerable outmigration of males looking for cash employment. With these already large requirements on female labor, potential technologies must be evaluated in light of which members of the family will be expected to provide the labor.

Table 3.18. Percentage of Cropping Labor Performed by Females.

District	Digging	Planting	Weeding	Bean Harvest	Maize Harvest
Kakamega	62	60	60	77	61
Siaya	57	66	69	84	71

Source: Adapted from Job (1983)

No farmers purchased commercial fertilizers; however, 20% of the farmers utilized composted manure at planting time for maize. Generally, individual planting holes were dug with a jembe. A handful of compost and several maize seeds were placed in the hole which was then covered.

Reports from surveys of nearby Divisions indicated more use of manure. Wangia (1980) in a survey of Kakamega dairy cattle owners reported that 46% and 63% of the farmers used manure for long rains and short rains maize crops, respectively. Enserink (1981) reported 62% of Siaya farmers used manure, primarily on maize or cotton.

Maize and Bean Yields. Crop yields were extremely low (Table 3.19) with maize yields ranging from 900-2400 kg/ha. District differences were significant ($P<.001$). Smaller farms tended to yield more than large farms per unit of land, probably due to more intensive use of labor. Allan (1971) showed the importance of proper husbandry on maize yields. After trials at various locations in western Kenya, he concluded that timeliness of planting was the single most important factor in maize yields. Late planting resulted in poor soil aeration and cold soil temperatures in early stages of plant growth followed by moisture stress at tasseling and grain filling. These various tasks were probably completed more quickly on small farms simply because of less land and larger number of workers/ha.

Increased moisture stress might explain the better yield for monoculture maize on farms above 2 hectares. The difference in monoculture maize yields on livestock farms (1707 kg/ha) and nonlivestock farms (1459 kg/ha) was not significant (Appendix Table 2). No significant differences were found in maize yields between cash and subsistence farms (Appendix Table 1).

Table 3.19. Maize and Bean Yields/Hectare by Farm Size and District (LR81).

Farm Class (ha)	Maize (kg/ha)		Beans (kg/ha)
	Maize alone	Intercropped maize	
< 0.5	2094	1727	934
0.5 - 1.0	1476	1180	621
1.0 - 1.5	1555	1396	1353
1.5 - 2.0	1191	1512	235
> 2.0	1599	1000	310
Siaya	972[a]	980[a]	378[b]
Kakamega	2194	1786	1004

[a] District differences have $p<.001$
[b] District differences have $p<.05$

Bean yields from beans intercropped with maize on the smallest farms (934 kg/ha) were not significantly larger than yields of 310 kg/ha on farms over 2 hectares. Yields in Kakamega with its higher rainfall were significantly ($P<.05$) higher than in Siaya (1004 vs 378 kg/ha).

While the largest farms produced 169 kg of maize/person the smaller subsistence farms produced only 60 kg/person (Table 3.20). These are below the required 190 kg discussed in Section 3.1.2.

Table 3.20. Maize and Bean Yields/Person by Farm Size and District (LR81).

Farm Class (ha)	Maize (kg)	Beans (kg)
< 0.5 ha	60	29
0.5 - 1.0	87	27
1.0 - 1.5	82	49
1.5 - 2.0	178	37
> 2.0	169	21
Siaya	89	10
Kakamega	106	48

3.2.5. Livestock Activities

Livestock Ownership. Livestock represent an important component of small farms in Western Kenya. Some type of livestock are seen on almost all farms, poultry on 83% and ruminants on 61%. Livestock were kept for a variety of reasons, including nonfood uses. Although poultry and milk

from cattle was consumed, most livestock were not reared to produce food for on-farm consumption. Livestock were kept primarily to be sold when cash was required. Thus, the more wealthy farmers tended to have more livestock not because the animals were particularly productive and made money for the farmers but because they were a means of storing wealth. Livestock ownership was a result of wealth, not a cause. Secondary objectives for livestock included manure production and traction.

The percentages of farms having various types of livestock are in Table 3.21. Total Livestock Units (TLU) were calculated from metabolic body size. The following conversion constants were used:

Bulls/oxen > 2 years	1.0
Bulls/oxen < 2 years	.5
Zebu cows	.6
Crossbred cows	.8
Zebu heifers	.4
Crossbred heifers	.5
Calves	.2
Sheep/goats	.2

There was a positive relationship between livestock numbers and farm size, especially with crossbred cattle where ownership increased from none on farms under 0.5 ha to 20% of the farms over 2.0 ha. No farmers in Siaya owned crossbred cattle while 17.5% of Kakamega farms had some. Similarly, 27.3% of the cash crop farms owned crossbred versus 1.7% of the subsistence farms.

Table 3.21. Percentages of Farms With Various Types of Livestock.

Farm Classification	Cattle		Sheep	Goats	Poultry	TLU
	Zebu	Crossbred				
All Farm	48.8	8.8	28.8	5.8	83.7	61.3
Siaya	50.0	-	25.0	15.0	80.0	60.0
Kakamega	47.5	17.5	32.5	2.5	85.0	62.5
Cash	59.1	27.3	40.9	9.1	91.0	62.6
Subsistence	46.6	1.7	24.1	8.6	81.0	60.3
Under 0.5 ha	44.0	-	20.0	4.0	72.0	48.0
0.5 - 1.0 ha	48.0	4.0	28.0	8.0	91.0	68.0
1.0 - 1.5 ha	53.8	7.6	50.0	37.5	78.6	76.9
1.5 - 2.0 ha	57.1	14.3	57.1	14.3	100.0	57.1
Over 2.0 ha	50.0	20.0	30.0	-	80.0	60.0

(also see next page)

Sheep ownership tended to increase with farm size (20.0 to 57.1%) except for farms over 2.0 ha (Table 3.21). Of the cash farmers 40.9% owned sheep in comparison to 24.1% of the subsistence farmers, again an indicator of their use for capital storage.

Goats were much more common in Siaya District (15.0% of farms). Kakamega farmers contended goats were extremely difficult to manage around crops. For this reason they felt that native hair sheep were a much better small ruminant for their purposes. In fact, the only surveyed farmer in Kakamega who owned goats grazed them in a bordering National Forest, not an officially sanctioned practice.

The distribution of total value of livestock kept on surveyed farms is shown in Figure 3.3. The values of individual livestock were assigned by the owners. The values matched very well with prevailing market and subsequent sale prices of animals sold.

To evaluate the association among livestock and other variables relevant to the small farm production systems survey, Kendall Tau correlation coefficients were estimated. Livestock numbers per farm were strongly correlated with each other (Table 3.22). Generally, when farmers decide to own livestock, they are inclined to own several species, possibly to reduce risk of losing all individuals to a breed specific disease.

Table 3.22. Correlation Coefficients Between Types of Livestock Per Farm.

	Sheep	Goats	Poultry
Kakamega District			
Cattle	.27	.07	.44**
Sheep		.32*	.09
Goats			.15
Siaya District			
Cattle	.37**	.49**	.30*
Sheep		.39*	.38**
Goats			.42**

* $p<.05$
** $p<.01$

In Table 3.23 livestock numbers per farm are correlated with variables such as hectares owned, food crop ratio, number of years the farm has been owned, maize produced per person, total family members, total members at school and total value of farm implements. Several correlation coefficients in Kakamega District were statistically significant. Cattle numbers were positively correlated with hectares owned, school attenders, and value of farm implements. Cattle numbers were negatively correlated with the food crop ratio. Poultry were positively correlated with hectares owned. In Siaya livestock did not have any significant correlation with other variables tested, except for sheep numbers and years the shamba had been owned.

Sands (1983) pointed out that crop production per farm was a potential indicator of residues for animal feed; however, the correlations in

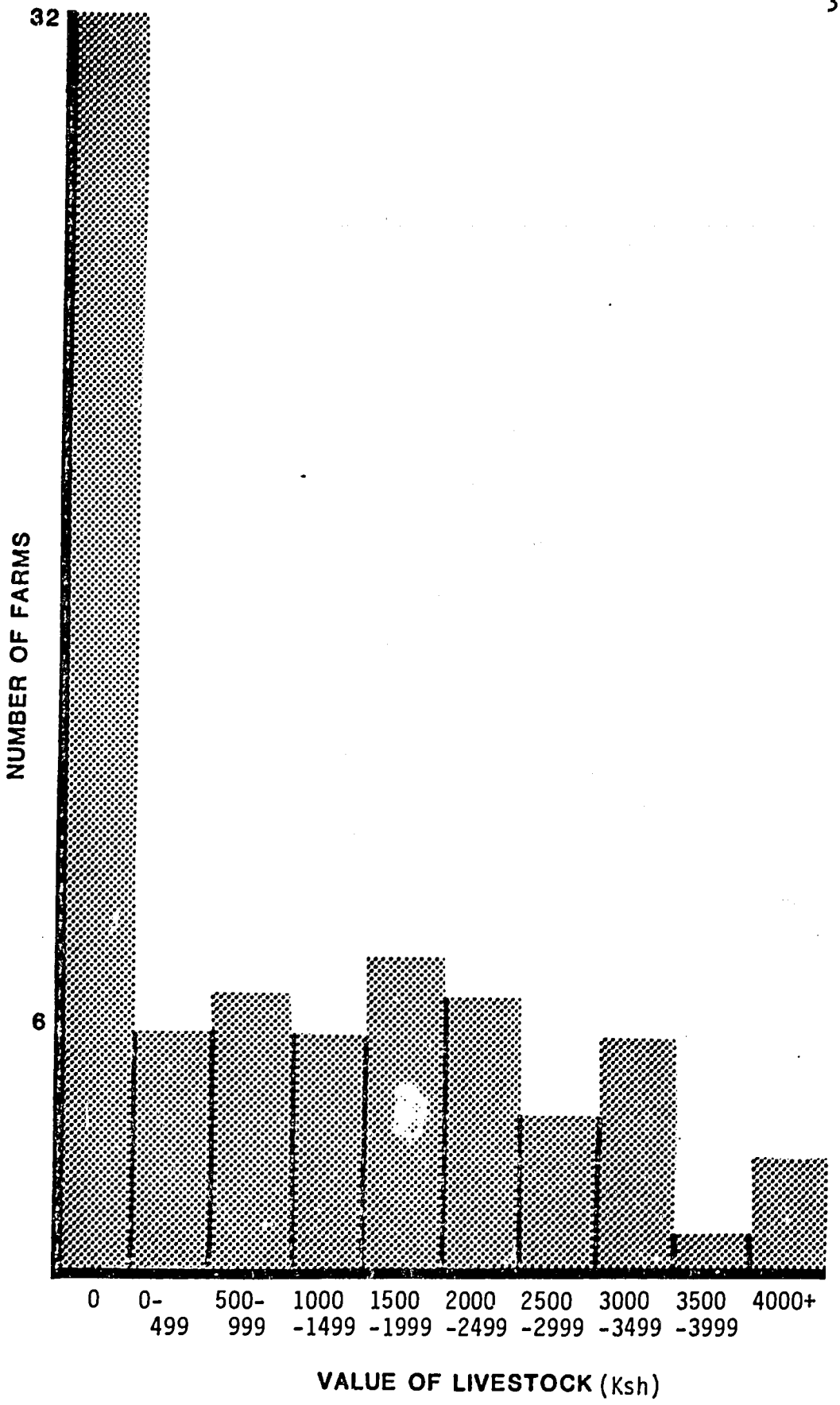


Figure 3.3 Distribution of Livestock Value Per Farm.

Table 3.23 are inconclusive in this respect. Generally, the negative food crop ratio correlations indicate that fallow land may be a more important source of animal feed than crop residues.

Table 3.23. Correlation Coefficients Between Livestock Types and Other Farm Variables.

	Hectares	No. of years owned	Feed crop ratio	Total members	Total at school	Maize/ person	Value of farm implements
				Kakamega District			
Cattle	.27*	.18	-.26*	.24	.42**	-.09	.26*
Sheep	.14	.00	-.19	.19	.10	.25	.16
Goats	.07	-.06	.18	.09	.14	.19	-.12
Poultry	.33**	.23	-.15	.03	.19	.06	.15
				Siaya District			
Cattle	.08	.20	-.13	-.04	-.16	.14	.22
Sheep	.09	.30*	.04	.08	.16	.04	.19
Goats	.02	.12	-.03	-.13	-.16	.11	.00
Poultry	.14	.23	-.10	.09	-.04	.14	.23

* $p<.05$
** $P<.01$

The relations between livestock numbers and other farm variables were further defined using regression analysis. Total Livestock Units (TLU) were defined as functions of the independent variables hectares owned, grazing land, stover production, persons per hectare, and maize per person. Hectares owned refer to total land available while grazing land and stover production reflect the feed available. The maize per person is a proxy for the productivity of the system. Labor available for livestock is indicated by the total persons per hectare. Total members per hectare was used instead of workers per hectare to account for young children and old men who often assist with herding livestock.

Equations for all farms including those with no livestock in the two Districts were:

Kakamega

$$TLU = \underset{(.55)}{.82} + \underset{(.35)}{.23}\,HA + \underset{(7.5 \times 10^{-5})}{.0002}\,GRAZ - \underset{(.0003)}{2.9 \times 10^{-5}}\,STOV - \underset{(.01)}{.02}\,P/H - \underset{(.004)}{.003}\,M/P$$

$r^2 = .37$

Siaya

$$TLU = \underset{(1.14)}{2.08} - \underset{(1.13)}{1.12}\,HA + \underset{(.0002)}{.0001}\,GRAZ + \underset{(.002)}{.001}\,STOV - \underset{(.065)}{.047}\,P/H - \underset{(.012)}{.002}\,M/P$$

$r^2 = .05$

where, TLU = livestock units/farm
HA = hectares owned/farm
GRAZ = on farm grazing land (m^2)
STOV = kg stover produced long rains 81/farm
P/H = persons per hectare
M/P = kg maize per person

Values in parenthesis below the partial regression coefficients are the standard errors of the estimates.

Equations were also fitted for data from only those farms that kept livestock. The resulting equations were:

Kakamega

$$TLU = 2.42 - .17\ HA + .0002\ GRAZ + .0002\ STOV - .068\ P/H - .007\ M/P$$
$$(.82)\quad (.46)\quad (.0001)\quad (.0004)\quad (.034)\quad (.005)$$
$$r^2 = .45$$

Siaya

$$TLU = 3.55 + .99\ HA - .0002\ GRAZ - .0006\ STOV - .066\ P/H - .004\ M/P$$
$$(1.89)\quad (2.56)\quad (.0003)\quad (.0029)\quad (.091)\quad (.015)$$
$$r^2 = .07$$

Equations for cattle numbers on farms having at least one bovine were estimated:

Kakamega

$$CAT = 4.55 + .18\ HA + .0003\ GRAZ + 4.3 \times 10^{-5}\ STOV - .099\ P/H - .011 M/P$$
$$(1.48)\quad (.81)\quad (.0002)\quad (.0009)\quad (.060)\quad (.010)$$
$$r^2 = .46$$

Siaya

$$CAT = 7.03 + 3.11\ HA - .0005\ GRAZ - 3.4 \times 10^{-5}\ STOV - .095\ P/H - .028\ M/P$$
$$(3.00)\quad (3.84)\quad (.0005)\quad (.0044)\quad (.132)\quad (.023)$$
$$r^2 = .20$$

where, CAT = number of cattle/farm
Other variables as previously defined.

The numbers of animals found on livestock farms are given in Table 3.24. District differences were significant for poultry numbers ($p<.05$).

Table 3.24. Numbers of Livestock on Livestock Farms by Size and District.

Farm Class (ha)	Cattle	Sheep	Goats	Poultry	TLU
< 0.5	3.09	1.80	3.00	5.68	1.87
0.5 - 1.0	3.38	3.14	2.50	8.36	1.54
1.0 - 1.5	6.13	5.00	4.67	6.15	3.20
1.5 - 2.0	3.75	2.50	1.00	12.43	2.32
> 2.0	4.67	2.67	-	-13.20	2.45
Siaya	4.80	3.60	2.83	12.31	2.63
Kakamega	3.36	2.54	6.00	7.53	1.66

Cattle. Cattle were primarily of the East African Zebu type. Some influence of the national AI program was seen in Kakamega with crossbred cattle found on 17.5% of the farms; Friesian and Ayrshire were the most popular breeds for crossing. Females represented 60-70% and reproductive females (>2 yrs age) represented 36-44% of the surveyed herds (Table 3.25). There were few old males. No males over 5 years were observed in Kakamega and only 6 bulls and 3 oxen were recorded in Siaya. Breeding was primarily by young bulls (2-5 years) before they were marketed or butchered. Sex differences were small for calves under 1 year. Males in Kakamega were usually sold at about 1 year of age whereas males in Siaya were sold at 4-5 years of age.

Table 3.25. Cattle Populations by Age and Sex.

	Under 1 year	1-2 years	2-5 years	Over 5 years	Sex percentage
Kakamega					
Males	18	9	3	0	29%
Females	15	20	21	16	71%
Age percent	33%	28%	24%	16%	102 animals
Siaya					
Males	14	7	16	6	37%
Females	10	8	15	37	60%
Oxen	0	0	1	3	3%
Age percent	21%	13%	27%	39%	117 animals

Mature weights were relatively low (Table 3.26). Females averaged 172 kg in Siaya and 213 kg in Kakamega, and intact males averaged 161 kg in Siaya and 171 kg in Kakamega. Low male weights were a consequence of the relatively young ages of the males. Growth curves were constructed from the cross sectional data. Each weight for age was considered as an independent data point (Figure 3.4). Limited longitudinal analysis of individual animals showed large seasonal variation. The relatively slow growth rates between 5 and 10 months of age resulted from weaning during that period. With no supplement and poor quality grazing offered, the transition from milk to forages was traumatic for young animals.

Table 3.26. Cattle Production Coefficients by District.

Variable	Siaya	Kakamega
Mature Weight (kg)		
Males	161(59)[a]	171(11)
Females	172(43)	213(45)
Oxen	196(26)	-
Calving Interval (mo)[b]	21.3(3.2)	19.6(4.1)
Lactation length (mo)	9.8(1.4)	10.9(1.3)
Milk Yield (kg)	302(81)	419

[a] Numbers in parenthesis are standard deviations
[b] Only for animals having 2 parturitions

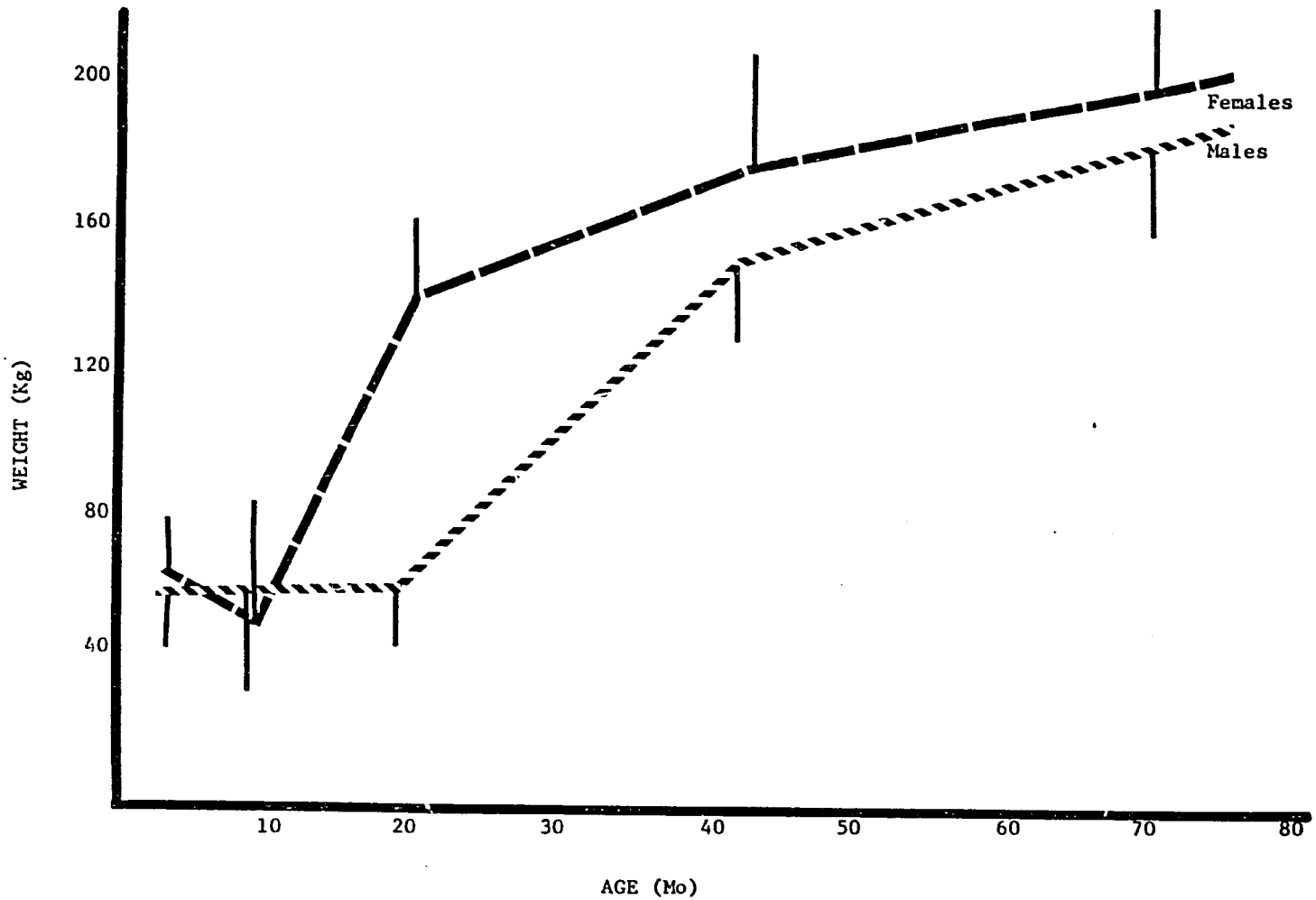


Figure 3.4 Growth curves of cattle on small farms in western Kenya

Mean parturition interval for 22 cows was 20.6 months. Intervals could only be calculated for animals with at least two calvings with the second occurring during the actual survey period. An approximately equal number had one calving at least 20 months prior to the end of the sampling period so the mean interval gives an optimistic estimate of productivity. Differences between District, parity or season for parturition interval were nonsignificant.

Lactation length for 39 cows averaged 10.3 months. Lactations following a dry season calving (9.6 months) were significantly shorter ($P<.05$) than those following a wet season calving (11.2 months).

Attempts to construct lactation curves were frustrated by the relatively constant amount of milk taken by the farmer (Table 3.27). Typically, the farmer allowed the calf to briefly suckle all four quarters to stimulate milk letdown. A predetermined amount of milk (usually 1-2 liters) was collected and the calf was allowed to remove the residual.

Table 3.27. Least Square Means for Weekly Milk Yield (kg) by District.

	Month of Lactation											
District	1	2	3	4	5	6	7	8	9	10	11	12
Siaya	7.0	7.0	7.4	7.8	6.8	8.0	6.3	6.8	6.6	8.8	5.3	--
Kakamega	11.6	10.0	9.8	9.8	10.6	8.6	7.9	7.8	9.2	7.0	5.8	5.3

Lactation yields estimated from weekly yields were 302 kg and 419 kg for Siaya and Kakamega. Yields for 11 cows which completed lactations during the study period averaged 525 and 610 kg in Siaya and Kakamega, respectively. These higher yields were probably due to long lactation lengths (11.6 and 12.7 months) for these animals.

Daily yield per cow and lactating cows per farm varied little over the year in either District (Figures 3.5 and 3.6).

Milk was consumed, primarily in tea, or sold to neighbors. The Kenya Cooperative Creameries (KCC), the parastatal with control over all commercial fluid milk marketing has no collection routes in either Division.

There was no significant effect of season on parturitions (Figure 3.7). No twins were born. An annual calving percentage of 33.7% was calculated for females over 2 years old.

Mortality rate averaged 8.2% (Figure 3.7), with no apparent effects of District or age. There was a significant effect ($P<.05$) of season with 76% of the deaths occurring during the wet season. While no postmortems were possible, livestock officers and local vets reported East Coast Fever, Anaplasmosis, and Babesia were the most important diseases causing mortality. These are tick borne diseases, indicating the importance of tick control.

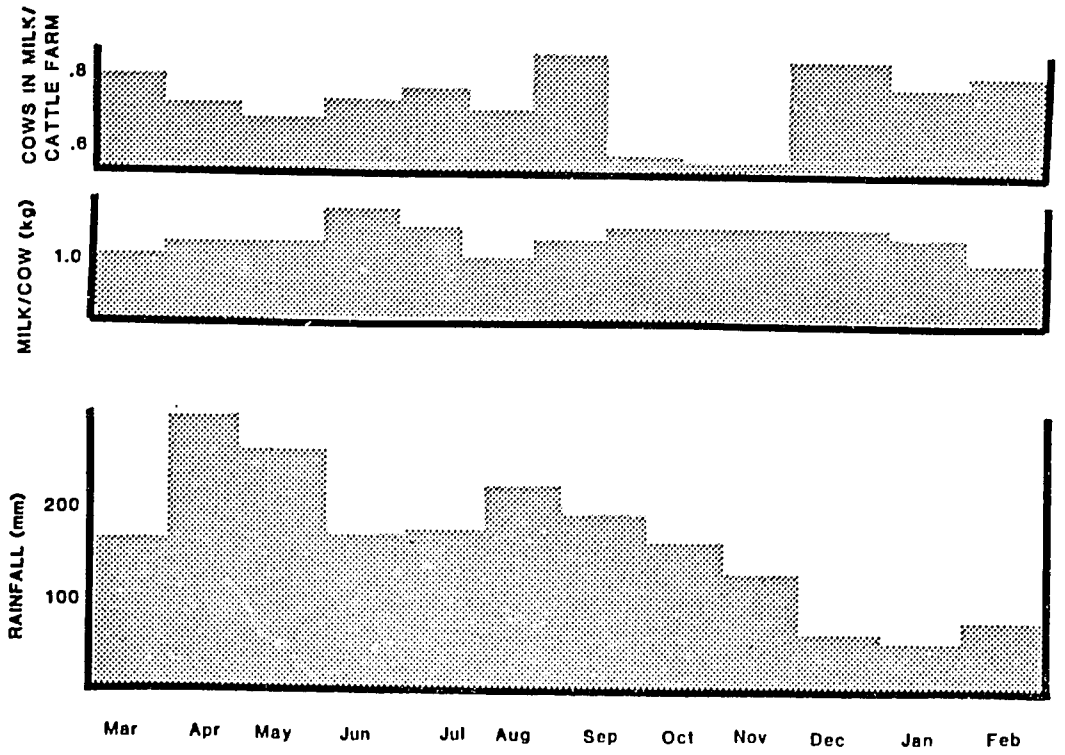


Figure 3.5 Rainfall, cows in milk, and daily milk per cow in Kakamega District.

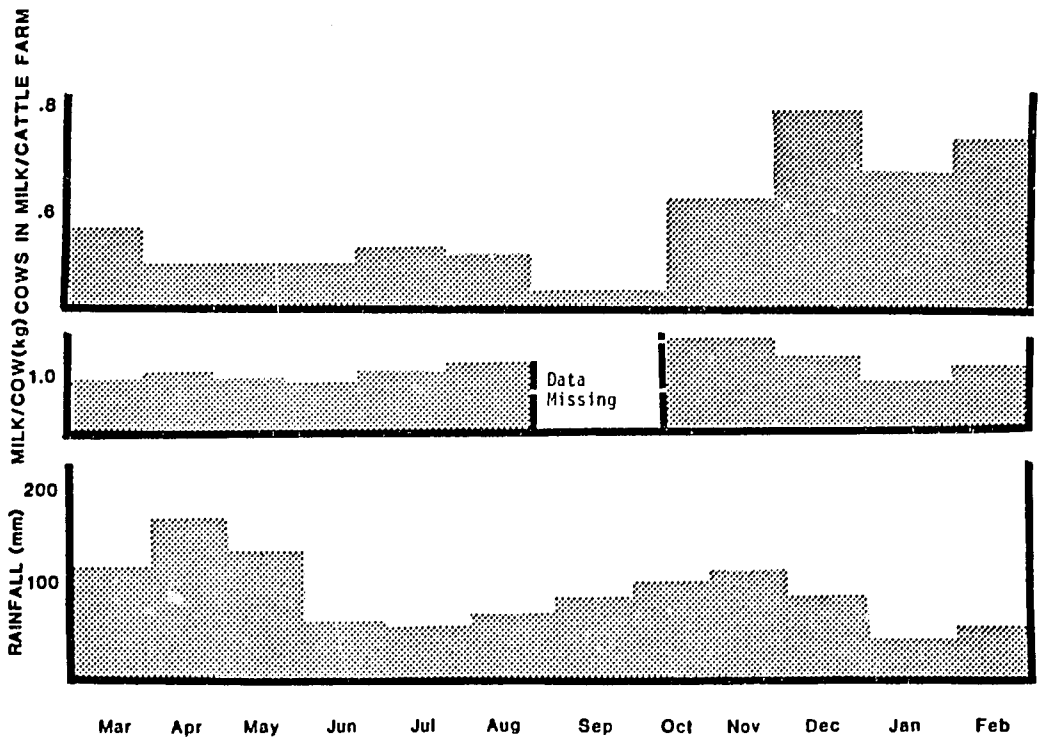


Figure 3.6 Rainfall, cows in milk, and daily milk per cow in Siaya District.

Sheep. Native breeds of hair sheep included both fat rump and fat tail types. Coat color was variable, white, brown or black with patterns (solids, piebalds, etc.).

Treating populations as single interbreeding herds within Districts, between 66 and 74% of the population were females (Table 3.28). Breeding ewes (>12 months) represented 40-44% of the total flock. Most males left the flock between one and two years of age.

Table 3.28. Sheep Populations by Age and Sex.

	0-6 mo	6-12 mo	1-2 years	2-5 years	>5 years	Sex percent
Kakamega						
Males	7	5	2	1	0	26%
Females	14	6	10	12	1	74%
Age percent	36%	19%	21%	22%	2%	
Siaya						
Males	9	4	1	8	0	34%
Females	8	6	11	10	7	66%
Age percent	27%	16%	19%	28%	11%	

Weights for rams over eighteen months were 23.8 and 27.5 kg in Siaya and Kakamega (Table 3.29). Mature ewes averaged 20.9 to 26.0 kg in the two Districts. Differences between sexes in gain/day over 180 days were nil. District differences (44 vs 90g/day) were significant ($p<.10$).

Table 3.29. Sheep Production Coefficients by District.

Variable	Siaya	Kakamega
Mature Weight (kg)		
Male	23.8(5.6)[a]	27.5(-)
Females	20.9(3.2)	26.0(5.1)
Lambing interval (mo)[b]	9.1(2.4)	9.8(1.8)
Gain 1-180 days (g/day)	44.0(10.1)	90.0(12.3)
Young/birth	1.0(-)	1.0(-)

[a] Numbers in parenthesis are standard deviations
[b] Only for animals having 2 parturitions

Lambing interval based on 19 ewes was 9.5 months. An additional 17 mature ewes had at least 12 months since their previous parturition. No multiple births occurred. The number of lambs divided by the number of breeding age ewes gave an annual flock lambing percentage of 64.7%. No seasonality in lambing was observed (Figure 3.8).

Mortality averaged 8.2% with no relation to season (Figure 3.8) or age. Livestock officers reported that Anaplasmosis and East Coast fever were the two most important diseases.

Figure 3.7 Cattle herd activities over seasons.

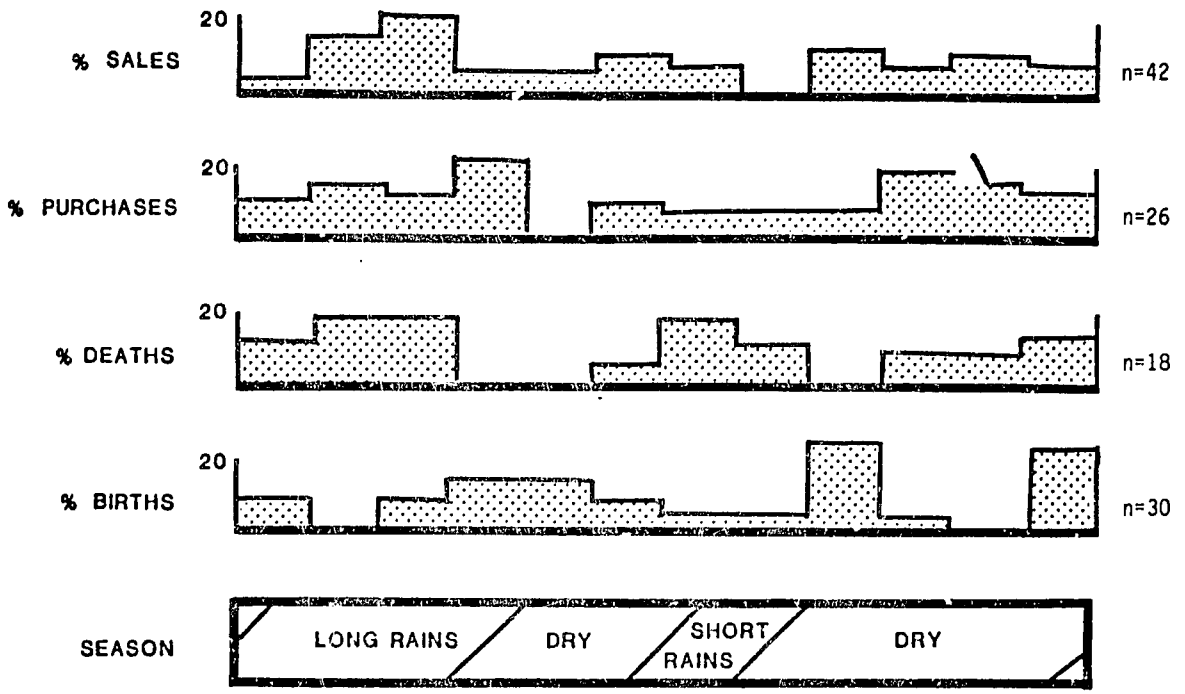
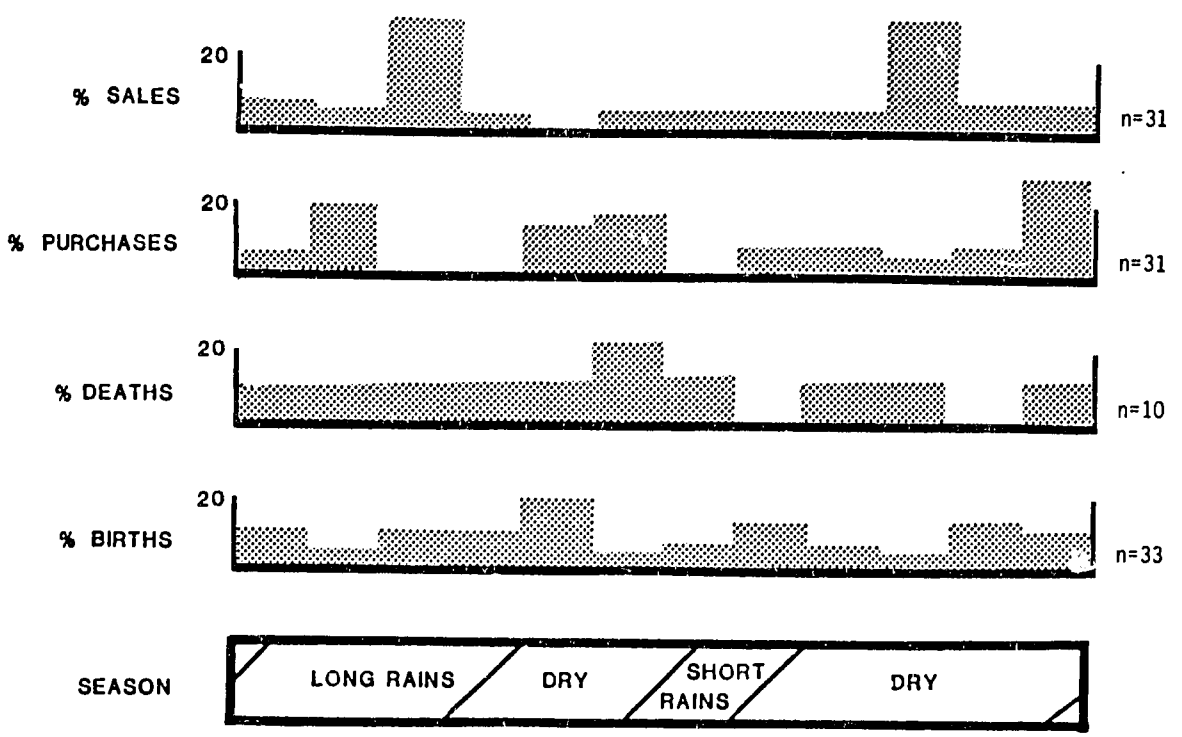


Figure 3.8 Sheep flock activities over seasons.



Goats. Goats were of the native small East African type. Coats were varied in color (black, brown, white) and pattern (solids, piebalds, etc.).

Table 3.30. Goat Populations by Age and Sex.

	0-6 mo	6-12 mo	1-2 yr	2-5 yr	>5 yr	Sex Percent
Kakamega						
Males	1	1	0	1	1	35%
Females	1	1	4	1	0	64%
Age percent	18%	18%	36%	18%	9%	11 animals
Siaya						
Males	5	1	4	2	1	36%
Females	4	4	6	6	2	61%
Castrates	0	0	0	1	0	3%
Age percent	25%	14%	28%	25%	8%	36 animals

Females represented 61 to 64% of the flock and breeding does (>12 months) accounted for 39-45% (Table 3.30). Weights for mature bucks were 31.3 and 28.2 kg in Siaya and Kakamega (Table 3.31); does averaged 23.6 and 23.4 kg. Average daily gain birth to 180 days was 71 g in Siaya.

Table 3.31. Goat Production Coefficients by District.

Variable	Siaya	Kakamega
Mature Weight (kg)		
Male	31.3(8.5)[a]	28.2(0.3)
Females	23.6(4.8)	23.4(4.1)
Kidding interval (mo)[b]	11.0(3.8)	10.0(2.7)
Gain 1-180 days (g/day)	71.0(21.2)	-[c]
Young/birth	1.1(-)	1.0(-)

[a] Numbers in parenthesis are standard deviations
[b] Only for animals having 2 parturitions
[c] Insufficient animals

Kidding interval for 4 does was 10.8 months; however, 3 does had not had a second parturition in over 1 year. Twins occurred in 13% of the parturitions. While the kids born/parturition was 1.1 the kids born/doe of breeding age was only 0.89. No seasonality in kidding was evident (Figure 3.9).

Mortality rate was 11%. No postmortems were conducted, but two of the animals died after complications in kidding.

Poultry. Poultry were kept on 83% of the farms. These were principally local native types, though one farmer in Kakamega had bought 250 improved layers which he kept confined. Ducks were found on 13% of the farms and turkeys on one farm. Average chicken flock size was 8-14 birds (Table 3.32).

Figure 3.9 Goat flock activities over seasons.

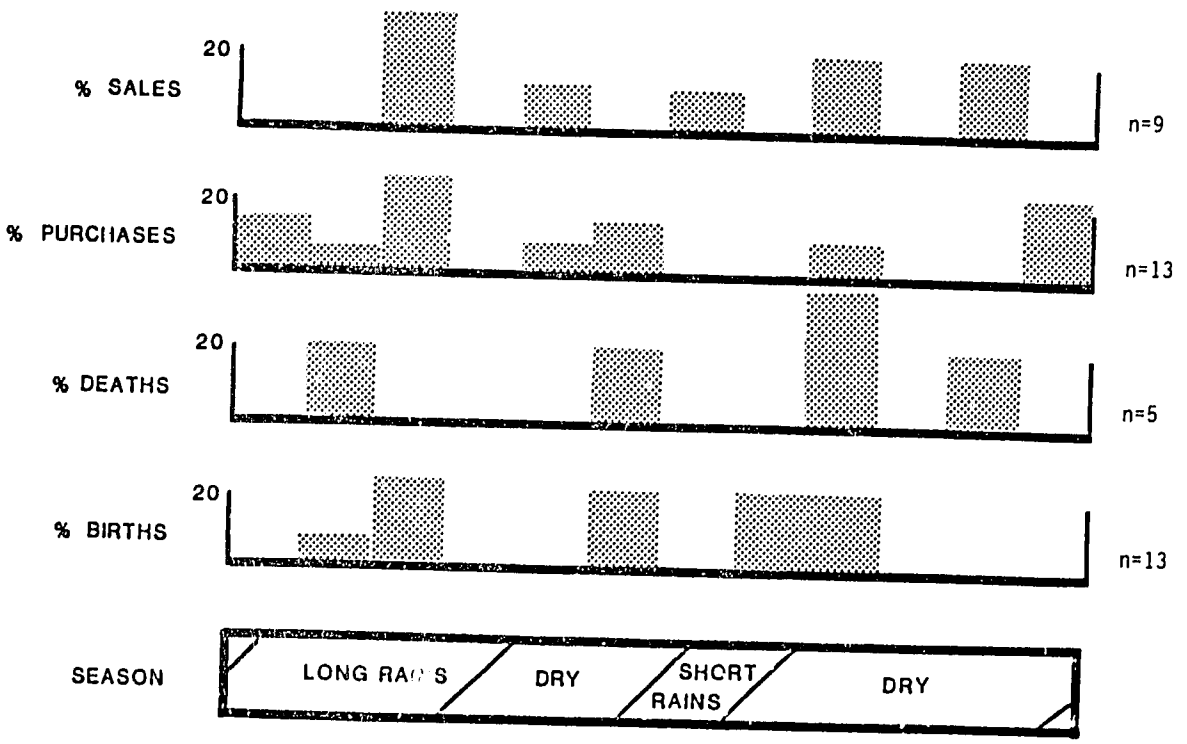


Table 3.32. Chicken Flock Composition in Siaya and Kakamega.

	Siaya	Kakamega
Roosters	1.03	1.00
Hens	3.77	2.90[a]
Chicks	8.38	4.65
Total	13.18	8.55

[a] Does not include one farmer with commercial flock of 250 layers.

Poultry consumption was infrequent, 80% of the poultry owners slaughtered and consumed birds less than twice a month, principally to celebrate some occasion, e.g., a visit by an esteemed visitor. Seventy percent of the farmers reported that the slaughtered bird was picked at random. Eggs were consumed more often, 30% of the families ate eggs at least twice a month. The rest of the eggs were allowed to hatch.

The Ministry of Livestock Development has been trying to stimulate the development of a commercial small scale poultry sector. The major constraints identified are large capital investment requirements (housing, purchased feeds and birds) and increased amounts of risk (Kenya, 1979). To reduce risk, 23% of the farmers purchasing exotic stock bought 8 week old birds as opposed to day old chicks.

One farmer in the survey obtained credit to purchase chicks and enough commercial feed to feed the flock until they started laying. He had built a house of mud and thatch for about 3000 ksh. The birds had just started laying at the end of the survey period. His mortality rate was only 5%, below the 7.5% the MLD estimated as required to realize a profit (Kenya, 1982).

Livestock Feed Sources. The principal source of ruminant feeds on small farms in western Kenya was grazing unimproved land. Animals were typically removed from the night enclosure (boma) at 8-10 in the morning and tethered in the compound. Later they would be herded by a male member on adjacent fallow land.

Farmers in Siaya herded their cattle 5-7 hours/day and left them tethered 3-6 hours (Figure 3.10). Livestock generally had access to at least limited feed 10-12 hours/day. During August and September, while labor was required to harvest the long rains crop and prepare and plant the short rains crop, animals were tethered for longer periods. The use of harvested residues was relatively unimportant in Siaya, as only 8% reported using this feed source. Animals were often grazed or tethered in harvested fields to utilize the standing residue.

Farmers in Kakamega herded their cattle 4-5 hours/day and tethered them 6-8 hours/day (Figure 3.11). Tethering was a more important form of feeding management in Kakamega than Siaya. While Siaya farmers only rarely fed harvested residues, 88% of the Kakamega cattle farmers fed some crop residues to tethered animals. These were principally maize stalks or thinnings and banana leaves or stems. Availability of these feeds was extremely seasonal.

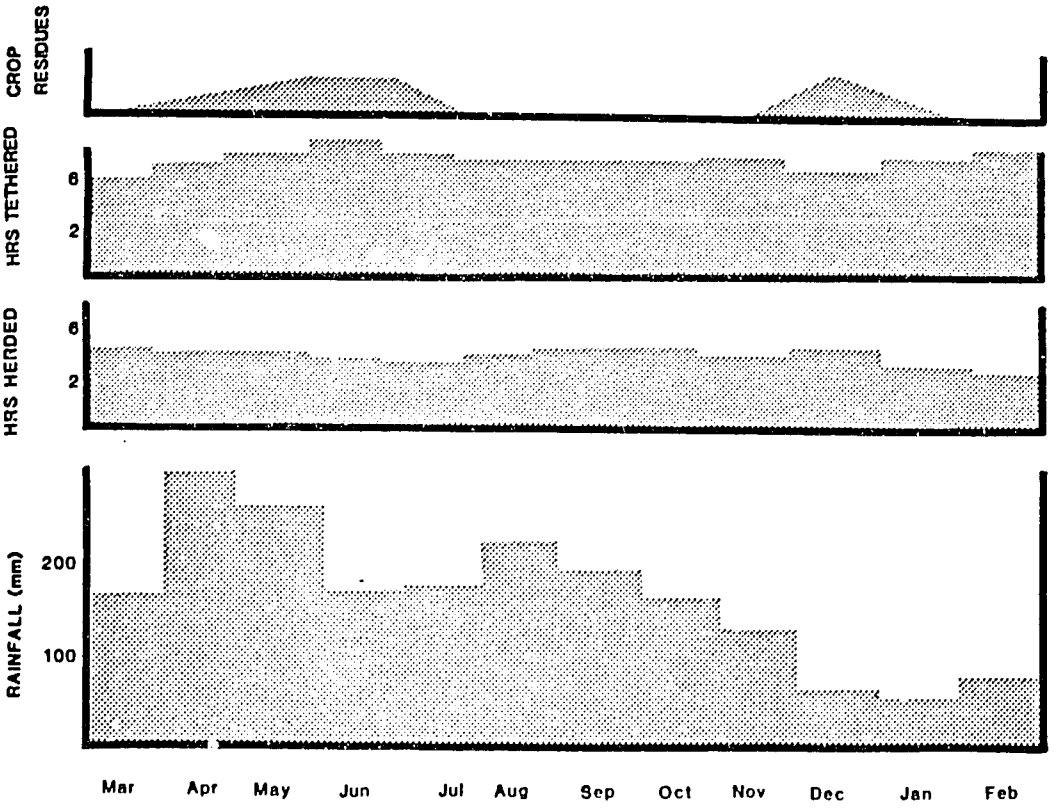


Figure 3.10 Seasonal rainfall patterns and cattle feeding strategies in Kakamega District.

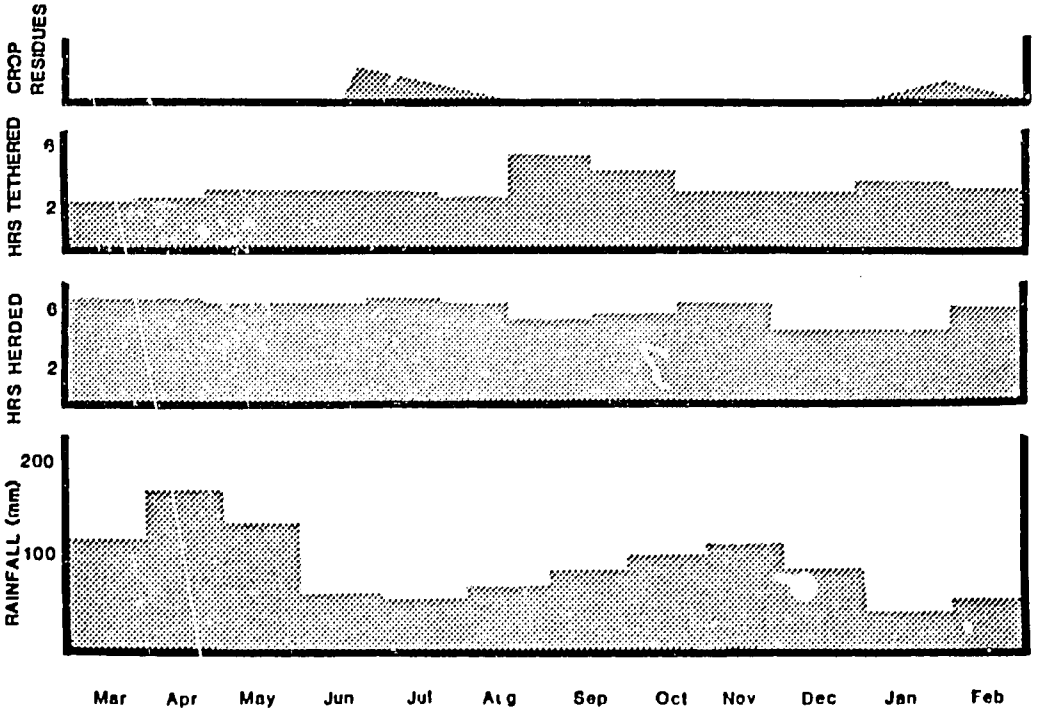


Figure 3.11 Seasonal rainfall patterns and cattle feeding strategies in Siaya District.

Seasonal variation in hours herded or tethered was small but there was a slight increase in hours tethered during May and June. The reason is not obvious because cropping activities that would compete for labor (e.g., weeding) would have been completed.

Farmers owning sheep and goats along with cattle herded them together for feeding; whereas, farmers with only sheep and/or goats rarely herded. Tethered stock were moved 3-4 times/day. Animals were moved more frequently during the dry season. Farmers in both districts rarely fed sheep or goats any harvested crop residues. No surveyed farmers ever purchased either forage or concentrate to feed livestock.

Direct measurements were not made on herbage yields of the pastures. However, Goldson (1977) reported the mean annual yield of 18 pastures on six small farms in western Kenya was 4747 kg DM/ha. Based on Goldson's results for botanical composition and annual rainfall, values of 5757 kg/ha/yr and 3752 kg/ha/yr were used for Kakamega and Siaya farms. Of this annual total, the short rains accounted for 1250 and 1919 kg/ha/season in Siaya and Kakamega, while the long rains yields were 2502 and 3838 kg/ha/season. Total DM yield was calculated by multiplying the seasonal grazing area by the appropriate conversion factor and summing the two seasons together. Estimates of on-farm grazing DM yields are in Table 3.33.

The other major source of DM was crop residues. Maize stover was by far the most important. Cassava foliage was not fed at all. Sweet potato vines, while high in quality, were not available in sufficient quantity to represent an important feed resource.

Table 3.33. Annual Fodder Production (kg/farm).

Farm Class (ha)	Grazing DM		Maize Stover DM		Total DM	
	SR80[a]	LR81[b]	SR80	LR81	SR80	LR81
< 0.5	295	516	99	348	394	864
0.5-1.0	576	716	168	736	744	1452
1.0-1.5	1257	1202	149	1043	1406	2245
1.5-2.0	1336	1786	273	1648	1609	3434
> 2.0	2384	1989	279	1893	2663	3882
Siaya	740	919	162	584	902	1503
Kakamega	1093	1085	192	1221	1285	2306

[a] 1980 short rains
[b] 1981 long rains

Maize stover yields were calculated from grain yields. Based on field measurements, grain accounted for 37-49% of maize plant DM at harvest. Stover yields were therefore estimated as 150% of grain yields (Table 3.33).

Feed Quality. Averages for chemical fractions of various feeds are in Table 3.34. Crude protein (CP) levels were moderate to high in all except the grass *Cymbopogon* spp and ugali (maize flour). The CP levels of two other grasses, *Cynodon* (21.25%) and roadside mix (18.73%), were also high. The roadside mix (*Digitaria scalarum* and *C. dactylon*) and

Table 3.34. Averages of Chemical Fractions From Feeds in Western Kenya.

Feed	Crude Protein	NDR	ADR	Hemi-Cellulose	Cellulose	Lignin	L/ADR	Silica
Crop Residues								
Maize thinnings(11)[1/]	14.28(3.68)[2/]	56.58(2.78)	33.56(2.34)	23.02(3.03)	29.58(1.45	3.98(1.94)	.12(.05)	2.01(.36)
Sorghum thinnings(12)	12.08(5.46)	61.06(3.92)	35.96(3.52)	25.09(3.67)	31.00(2.62)	4.96(1.65)	.14(.04)	1.98(.67)
Sweet potato vines (20)	19.81(2.70)	34.92(3.77)	33.52(4.24)	2.25(1.57)	23.70(1.94)	9.82(2.93)	.29(.05)	1.38(1.97)
Banana leaves(10)	15.66(2.79)	63.97(3.14)	37.03(2.37)	26.93(3.90)	25.25(1.39)	11.78(2.11)	.32(.04)	0.76(1.08)
Grasses								
Cynodon dactylon (6)	21.25(1.00)	64.56(4.03)	31.35(1.24)	33.21(2.87)	27.33(1.38)	4.02(.38)	.13(.01)	2.32(.56)
Cymbopogon afronadus(11)	6.56(2.17)	74.36(1.35)	44.90(2.34)	29.46(1.50)	38.13(1.70)	6.78(.86)	.15(.01)	3.31(.45)
Pennisetum purpureum(10)	10.06(2.96)	65.92(3.72)	38.25(3.54)	27.67(1.68)	34.28(2.84)	3.97(1.09)	.10(.02)	4.40(.61)
Roadside mix(5)	18.73(5.52)	69.39(6.86)	33.59(4.08)	35.80(3.72)	29.25(3.35)	4.34(.89)	.13(.02)	2.67(.52)
Legume								
Tylosema fassoglensin(5)	14.74(2.41)	49.39(1.35)	32.83(1.18)	16.57(1.53)	23.84(1.26)	8.98(.55)	.27(.02)	.30(.40)
Browse								
Sida cunefolia(1)	15.30	51.58	38.56	13.02	30.33	8.23	.21	Tr
Commercial Feeds								
Dairy meal (1)	15.99	34.15	12.70	21.45	9.65	3.05	.24	Tr
Layers meal (1)	15.74	28.38	10.21	18.17	7.78	2.43	.24	Tr
Wheat bran(1)	17.66	56.24	17.72	38.52	12.98	4.74	.27	Tr
Ugali(1)	7.36	7.82	3.77	4.05	3.01	.77	.20	Tr

1/ Number in parenthesis is number of samples
2/ Number in parenthesis is standard deviation

Cynodon were always heavily grazed. This heavy grazing pressure maintained the high quality by preventing the production of substantial structural carbohydrates (Van Soest, 1982). The high CP levels of sweet potato vines (19.81%) made them attractive as a possible supplement. The low CP content (15.74%) in Tylosema is disappointing for a legume.

Cell wall levels (NDR) of the grasses were higher (64.56-74.36%) than those of Tylosema (49.39%), Sida (51.58%) or sweet potato vines (34.92%). The acid detergent fiber (ADR) levels were remarkably similar for all feed types (31.35-44.90%) except the commercial feeds (3.77-17.22%). The higher cell wall in grasses was principally the result of higher hemicellulose levels. Pectin levels in sweet potato vines were estimated by the difference of conventional ADR and sequential NDR-ADR levels. The mean pectin level was 4.92% (Table 3.35). Though pectin is part of the ADR fraction, it is usually highly digestible.

Table 3.35. Pectin and Conventional Versus Sequential Sulfuric Acid Lignin Estimates for Sweet Potato Vines, % DM.

Sample	Pectin[a]	C-LS[b]	S-LS[c]	Difference
40	3.09	5.76	5.67	.09
96	3.82	10.50	8.64	1.86
86	4.04	12.65	12.12	.53
87	6.55	10.11	6.83	3.28
88	7.74	10.46	8.04	2.42
89	5.12	10.94	9.48	1.46
90	5.44	15.56	13.63	1.93
91	5.74	8.65	7.43	1.22
92	4.26	13.13	11.43	1.70
93	5.95	15.65	14.64	1.01
94A	3.60	8.39	7.51	0.88
95	6.83	11.34	9.39	1.95
32	7.30	8.56	6.45	2.11
33	6.25	11.60	9.50	2.10
34	4.36	8.84	7.84	1.00
41	3.78	6.66	5.55	1.11
42	5.45	7.47	5.61	1.86
43	4.24	8.17	6.48	1.69
44	5.11	5.87	4.84	1.03
45	4.44	6.17	5.30	0.87
56	0.25	13.27	14.39	-1.12
Mean	4.92	9.99	8.61	1.38

[a] Pectin measured as difference between sequential neutral detergent acid detergent residue and acid detergent residue.
[b] Conventional sulfuric acid lignin.
[c] Sulfuric acid lignin after sequential ND-AD treatment.

Apparent lignin levels ranged from 0.77% (ugali) to 11.78% (banana leaves). Relatively high lignin levels were also found in sweet potato vines (9.82%), Tylosema (8.98%) and Sida (8.23%). Lignin: Acid Detergent Fiber ratios (L/ADR) were highest in banana leaves (.32), sweet potato

vines (.29) and Tylosema (.27). Grass L/ADR levels ranged from .10 (Pennisetum) to .15 (Cymbopogon). Only Napier grass (Pennisetum) had any significant levels of silica (4.40%).

In vitro cell wall digestibility (IVTDCW), in vitro organic matter digestibility (IVTDOM), and predicted values for cell wall digestibility (PDCW), digestible organic matter (PDOM), digestible energy (DE) and intake are in Table 3.36. IVTDOM values ranged from 45.36% (banana leaves) to 97.78% (ugali). Cell wall digestibilities followed the same pattern, lowest in banana (23.30%) and highest in ugali (71.95%) and maize thinnings (72.27%). The high IVTDCW (67.46%) and IVTDOM (86.54%) for sweet potato vines are interesting in light of the high apparent lignin and L/ADF values. The high pectin levels probably interfered with the lignin analysis. Lignin values in samples sequentially treated with ND and AD were 1.38 units lower with a mean of 8.61%. Cutin contamination was also possible.

When the PDCW was plotted on IVTDCW (Figure 3.12) values above the unity line would represent samples that had a higher predicted value than "in vitro." Only four feeds were above the line, banana leaves, Tylosema, Cymbopogon, and Napier grass. Similar results were observed when plotting IVTDOM and PDOM. All four feeds contained inhibitory substances not adequately accounted for in the summative equation. Silica was the inhibitory substance in Napier grass. Cymbopogon had extremely high levels of turpenoids. These were low enough in molecular weight for extraction in ND and counted as cell contents (Reed and Horvath, pers. comm.) but were low digestibility and moderately toxic to rumen microflora.

Banana leaves and Tylosema were analyzed for condensable tannins using Ytterbium (Reed et al., 1982a). Acetone soluble condensed tannins in banana leaves were 1.27% of the dry matter and 4.33% of the cell wall was condensed tannins (Table 3.37). Tylosema had values of 6.15% DM and 3.38% NDR. These levels would significantly reduce both cell wall and organic matter digestibility. Reed et al. (1982b) found each unit of NDR condensed tannin increased pepsin insoluble NDR crude protein by a factor of 3.24 in cassava forage.

There were important seasonal variations in quality of forages. Organic matter digestibility (IVTDOM) declined after the start of the rains (Figure 3.13). IVTDOM over the season declined 15-27% in sorghum and Cymbopogon, but only 5% in Cynodon and the roadside mix of grasses. Similar trends were seen in cell wall digestibility. CP levels declined more precipitously (Figure 3.14). CP in young growth after the beginnings of the rain was high for Cynodon (22.95%) and sorghum thinnings (20.85%) but declined 23-72% over the growing season in all materials except for Cynodon with only a 10% decline. The decreases in IVTDOM and IVTDCW were principally the result of increases in ADR (15-37%) and lignin with increasing age (Figure 3.15). There were no significant changes in silica over the growing season.

Table 3.36. In Vitro Cell Wall (IVTDCW), Organic Matter (IVTDOM) Digestibilities and Predicted Values for Cell Wall (PDCW), Organic Matter (PDOM) Digestibilities, Digestible Energy (DE) and Intake.

Feed	IVTDCW	IVTDOM	PDCW	PDOM	DE[c]	INTAKE[d]
Crop Residues						
Maize thinnings(11)[a]	72.27(9.22)[b]	82.60(5.36)	65.36(11.81)	84.09(8.58)	3.36(.22)	70.73(2.60)
Sorghum thinnings(12)	63.20(12.79)	75.70(7.66)	58.92(9.02)	77.79(6.25)	3.04(.31)	65.90(4.69)
Sweet potato vines(20)	67.46(7.19)	86.54(3.65)	32.74(6.61)	77.05(4.69)	3.54(.15)	83.95(1.54)
Banana leaves(10)	23.30(6.42)	45.36(5.02)	29.21(4.58)	56.13(4.42)	1.64(.21)	62.45(4.17)
Grasses						
Cynodon dactylon(6)	69.79(4.42)	78.02(2.80)	59.97(3.83)	78.69(3.00)	3.14(.11)	61.43(5.92)
Cymbopogon afronardus(11)	45.46(11.46)	55.87(9.57)	54.49(2.83)	69.26(2.61)	2.12(.39)	43.30(3.57)
Pennisetum purpureum(10)	64.81(5.47)	72.66(4.85)	67.94(5.49)	86.05(6.30)	2.90(.19)	59.50(5.73)
Roadside mix(5)	69.42(5.36)	76.23(5.17)	60.02(4.18)	75.89(5.88)	3.06(.21)	52.35(11.20)
Legume						
Tylosema fassoglensis(5)	23.85(7.97)	62.33(4.62)	33.94(2.36)	67.80(1.39)	2.42(.18)	76.47(0.90)
Browse						
Sida cunefolia(1)	51.88	72.95	42.42	71.61	2.91	74.96
Commercial Feeds						
Dairy meal(1)	54.89	83.69	38.38	78.42	3.21	84.34
Layers meal(1)	51.20	84.56	34.49	83.13	3.45	86.44
Wheat bran(1)	48.40	68.99	34.78	63.54	2.73	71.19
Ugali(1)	71.95	97.78	43.93	93.87	4.06	91.78

a/ Number in parenthesis in number of samples.
b/ Number in parenthesis is standard deviation.
c/ Mcal/kg DM
d/ g/kgBW.^{75}

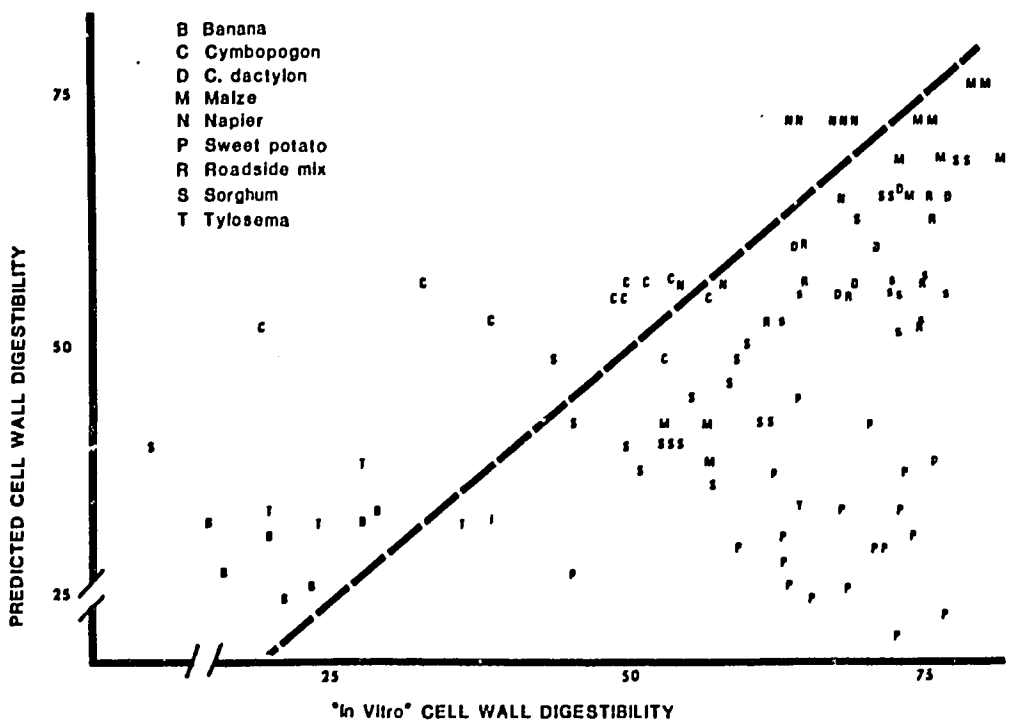


Figure 3.12 Relationship between predicted cell wall digestibility and "in vitro" cell wall digestibility.

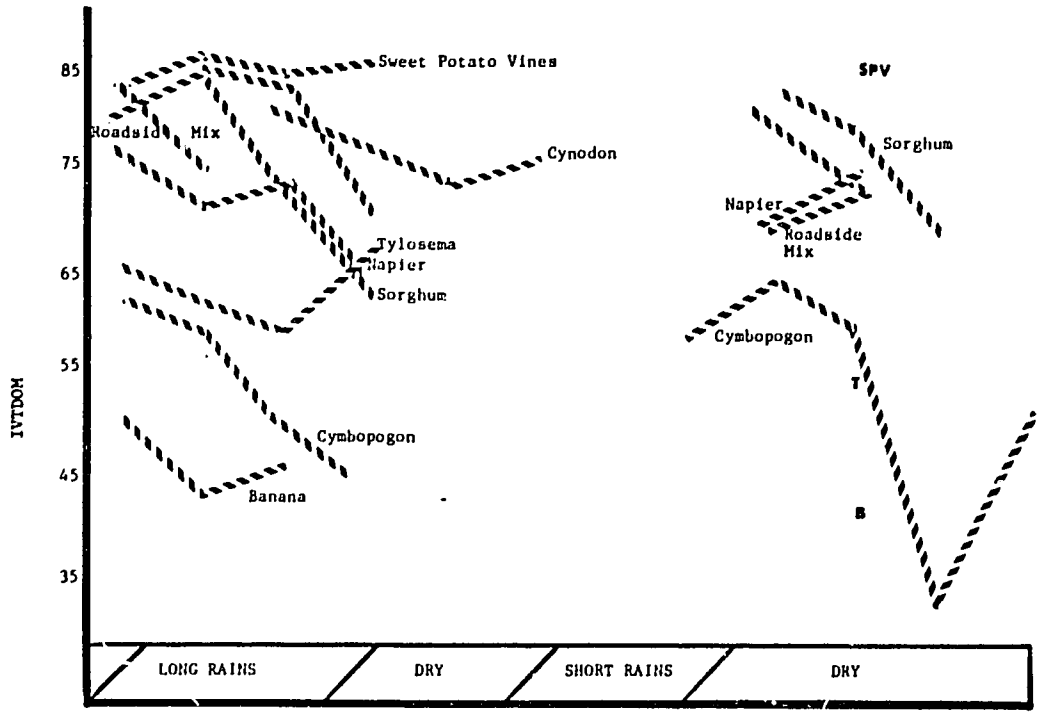


Figure 3.13 Effect of season on in vitro digestibility of organic matter (IVTDOM)

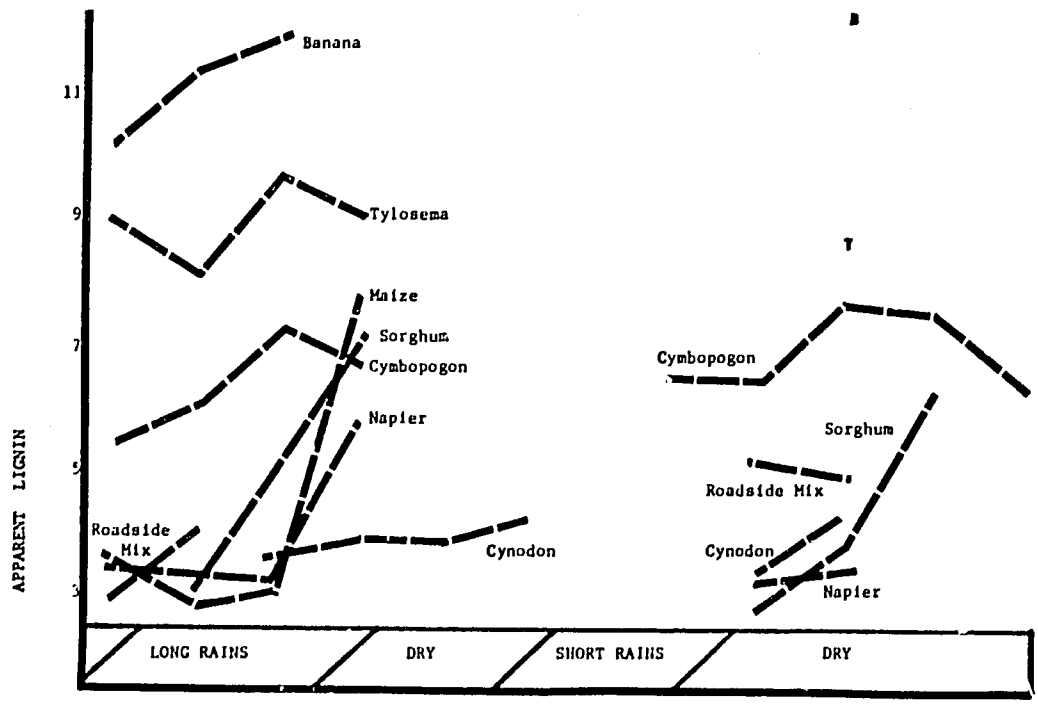


Figure 3.14 Effect of season on apparent lignin

Table 3.37. Condensed Tannin Levels in Banana Leaves and *Tylosema fassoglensis*.

Sample	ASCD[a] (% DM)	NDRCT[b] (% NDR)
Banana leaves		
020	2.00	3.82
021	1.21	4.77
023	0.61	4.41
$\bar{x}$	1.27	4.33
Tylosema fassoglensis		
015	6.40	3.55
038	5.98	3.63
060	6.06	2.95
$\bar{x}$	6.15	3.38

[a] Acetone soluble condensed tannins
[b] Neutral detergent fiber bound condensed tannins

Mineral analyses were conducted on selected samples. Mean values for various elements are in Table 3.38. Calcium levels (Ca) were adequate for low to moderate levels of milk production in all feeds except *Cymbopogon* (.156%) and maize thinnings (.184%). The high Ca levels in sweet potato vines (.569%) made this an attractive supplement for lactating animals.

Phosphorus levels in sorghum (.06%), maize (.17%), *Cymbopogon* (.22%) and *Tylosema* (.23%) were considered inadequate to support milk production and acceptable fertility levels. Magnesium levels were adequate in all feeds except *Cymbopogon* (.09%). Potassium (K) levels were high enough to support moderate levels of milk production in all feeds. Sodium (Na) levels, however, were uniformly low and animals would be expected to respond to supplemental salt. Zinc levels were low in *Cymbopogon*, *Pennisetum* and *Tylosema*, and adequate in the rest of the feeds. Reid et al. (1979) found that in general levels of Ca, Mg and Zn in 53 tropical forages grown under controlled conditions in Uganda did not vary significantly with stage of maturity. However, postharvest leaching of minerals would be expected in maize and sorghum residues. Levels of K, Na, Cu and Mo tended to decrease with increasing stage of maturity especially in grasses. Levels of Mn rose in some species (i.e., *Cymbopogon* and *Digitaria*) but decreased in others (i.e., *Setaria* and *Brachiaria*) with increasing maturity (Reid et al., 1979). Arroyo-Aguilu and Coward-Lord (1974) found that P, Mg, and K levels declined with age while Ca remained constant.

Mineral supplements (Maclik Super and Maclik Plus) were available at Kenya Farmers Association (KFA) outlet stores in Siaya, Kisumu and Kakamega towns. The use of these supplements was nonexistent among surveyed farmers presumably because of cost (2.5-4.5 ksh/kg) and distance to KFA stores.

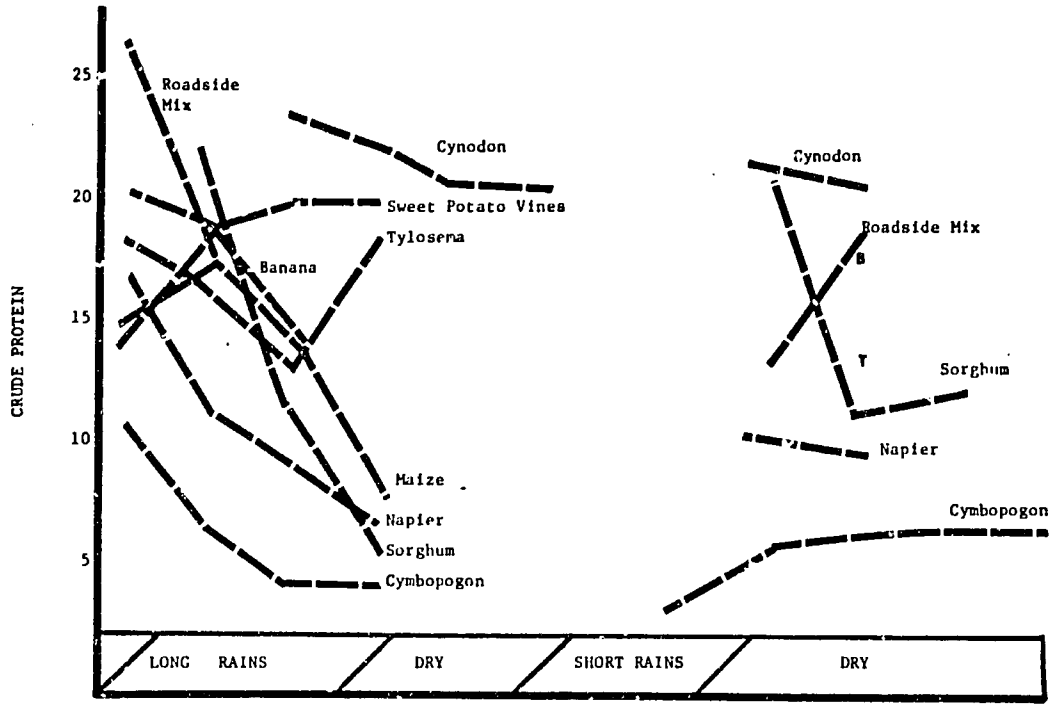


Figure 3.15 Effect of season on Crude Protein

Table 3.38. Mineral Analysis of Selected Feeds.

Feed	Percent DM					ppm			
	Ca	P	Mg	K	Na	Fe	Zn	Cu	Mn
Maize thinnings	.184	.17	.16	3.50	.0017	105	36	5	84
Sorghum thinnings	.259	.06	.17	2.07	.0028	84	55	8	66
Sweet potato vines	.569	.32	.29	5.59	.0020	543	30	12	16
Roadside mix-grass	.472	.33	.19	.381	.0122	202	49	9	77
Cymbopogon afronardus	.156	.22	.09	1.63	.0012	75	19	2	12
Pennisetum purpureum	.212	.35	.14	5.48	.0038	51	18	5	80
Tylosema spp.	.819	.23	.23	1.45	.0027	95	15	6	63
Commercial dairy meal	.766	.87	.35	1.11	.1276	1021	142	12	39

In an attempt to learn how farmers viewed various feeds they were asked to rank 8 common forages. The relative rankings given by farmers in the two districts are in Table 3.39. The influence of the extension agents in Kakamega can be seen in the ranking of Napier grass. No farmer actually grew Napier, but it was being recommended to farmers with livestock. Cassava was held in poor regard because farmers heard of animals getting into a patch unattended and dying. Perhaps, the largest surprise was the relatively poor ranking that was generally given to sweet potato tops that are a very good feed. The reason is unknown at this time.

Table 3.39. Farmer Ranking of Selected Forages by Quality.

Forage	Siaya	Kakamega
Maize thinnings	1	2
Maize stover	2	3
Wild grasses	3	5
Napier	3	1
Sweet potato vines	5	4
Sugarcane tops	6	7
Cassava tops	7	8
Banana leaves	8	6

In general, most feeds were at least marginally adequate in quality for animal growth during the early parts of the rainy season. Cymbopogon afronardus was an notable exception being of poor quality throughout the year. However, only Cynodon, sweet potato vines and the roadside mix contained adequate levels of CP, energy and most minerals to support animal growth throughout the year. The importance of inhibitory compounds (tannins, turpenoids, and refractory compounds) and mineral levels (Conrad et al., 1981) in the overall quality of tropical forages was evident in the feeds analyzed.

Digestible Energy. Digestible energy (DE) in Mcal/kg organic matter (OM) was calculated for each feed sample. The total annual DE available on each farm was estimated from the calculated dry matter yields reported earlier.

Cymbopogon values were used for Siaya while the roadside mix values were used for Kakamega. Values for maize residues were the same for both districts. The amounts of other material fed (i.e., sweet potato vines, banana leaves, etc.) were so small that they were ignored in these calculations.

The annual DE in Mcal/farm are in Table 3.40. The importance of grass production during the short rains and ensuing dry season were apparent in light of the small amount of DE from maize residues during this period. During the long rains maize residues and on-farm grazing land provided approximately equal amounts of energy.

Table 3.40. Annual DE(Mcal/farm) Production.

Farm Class (ha)	Grazing DE		Maize Stover DE		Total DE	
	SR80[a]	LR81[b]	SR80	LR81	SR80	LR81
< 0.5	761	1338	276	971	1037	2309
0.5-1.0	1489	1828	469	2053	1958	3881
1.0-1.5	3245	3002	416	2910	3661	5912
1.5-2.0	3501	4610	762	4598	4263	9208
> 2.0	6150	5043	778	5281	6928	10324
Siaya	1794	2228	452	1629	2246	3857
Kakamega	3170	3277	536	3407	3706	6684

[a] 1980 short rains
[b] 1981 long rains

Maize stover provided 34-39% of the total DE in both districts. The low levels of DE production, particularly in Siaya, were apparent when compared against the maintenance requirements of the livestock actually found on the farms. For instance, 7250 Mcal of DE would be required for maintenance requirements of the average 2.63 livestock units per farm in Siaya, a deficit of 1147 Mcal DE. This per farm deficit increases when DE for milk production and growth are added. Off-farm grazing must, therefore, provide a major portion of total nutrient requirements.

Seasonal Variation in Livestock Productivity. The effects of seasonal changes in feed availability and quality was apparent in the status of the livestock over the year. Weight changes in mature livestock are shown in Figure 3.16. The effects of the long dry season (Nov.80-March 81) are evidenced in the weight losses of all species. Cattle lost a greater percent of their initial weight (-3.75%) followed by sheep (-.90%) and goats (-.70%). All animals gained weight during the subsequent long rains, with sheep gaining the greater proportion (4.88%) and cattle (2.34%) the least.

Over the short rains cattle lost weight (-5.22%) while both sheep (1.92%) and goats (8.18%) gained weight. Change in investigators during this period may have affected estimates. The taping of cattle would be much more sensitive to people differences than scale weights for sheep or goats. However, the more selective feeding habits of the goat and hair sheep do allow them to better exploit the feed environment.

During the next traditionally dry period (Oct. 80-Mar. 82) there was slightly higher than average rainfall in western Kenya and all species gained weight with goats highest (17.13%) followed by cattle (11.53%) and sheep (3.55%).

The correlation between condition codes and seasonal weight changes was low. This was particularly true with sheep and goats. Several factors may have bearing. Goats deposit excess fat around the internal organs more than externally where it can be easily seen (Ladipo, 1973). For sheep the small amount of wooly hair on the back and significant amounts of manure caked on the rump made visual scoring difficult. To accur-

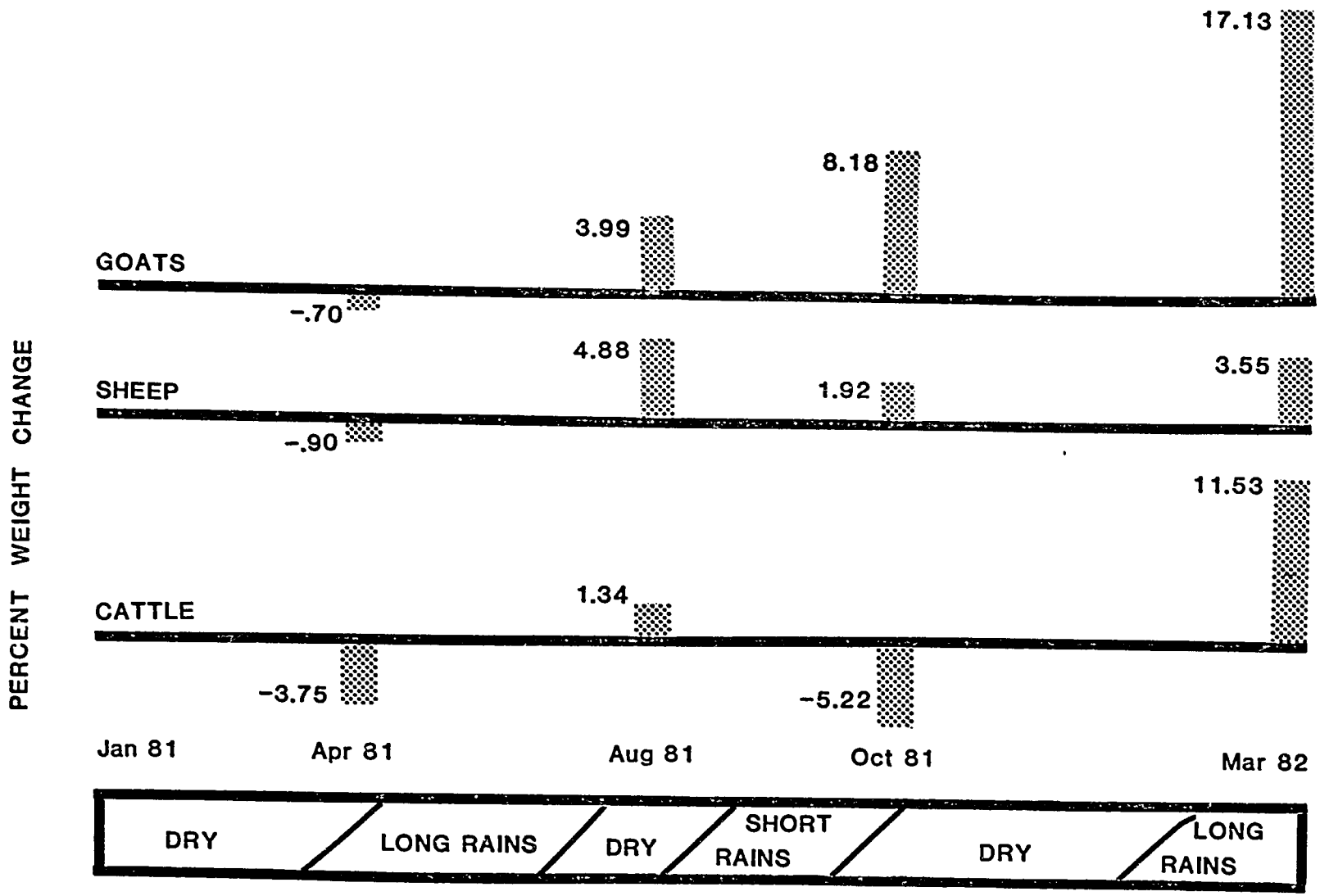


Figure 3.16 Seasonal weight change in goats, sheep, and cattle.

ately assess condition most animals had to be handled. Because difficulty in catching the animals and the manure covered rump, enumerators often only visually scored sheep.

Cattle scoring was somewhat more indicative of condition, but variation among the enumerators resulted in less than desired results.

Condition scores tend to vary more between individuals than among repeated observations by same individual. To improve scoring consistency, a reference guide including pictures and detailed descriptions of the various scores should be used by enumerators on all visits. Scoring should be in relation to the reference animals in the guide, not to the relative condition of the animals on the farm. Such a guide was provided; however it appears that enumerators did not use it conscientiously.

Animal Breeding and Management. All zebu cattle, goats and sheep were bred by natural service. In Kakamega, 37% of the crossbred cattle owners used AI, the rest (63%) used bulls owned by neighbors. All zebu owners in Kakamega and 62% of the Siaya farmers used neighbor's bulls, while others used their own bulls. The majority of goats were bred by neighbor's bucks in both Siaya (50%) and Kakamega (100%). Sheep owners followed a similar pattern with 73% and 89% in Siaya and Kakamega having their ewes bred by rams owned by others.

Cattle owners rarely used AI, even when AI was strongly encouraged by the Ministry of Livestock Development (Table 3.41). To use the AI service farmers had to bring their cows to a roadside crush where a government inseminator would be available once a day. The cost of up to 3 inseminations was only one Ksh, a substantially subsidized charge. However, Hopcraft (1976) and Wangia (1980) found that equipment problems often kept inseminators from making their appointed rounds; thus, it is not surprising that farmers reported that poor conception rates and poor reliability of technicians were the major reasons for not using AI. Heat detection without a bull was also a major reason for the poor conception rates for AI.

Table 3.41. Farmer's Reasons for Not Using AI on Cattle.

Reason	Siaya	Kakamega
Don't know about it	19%	5%
Crush is too far	0%	35%
Technicians are not reliable	19%	10%
Poor conception rate	24%	40%
Other	14%	10%
Cultural reasons	24%	0%

The majority of farmers (70%) felt that the rainy season was the best time to have animals give birth, because there was adequate feed available. However, all farmers said it was very difficult to get animals to

breed on a desired schedule. Farmers had widely divergent views when asked at what age livestock should have first parturition. Over 55% felt that cattle should be over 5 years at first calving. This older age accurately reflects the present poor growth rates of the animals. Successful conception and parturition even if possible would increase the risk of losing the cow because of immature body weights at younger ages.

The preferred weaning age for cattle was between 10 and 12 months. This corresponds to the length of lactations reported. Sheep and goats were weaned by the dams and farmers paid little attention to appropriate ages.

The primary emphasis in veterinary health in the area was directed towards tick control, principally through community dips. In 1980 the Ministry of Livestock Development took over maintenance of these to try to improve their use. Theoretically, all cattle must be dipped once per week at a cost of between .10 and 1.00 Ksh/animal. In Kakamega the percentage of animals dipped weekly increased from 9.3% in 1977 to 28.4% in 1980 (Kenya, 1980a).

Tick counts taken during the short rains weighings revealed that cattle had significantly ($P<.01$) more ticks per animal than sheep or goats (Table 3.42). The differences between sheep and goats were insignificant. There were no differences between districts; however, Abinanti (1982) reported significantly more ticks on Siaya animals. The ticks were primarily of three species (*Rhipicephalus appendiculates*, *R. avertsi*, and *Ambylomma variegatum*) with the two *Rhipicephalus* species accounting more than 90% of the ticks identified.

Table 3.42. Means of Ticks/Head Across Breeds and Districts (Oct. 81).

	n	Ticks/Head
Cattle	142	21.9^a
Goats	29	6.0^b
Sheep	68	2.8^b
Siaya	239	7.5
Kakamega	100	12.9

$^{a\ b}$ Different superscripts in the same column are significant ($p<.01$)

Thirty-nine percent of the surveyed farmers dipped their cattle for ticks. The rest picked ticks off by hand or practiced no form of tick control. Sheep were dipped by 4 farmers and goats were never dipped. However, the majority (56%) of farmers only dipped monthly. The most common reason given was that the dip was too expensive. Other reasons included: distance from dip, ineffectiveness of dip and a feeling that cattle got other diseases from the assembled animals at the dip.

Most farmers (90-95%) did not drench against gastrointestinal parasites. Those that did used local herbs purchased at the local market. Worm eggs were found in 80% of the goats (Abinanti, 1982), with an

average of 532 eggs per gram of feces. Coccidia were also found in both sheep and goat feces though their impact on the health of young animals needs further investigation.

Except for a compulsory cattle vaccination program for anthrax in Hamisi Division (Kakamega) in Jan.-Mar. 81, no surveyed farmers vaccinated their ruminant livestock. Preliminary testing for Brucellosis (B. melitensis) was negative for goats (Abinanti, 1982). However, there is serological evidence of infection in adjacent areas. On-farm testing for other viral and mycoplasma infections was continuing under the auspices of the Ministry of Livestock Development and Washington State University.

Livestock Markets. Four livestock markets were surveyed on a regular basis. Cattle were the most actively traded animals in the markets (Table 3.43), accounting for 43% of total sales. Sheep and goats represented 30% and 27%, respectively. These estimates may be slightly biased in favor of cattle. Total number of livestock sold were obtained from the receipt books of city council agents who collect a small fee for each livestock sale within the "market yard." This will be an underestimate because people tried to avoid paying these fees by trading just outside "market yard", sneaking animals out of "market yard", and reusing individual receipts. These techniques were easier with sheep and goats than with cattle. Unofficial observations estimated that the undercount was around 10% with sheep and goats and around 5% for cattle.

The importance of livestock as capital storage is seen by the fact that 65% of all sales were to raise cash for a specific requirement, with school fees and food purchases being most common. The lower unit price of the small ruminants made them a more convenient animal to sell to purchase food grains. These sales were more common near the end of the dry season when farm-stored grains were depleted. Sales for school fees were most common at the beginning of the school terms in January, May, and September.

Table 3.43. Percent of Livestock Sales for Various Reasons.

Reasons for sale	Cattle	Sheep	Goats	All Species
Livestock trader	45	23	19	28
Cash for food purchases	15	27	22	21
Cash for school fees	21	26	34	28
Cash for other	13	21	14	16
Get rid of animal	6	3	11	7
Total Sales	43	30	27	100

Only 7% of the sales were primarily to reduce herd size or get rid of an individual animal. Goats, however, were sold for this reason at a slightly higher rate (11%).

Livestock traders typically purchased animals, moved them on foot, and resold them to butchers or in other markets. No animals were sold to the parastatal Kenya Meat Commission.

Prices of livestock were significantly affected by condition code ($P<.001$), maturity ($P<.001$) and sex ($P<.05$). As expected, animals in better condition brought higher prices. No effect of month, market, or district was apparent. Price statistics for various classes of livestock are in Table 3.44. Males tended to fetch higher prices than females. Prices paid for sheep and goats were similar.

Table 3.44. Mean and Standard Deviation for Prices Per Head (Ksh) in Western Kenya 1980-1981.

Animals	Male		Female	
	Mean	SD	Mean	SD
Cattle				
Mature[a]	820	250	664	252
Immature	462	141	552	150
Sheep				
Mature[b]	127	45	94	30
Immature	87	31	73	28
Goats				
Mature[b]	118	40	93	40
Immature	67	20	51	18

[a] Cattle older than 36 months were considered mature.
[b] Sheep and goats older than 18 months were considered mature.

3.2.6. Household Food Consumption

To get an appraisal of the purchase and consumption of foodstuffs in the individual households a survey was carried out in April and June of 1981, based on farmer recall of the previous week's food use.

Values for household consumption were based on farmer estimates of amount and value of commodities consumed (Table 3.45). Their valuations were similar to market prices for commodities in local markets.

Energy foods had the highest values in both Kakamega and Siaya. On a weight basis the importance of "energy foods" is even more obvious because they tended to cost less per unit weight than did protein and other types of foods.

Protein foods included meat, milk, fish, eggs and beans. Traditionally there were taboos against the consumption of almost all livestock products including fish and eggs by women in certain subgroups of both the

Table 3.45. Value (Ksh) of Weekly Household Food Consumption.

Type of Food	Siaya	Kakamega
Protein sources[a]	39.00	42.70
Energy sources[b]	98.30	74.70
Other [c]	4.10	8.20
Total	141.41	25.60

[a] Meat, milk, fish, eggs, and beans
[b] Cereals, tubers, bread, fruit, vegetables, oils and sugar
[c] Beer, soft drinks, tea, condiments

Abaluhya and Dhcluo. Although some elderly women still adhered to these taboos, most women now consume a variety of livestock products. Prices for chevon, mutton and beef, although highly variable within districts from time to time, were roughly similar in both districts.

Meat was from two major sources, poultry slaughtered on the farm and red meat purchased from a village butcher (Table 3.46). The butcher slaughtered one cow per week and sold meat until it was gone, usually within twenty-four hours. Mature cattle weighed only 180-210 kg. Given the high population densities, selling the 100 kg of meat in one day was not a difficult task. Livestock other than poultry were rarely slaughtered on the farms, except as part of a cultural ceremony or because the animal was obviously going to die. In either case, neighbors and guests would be given meat. However, it was expected that a reciprocal transaction would take place in the future.

Table 3.46. Amount of Animal Products Consumed Weekly Per Capita April-May 1981.

	Siaya	Kakamega	$p<$[b]
Meat (kg)[a]	2.6	1.6	.05
Fish (kg)	1.2	.5	.05
Milk (liters)	2.6	7.1	.01

[a] Beef, sheep, goat, poultry
[b] District differences

Poultry were usually slaughtered in honor of a guest or returning family members. When farmers were asked how a chicken was picked for slaughter, they indicated that essentially the only selection was for an appropriate sized bird for the number of people eating. Although 30% of the surveyed farmers ate eggs at least twice a month, most farmers felt that a chick had more value than an egg. This is logical given the high mortality rate of chicks. Farmers felt they needed a clutch of at least 6-7 day-old chicks to get one mature chicken.

Fish consumption (Table 3.46) in Siaya (1.2 kg) was significantly higher ($p<.05$) than in Kakamega (.5 kg), primarily because of proximity to Lake

Victoria (Figure 2.1). Fish (Tilapia, Nile Perch and a small minnow, species unknown) was generally purchased in a dried, smoked form. Occasionally, in Siaya fresh fish would be purchased in the village markets.

Household milk consumption (Table 3.46) was higher in Kakamega (7.1 liters) than in Siaya (2.6 liters). Milk was primarily consumed in tea, often replacing stream water as the liquid base. Some was soured and consumed the next day. No cheeses, yoghurt or processing is used for longer term storage of milk products.

When milk was purchased, it was usually fresh from a neighbor, or locally boiled milk in a village shop. Occasionally, KCC tetrapacks were purchased from roadside shops. However, because they are transported from Kitale or Nakuru they had often gone rancid by time of sale.

Of particular importance is the high percentage of food that was actually purchased with cash (Table 3.47). It is likely that the percentages of total food purchased (52% and 71%) reflected a seasonal variation. The period in question (April-June) preceded the long rains harvest of cereals and beans. Additionally, the short rains crop in 1980 was poor, hence household stores were almost completely exhausted. The high percentage of protein foods actually purchased is probably not quite as variable seasonally. Although bean harvest was seasonal, local production of milk and meat was not particularly seasonal (Section 3.2.5). Unlike beans, almost no meat or fish were produced on the farm, therefore any seasonal variation in purchases would be closely correlated with consumption variation, and not with replacement from on-farm production.

Table 3.47. Percentages of Home Consumption From Purchased Food, % Value.

Type of Food	Siaya	Kakamega
Protein[a]	42	65
All foods	52	71

[a] Meat, milk, fish, eggs, beans

3.3. Discussion

3.3.1. Farm Models

In order to better visualize various interactions in farming systems research, schematic models are often used (Fitzhugh and Byington, 1978; Hart, 1979). The format used by McDowell and Hildebrand (1980) was used here. Figure 3.17 is a schematic representation of a "typical" small farm in western Kenya. The box identified as "Market" represents all off-farm activities and resources (except land); hence it includes purchased inputs and household items, as well as products and labor sold off the farm. The "Household" is the core of the family unit. Labor use, sources of human food, animal feed, and the interactions between

the crop and livestock subsystems are considered. The solid arrows (——) depict strong flows while the broken arrows (----) indicate intermittent or weak interchanges. Commodities stored on the farm are represented by tank symbols. Crop and livestock subsystems are represented by rectangles.

Farmers sold maize, beans, livestock, and labor. They bought maize, salt, sugar, tea, etc. Major cropping activities were intercropped maize and beans, maize alone, sorghum, cassava, sweet potatoes and vegetables (kale, tomatoes, etc.). Wild vegetables were also collected and consumed. Improved maize seed was the major crop input from the market.

Livestock included cattle, sheep and goats, as well as 10-20 chickens. Animals were generally grazed on fallow land or cropped fields. Crop residues or cut forages were rarely brought to tethered livestock. Other crop-livestock interactions included occasional use of manure for fertilizer or oxen for plowing.

Animals and milk were sold, while animals and dippings were inputs from the market. Labor for herding was the primary household input to the livestock subsystem.

Typical Kakamega Farm. The "typical" small farm in Kakamega District is shown in Figure 3.18 The farm had 0.98 ha of land which was worked by 2.05 workers. The farm supported 5.90 dependents. The head of household was female on 58% of the farms because the male had left to sell his labor in the urban areas.

The major crop was a maize/beans intercropped on 0.41 ha during the long rains. Minor crops included maize, sorghum, bananas, sweet potatoes and vegetables planted on 0.3 ha. Improved maize seed was purchased for the long rains. Some purchased seed, as well as native varieties, were used during the short rains. Native varieties were used for planting materials in all other crops. The majority of labor required for the maize/beans intercrop (71 man days) came from the available household supply (642 man days). Family labor was also used for tending the other minor crops and in household activities such as fetching water, firewood and cooking.

The majority of maize harvested (843 kg) was consumed on the farm as ugali. Relishes included: sukuma wiki (kale), wild vegetables, and fish or meat. Harvested beans (382 kg) were eaten and sold in the market. Half of the families had 1-2 cows and 1 sheep and most families had 7-10 chickens. When cows were milked, a small proportion (20-30%) was sold and the rest consumed on farm with tea. No milk was stored as cheese or other products. Calves and lambs were usually sold and served as a major source of income to pay school fees, clothing, etc.

Most eggs were allowed to hatch, though 2-3/week were sold or eaten. Chickens were sold when cash was required. The visit of a relative or important neighbor warranted slaughter of a chicken.

Figure 3.17 Model of a typical small farm in western Kenya.

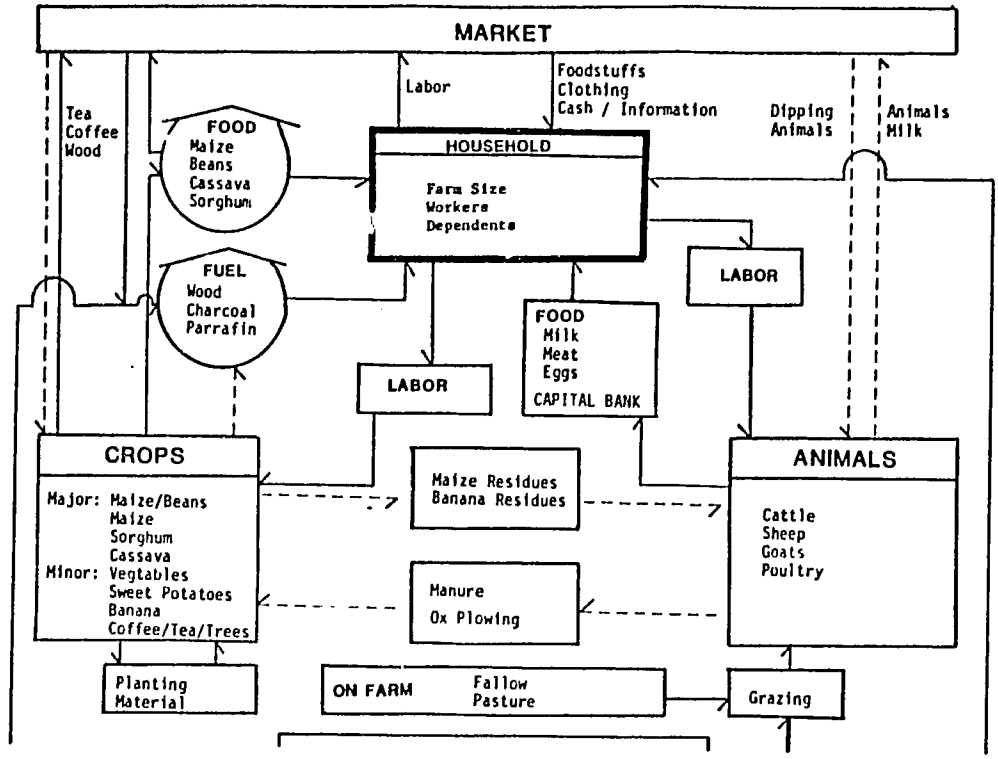
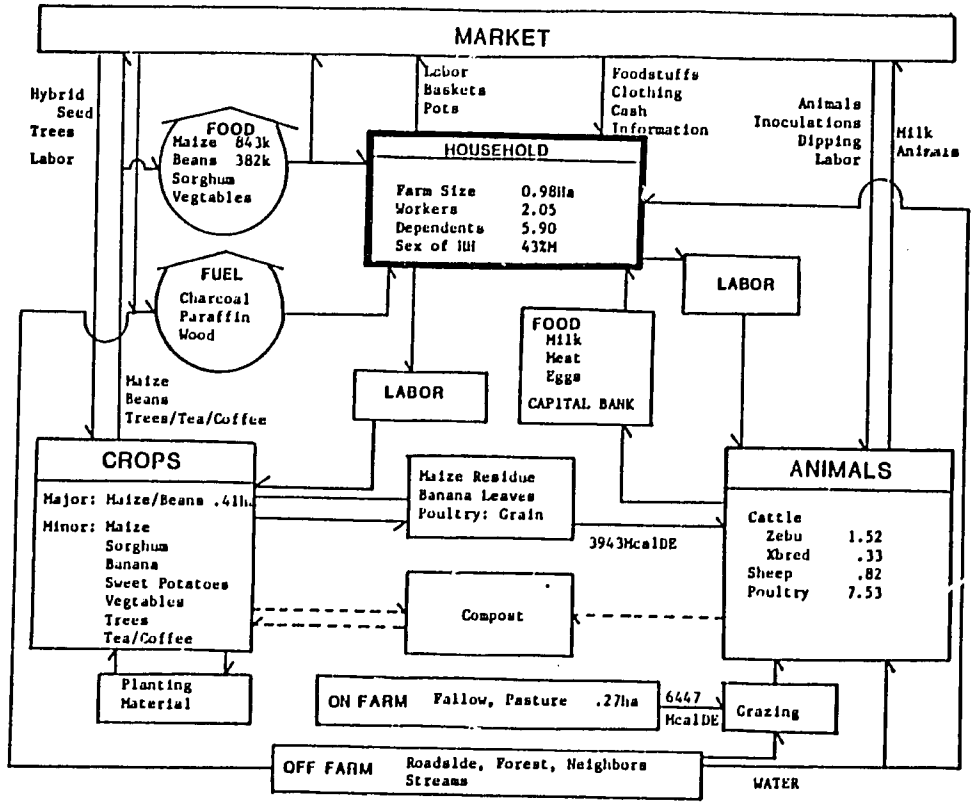


Figure 3.18 Model of a Kakamega small farm (long rains 81).



The interactions between crop and animal production systems were not particularly strong. The most important direct crop/livestock interaction was the crop residue fed to livestock. Maize stover and thinnings provided about 3943 Mcal of DE available for livestock consumption. Banana leaves were also fed. Spoiled maize grain was occasionally fed to poultry.

Grazing on unimproved land provided the majority of energy and protein for the ruminants. On-farm noncropped land provided approximately 6447 Mcal DE annually. Off-farm grazing along roadsides and other common land was used extensively. Forage quality could be quite high. Grasses such as Cynodon dactylon and Digitaria scalarum retained high levels of protein and digestibility when grazed heavily. In addition, local legumes (Glycine weightii, Trifolium ssp.) are found in many heavily grazed areas.

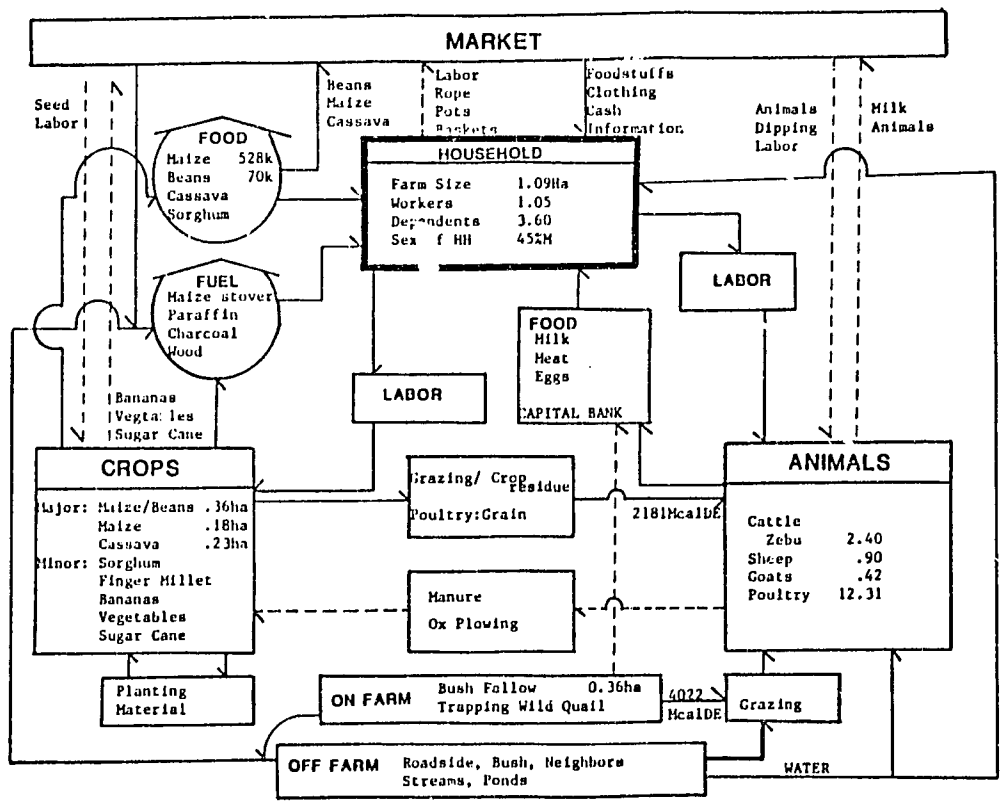
Manure was not utilized in a systematic fashion. Composted household scraps, manure, and crop residues were used by some farmers on their long rains hybrid maize. Oxen plowing was not utilized in this area of Kakamega District because of the small plot sizes.

Production constraints in the system can be viewed in terms of individual systems and in relation to the whole system. The principal constraints to crop production are water availability and nutrient levels in the soil. Though rainfall is generally adequate, yields would probably benefit from improved timeliness of planting and weeding (Allan, 1971). Also hybrid maize would respond to nutrient additions (manure, purchased fertilizers) to the humic nitosols in the area. While bean anthracnose, halo blight and rust were identified as important diseases of beans (Mukunya, 1974) only anthracnose was observed as an important constraint to production in Kakamega.

The principal constraint to livestock productivity was inadequate nutrition. Residue yields should increase as crop inputs increase. Because of land constraints, increased forage crop area is not a viable option; therefore, increased on-farm forage production will depend on the cropping system. Use of cover crops or relay cropping of a forage after harvest of beans and maize for use during fallow may be options.

Typical Siaya Farm. The Siaya small farm is modeled in Figure 3.19. The farm has 1.09 ha; the family has 1.05 workers and 3.60 dependents. Because of outmigration of males in search of wage employment, 55% of the farms are managed by a female head of household. The main crops are maize/beans intercropped (0.36 ha), maize alone (0.18 ha) and cassava (0.23 ha). Minor crops include sorghum, finger millet, sweet potatoes, bananas and vegetables. Unimproved planting material is used for all crops. Labor required for the maize/beans intercrop (86 days) and other crops is drawn from the pool of family labor (328 days). Household activities such as fetching water from streams, firewood and cooking require considerable family labor.

Figure 3.19 Model of a Siaya small farm (long rains 81).



The maize harvested (528 kg) is primarily consumed on the farm. This is supplemented by purchased maize, cassava, and sorghum. Harvested beans 70 kg are consumed and sold at the local market.

The farm has 2-3 cows, and several sheep and goats. Milk is consumed on farm primarily in tea. Calves, kids, and lambs are usually sold as major cash needs arise. Family labor, usually a male child or older male, is used to herd the livestock 7-8 hours per day. Livestock use little labor because feed is only rarely cut and carried.

Poultry include native chickens (10-15 birds) and a fraction of a duck on average. Eggs are allowed to hatch and only rarely eaten or sold. Birds are sold when cash is required. An important visitor will be occasion for the slaughter of a chicken. Poultry meat is supplemented by trapping wild quail on fallow bush land.

Interactions between crop and livestock subsystems are weak. Some crop residues are grazed after grain harvest. Though some 2081 Mcal of DE is potentially available from maize residues, the actual amount consumed is probably much less due to trampling and the use of stalks for fuel.

Farmers only rarely allow livestock to graze cassava leaves because of potential toxic effects.

Grazing on unimproved land provides the vast majority of feed. On-farm grazing land provides some 4022 Mcal DE. Off-farm grazing provides a minimum of 15% and probably more than 35% of the maintenance requirements plus nutrient costs for production. The primary grasses are poor quality *Cymbopogon* ssp. and *Brachiaria* ssp. under bushes (*Lantana camara*, *Albizia coriana*, and *Markhamia platycalyx*).

Manure is not systematically utilized; however, some manure from the night boma may be used when planting maize.

Potential intensification of the system is primarily dependent on increasing the present low yields of maize per hectare (900-1050 kg). Water availability is probably the major limiting factor. More timely planting and weeding are important in taking advantage of the water that is available. More use of manure and possible use of purchased fertilizer would undoubtedly increase nutrient availability. The parasitic weed, *Striga hermontheca*, is a major problem in maize and sorghum; it is best controlled by rotation of maize and sorghum with resistant crops (i.e., cassava, millet, or forages).

Ox plowing (usually hired) is sometimes used on larger plots. Because of soil conditions, ox plowing is usually done by teams of 6 oxen. Use of oxen for weeding is being investigated in other parts of Kenya (Rukandema et al., 1981). Adjustments to planting patterns would be required.

Improving crop productivity should increase residue yields. These increases should make feasible the collection and storage of these feeds for later use. Increased use of higher quality forages would require

additional management to discourage poor quality forages such as Lantana and Cymbopogon. Relay cropping of forages into old cassava stands or fallow maize fields may be sources of animal feed.

3.4 Conclusions

The main objective of this study was to provide a comprehensive description of the farming systems of Boro Division in Siaya District and Hamisi Division in Kakamega District. From this information, an attempt was made to identify the critical constraints which farmers face in their farming activities, particularly livestock production. These constraints include both biological and socioeconomic factors.

The overall productivity of the smallholder farming system was low. Maize yields ranged from 900-2300 kg/ha while bean yields were between 200-1000 kg/ha. Similarly, in the livestock subsystem milk production, reproductive rates and growth rates were low.

3.4.1. Cropping Systems

The principal constraints to increased crop productivity in western Kenya include:

- The principal biological constraint appears to be water availability at critical periods in maize growth. Timeliness of planting and weeding were essential in achieving production increases.
- The parasitic weed Striga hermontheca and termite damage further reduces yields of grain crops.
- Cost and restricted availability of inputs (fertilizer, pesticides, etc.) restricted their use on all crops but particularly on food crops.
- Improved genotypes for crops other than maize and sorghum were not readily available.
- Government restrictions on marketing of maize and beans reduced incentives to purchase inputs in order to increase production much above subsistence requirements.

3.4.2 Livestock Systems

Principal constraints to increasing animal production on smallholder farms in western Kenya include:

- Sufficient amounts of adequate quality feed are not available on a year-round basis. On small farms the demand for food crops supercedes production of feed for livestock. Thus, strategies are needed for meeting nutrient requirements from food crop residue and forages produced with no decline in food production. Preservation of seasonal surpluses for use in subsequent dry seasons is also needed.
- Health constraints are primarily from tick-borne diseases (Theileria spp., Babesia spp., Rickettsia, Anaplasmosis and Nairobi Sheep Disease) and internal parasites. In lower areas just outside of surveyed locations trypansomiasis is a problem. Tick control (dipping or spraying) and selective drenching is required for full control of disease problems.

- Increased milk production by cattle or goats will require improved genotypes capable of producing sufficient milk to meet needs of young stock with a surplus for human consumption. Suitable cattle genotypes are available in limited numbers but improved goat genotypes are essentially unavailable to the smallholder.
- Management constraints include the need for practices that allow animals longer daily access to grazing or harvested feeds, particularly at cooler times of the day (i.e., dawn and dusk). Dairy animals require more frequent access to water.
- Socioeconomic constraints are principally related to the role of livestock. They function primarily as a means of capital storage and only secondarily as units of production. Producer priorities are thus geared towards keeping the animal alive rather than increasing productivity. Interventions to increase productivity must not appreciably increase the risk of the animal dying or being stolen. Small ruminant production may be constrained by a long standing preference in favor of cattle.

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Appendix Table 1. Comparison of Cash and Subsistence Farms.

	Cash	Subsistence
Farm Size (ha)	1.62(1.08)[a]	.81(.65)
Members/farm	7.91(3.85)	5.69(2.96)
Members/ha	8.42(8.85)	15.49(29.25)
Workers/farm	2.23(1.72)	1.29(1.18)
Workers/ha	2.34(2.60)	3.98(7.26)
Dependents/farm	5.68(2.78)	4.40(2.42)
Dependents/ha	6.08(7.16)	11.50(23.64)
Males	3.64(2.08)	2.72(1.74)
Females	4.18(2.52)	2.98(1.63)
Under 16 yrs.	4.23(2.74)	3.16(2.33)
16-40 yrs.	2.23(1.72)	1.29(1.18)
Over 40 yrs.	1.45(0.91)	1.24(1.05)
Percentage Male Head of Household	45.5	43.1
Head of household age	49 (13)	50 (16)
Head of household education	2.18(2.68)	1.33(2.57)
Number of children	4.18(2.59)	3.07(2.55)
Number of languages	2.14(0.71)	1.66(0.61)
Total at school	3.55(2.44)	1.90(1.81)
Males at school	1.73(1.52)	1.10(1.24)
Females at school	1.82(1.59)	.78(1.01)
Total at primary school	2.77(1.90)	1.82(1.76)
Total at secondary school	.77(1.11)	.07(0.26)
Number of residences	2.59(1.14)	2.28(1.42)
Value of Pangas & Jembes	78.45(63.06)	55.45(40.47)
Value of all farm implemen	199.36(136.76)	138.81(91.66)
Food crops ratio	.64(.16)	.69(.20)
Cash crops ratio	.18(.10)	--
Grazing land ratio	.22(.12)	.31(.19)
% farms w/maize(LR81)	55	52
% farms w/beans(LR81)	82	79
% farms w/cassava(LR81)	32	46
% farms w/cassava/maize(LR81)	5	10
% farms w/other cereals(LR81)	0	29
% farms w/sweet potatoes(LR81)	27	17
% farms w/fallow(LR81)	55	50
% farms w/trees(LR81)	64	5
Monoculture maize yield(kg/ha)	1796	1370
Intercropped maize yield(kg/ha)	1151	1616
Intercropped beans yield(kg/ha)	828	552
Maize/person	161(129)	73(48)
Beans/person	53(64)	22(20)
Cattle	3.50(1.51)	4.32(3.45)
Sheep	3.00(2.35)	3.00(1.80)
Goats	3.50(3.54)	3.20(1.64)
Poultry	9.55(9.07)	7.59(6.87)
Total livestock units	1.89(.87)	2.16(2.25)

[a] Numbers in parenthesis are standard deviations.

Appendix Table 2. Comparison of Farms With and Without Livestock.

	With Livestock	Without Livestock
Farm Size (ha)	1.08(0.83)[a]	.97(.93)
Members/farm	6.59(3.36)	5.84(3.36)
Members/ha	13.70(29.54)	13.29(17.62)
Workers/farm	1.59(1.47)	1.48(1.31)
Workers/ha	3.15(5.84)	4.14(7.16)
Dependents/farm	5.00(2.59)	4.35(2.54)
Dependents/ha	10.56(24.41)	9.15(12.61)
Males	3.16(1.91)	2.68(1.80)
Females	3.45(1.90)	3.10(2.09)
Under 16 yrs.	3.39(2.53)	3.55(2.43)
16-40 yrs.	1.59(1.47)	1.48(1.31)
Over 40 yrs.	1.61(1.00)	.81(.83)
Percentage male head of Household	53.1	29.0
Head of household age	54 (15)	44 (13)
Head of household education	1.33(2.19)	1.94(3.17)
Number of children	3.14(2.49)	3.74(2.74)
Number of languages	1.80(.64)	1.77(.72)
Total at school	2.51(2.25)	2.10(1.92)
Males at school	1.35(1.36)	1.16(1.32)
Females at school	1.16(1.37)	.90(1.11)
Total at primary school	2.16(1.83)	1.97(1.87)
Total at secondary school	.35(.80)	.13(.43)
Number of residences	2.61(1.43)	1.97(1.14)
Value of Pangas & Jembes	69.92(55.34)	49.26(31.66)
Value of all farm implements	184.82(113.49	109.06(82.25)
Food crops ratio	.65(.20)	.71(.16)
Cash crops ratio	.18(.10)	.18(.07)
Grazing land ratio	.30(.20)	.26(.15)
% farms w/maize(LR81)	47	61
% farms w/beans(LR81)	88	68
% farms w/cassava(LR81)	35	55
% farms w/cassava/maize(LR81)	6	13
% farms w/other cereals(LR81)	20	23
% farms w/sweet potatoes(LR81)	12	32
% farms w/fallow(LR81)	59	39
% farms w/trees(LR81)	27	13
Monoculture maize yield(kg/ha)	1707	1459
Intercropped maize yield(kg/ha)	1204	1563
Intercropped beans yield(kg/ha)	400	980
Maize/person	102(93)	89(79)
Beans/person	27(25)	40(61)
Cattle	4.05(2.95)	--
Sheep	3.00(1.98)	--
Goats	3.29(1.98)	--
Poultry	10.08(8.10)	--
Total livestock units	2.14(1.94)	--

[a] Numbers in parenthesis are standard deviations.

Appendix Table 3. Selected Characteristics of Surveyed Farms

District	Cluster	Farm	Family, Numbers: Total	Labor[a]	Dependents[b]	Head[c]	Value Farm Tools (Ksh)	November, 1980 Livestock Numbers: Cattle	Sheep	Goats	Poultry	TLU	Farm Size, ha	Long Rains (March-August), 1981 — Proportion of Farmland in Crop[d]: Maize	Maize/Beans	Cassava	Food Crops[e]	Cash Crops[f]	Grazing Land[g]	Crop Yields, kg: Maize/Person	Maize/ha[h]	Maize/ha[i]	Beans/Person	Beans/ha
Kakamega	301	15	9	3	6	M	212	7	3	0	10	4.1	1.74	.03	.20	.02	.29	.64	.44	51	1,342	778	25	492
		21	6	2	4	M	93	2	1	0	5	1.8	0.53		.39		.39	.33	.26	NA	NA	NA	NA	NA
		31	7	0	7	M	230	0	0	0	11	0	0.45	.02	.15	.20	.58	.18	.29	24	514	2,044	24	2,535
		40	4	2	2	M	271	3	0	0	12	1.3	0.24		.59		.68	.17	.20	116		3,272	62	1,734
		42	7	1	6	F	215	1	0	0	6	0.4	0.57		.69		.70	.19	.05	60		1,072	39	536
		58	8	3	5	F	511	5	0	0	7	2.4	2.23		.53		.59	.10	.25	57		736	16	208
		63	5	1	4	F	43	0	0	0	5	0	0.81		.65		.66		.39	63		662	22	227
		99	10	2	8	M	358	5	0	0	15	2.1	4.01		.52		.58	.21	.17	63		877	28	297
		105	9	2	7	F	119	0	0	0	2	0	0.24	.22	.78		1.00		.04	66	1,523	1,693	15	1,255
		110	2	2	0	M	211	0	0	0	0	0	0.08	.16			.31		.49	9	1,424			
		122	15	7	8	M	334	4	3	0	33	2.7	2.75	.28	.17		.50	.22	.25	135	3,749	647	20	657
		126	2	1	1	F	55	0	0	0	15	0	0.81		.32		.60	.22	.17	112		630	48	269
		146	6	1	5	F	187	4	0	0	7	1.6	0.81	.10	.55		.69		.31	60	605	1,201	20	512
		150	14	5	9	F	233	0	0	0	7	0	1.86		.48	.07	.77	.13	.14	37		941	14	348
		159	8	2	6	F	159	2	2	0	0	1.2	0.1		.26	.02	.29		.71	45		796	27	469
		168	12	3	9	F	141	3	0	0	5	1.2	0.32		.41		.47	.40	.14	31		684	17	363
		172	3	0	3	F	187	2	0	0	15	1.1	0.64		.79		.79		.21	177		1,033	64	400
		178	12	3	9	F	110	5	0	0	3	2.4	1.46	.07	.53	.05	.77	.14	.09	38	1,334	459	13	232
		187	8	1	7	M	48	2	0	0	5	0.8	0.57		.67		.67	.19	.14	35		778	22	484
		198	7	2	5	F	138	0	0	0	4	0	1.42		.18	.11	.43	.23	.32	48		1,332	241	7,870
	302	01	8	2	6	M	43	0	0	0	4	0	0.55		.43		.64		.36	166		2,219	40	539
		26	7	1	6	F	65	2	0	0	5	0.8	0.53		.28		.65		.35	72		1,784	25	637
		27	2	1	1	F	131	0	2	0	3	0.2	0.20		.68		.76		.24	176		1,735	81	1,114
		37	9	1	8	M	76	2	0	6	11	3.2	1.17		.74		.86		.16	202		2,123	68	714
		49	7	0	7	M	80	0	0	0	0	0	0.65	.45	.08	.04	1.00			103	1,495	2,849	23	1,604
		71	6	2	4	F	62	0	0	0	4	0	0.08	.50			.68		.33	30	3,912			
		75	8	2	6	F	68	0	0	0	0	0	0.12		.21		.58		.25	34		4,438	9	1,164
		76	9	2	7	F	220	0	2	0	6	0.2	1.01		.34		.82		.13	184		2,053	60	670
		88	5	2	3	F	75	0	0	0	4	0	0.40	.61	.02		.63	.25	.12	162	NA	1,831	50	568
		98	9	0	9	M	336	2	2	0	2	1.2	0.36	.10			.47	.22	.31	18	4,317			
		111	7	2	5	M	79	0	0	0	3	0	0.69		.88		1.00		.03	162		1,925	57	672
		115	15	4	11	F	322	0	0	0	0	0	2.14		.36		.36		.08	192		1,636	48	408
		126	9	1	8	F	216	10	0	0	15	5.1	1.38	.53	.13	.11	.77		.23	32	NA	1,636	14	717
		136	7	3	4	F	64	0	0	0	3	0	0.53	.19	.58		.77		.23	214	3,417	3,783	54	1228
		159	11	4	9	M	236	1	0	0	7	0.4	0.53		.67		.67		.33	60		2,157	22	801
		168	13	3	10	M	180	6	3	0	8	3.7	1.25		.35	.03	.48		.51	100		2,214	28	613
		172	13	4	9	M	247	0	1	0	0	0.2	1.45		.84		.84		.16	184		2,090	55	628
		204	7	3	4	F	82	3	2	0	8	1.6	1.38	.38			.58	.02	.40	236	2,231			
		235	7	2	5	F	445	2	2	0	5	1.2	1.86	.26	.15		.62	.06	.33	524	2,034	2,172	105	689
		258	3	0	3	M	92	1	1	0	4	0.6	0.28		.16		.61		.39	66		5,544	30	2,520
Siaya	311	05	6	1	5	F	109	2	0	0	4	1.4	0.04		.98		.97		.01	NA	NA	NA	NA	NA
		13	1	0	1	F	95	0	0	0	18	0	0.45	.15	.15	.45	.75		.25	128	983	941	26	376
		19	2	0	2	M	75	3	0	0	10	1.2	0.81	.59	.20	.05	.36		.64	30	652	NA	NA	NA
		21	5	0	5	M	49	0	0	0	0	0	3.97	.05	.46	.46	.58		.02	360	600	914	20	54
		27	6	0	6	M	154	5	0	0	7	3.0	0.85		.31		.39		.69	NA	NA	NA	NA	NA
		35	2	0	2	F	102	0	0	0	4	0	0.24	.07	.50		.65		.35	71	882	NA	NA	NA
		43	4	1	3	M	107	5	0	0	5	2.6	0.97	.11	.17		.77		.23	53	1,550	205	21	166
		47	5	1	4	F	166	0	1	0	5	0.2	0.69		.26	.44	.70		.30	105		1,300	3	264
		52	6	3	3	F	52	2	0	0	5	1.5	1.29	.29	.22	.36	.97		.03	113	830	1,562	9	284
		59	7	2	5	F	75	0	0	0	8	0	1.66	.28		.46	.80		.20	92	1,161			
		62	3	0	3	M	37	5	0	3	23	3.5	0.65	.54	.77		.62		.18	75	1,119	870	17	393
		63	8	5	3	M	238	5	0	0	29	2.4	2.95	.22	.08	.21	.67		.31	132	1,100	414	4	131
		66	7	1	6	F	181	0	0	0	6	0	0.93		.60	.19	.80		.20	61		766	11	138
		83	2	1	1	F	45	0	0	0	0	0	0.32	.38		.33	.70		.30	22	1,710			
		86	4	2	2	M	184	2	0	0	0	0.9	0.12	.04	.91		.95		.05	70	1,777	NA	NA	NA
		91	9	1	8	F	170	0	4	0	17	0.5	0.77	.23	.25	.35	.83		.17	33	766	1,112	4	168
		95	6	2	4	M	238	2	0	2	19	1.2	1.13	.25		.04	.29		.71	64	1,394	NA	NA	NA
		99	4	1	3	M	79	0	0	0	6	0	2.23	.17	.34	.24	.86	.07	.07	197	667	NA	NA	NA
		114	9	1	8	F	496	6	4	0	14	3.3	0.93		.13		.13		.87	9		635	9	675
		117	4	0	4	M	25	4	0	0	0	2.4	1.34	.06	.22		.52		.48	143	1,480	1,525	8	111
	312	14	11	4	7	M	191	0	0	0	11	0	0.49	.10	.12	.67	.89		.11	3	801			
		35	3	2	1	F	75	5	0	0	17	2.8	0.40	.28		.06	.78		.22	NA	NA	NA	NA	NA
		47	2	0	2	M	259	5	0	0	9	4.8	0.36	.33	.22		.54		.39	67	929	NA	NA	NA
		51	1	0	1	F	29	0	0	0	0	0	0.29	.93			.93		.07	45	217			
		70	5	0	5	M	233	6	3	0	10	3.7	2.51		.35		.47		.53	140		759	7	40
		87	2	2	0	F	293	6	2	3	19	6.2	0.49		.36	.13	.64		.36	85		806	3	25
		95	5	0	5	F	186	3	2	0	27	1.4	2.14	.19	.63		.83		.17	303	615	764	25	79
		99	4	1	3	F	153	0	5	0	11	1.0	0.65	.04	.10	.64	.96		.04	27	474	862	2	86
		102	7	1	6	M	50	18	7	6	11	1.4	1.34		.79		.82		.18	74		470	10	67
		115	6	0	6	F	24	0	0	0	8	0	3.20	.23		.12	.54		.46	93	825			
		129	3	1	2	F	159	0	0	0	11	0	0.40		.27	.10	.62		.36	60		754	9	114
		136	3	1	2	F	31	0	0	0	4	0	0.81	.23	.06	.14	.46		.54	74	400	1,562	6	321
		180	4	0	4	F	26	0	0	0	0	0	0.40				.45		.55					
		197	2	0	2	M	176	3	3	1	31	2.4	1.70	.42		.19	.65	.14	.21	270	754			
		218	6	2	4	M	162	2	0	0	2	0.8	0.49	.91		.09	1.00			97	436			
		224	2	0	2	M	42	6	5	2	21	3.8	1.01	.23	.14	.45	.82		.18	56	304	NA	NA	NA
		233	4	1	3	F	204	0	0	4	4	0.8	1.34		.12		.43		.56	36		820	3	52
		248	5	1	4	F	205	0	0	0	0	0	1.17	.19		.44	.79		.21	25	563			
		257	6	3	3	M	105	0	0	0	18	0	1.66	.13	.06	.40	.77		.23	33	297	2,501	3	311
		301	5	1	4	F	96	0	0	0	0	0	0.85	.05		.09	.71		.29	7	680			

[a]Persons between 16 and 49 years of age
[b]Persons less than 16 or over 49 years of age
[c]Sex of head of household
[d]Ratio of area in crop to total area owned
[e]Sum of all food crops
[f]Sum of tea, coffee, trees, and sugarcane area
[g]Sum of fallow and permanent pasture
[h]Yield of maize in monoculture
[i]Yield of maize in maize/beans intercrop

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