

PN-ABS-958

74721

ASPAP/DAI Rapport N° 150

République Rwandaise

Ministère de l'Agriculture,
de l'Elevage et des Forêts

Goat Production in Rwanda 1953-1984: Assessing the Potential for Future Development

Serge Rwamasirabo*

Daniel C. Clay**

Michael T. Weber***

Division des Statistiques Agricoles

(DSA)

October 1991

*Division des Statistiques Agricoles (DSA), Ministère de l'Agriculture, de l'Elevage et des Forêts, B.P. 621, Kigali, Rwanda.

**Department of Sociology, Michigan State University, East Lansing, Michigan, 48824, USA.

***Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, 48824, USA.

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Introduction

Livestock production has been an integral part of farming systems in Rwanda and other East and Central African countries for centuries. Though Rwandan farmers seldom use their livestock as beasts of burden, they nonetheless attach great importance to livestock ownership as a mechanism for capital accumulation and as a symbol of wealth and status in the local community. But the meaning of livestock ownership has changed over time. The precolonial period was characterized by the use of livestock for barter, often in trade for land, cloth, hoes, axes and so on. Cattle also formed the basis upon which relationships among members of traditional society were defined. Cattle ownership implied the receipt of goods and services from those who needed the protection in exchange (Maquet, 1961). During the colonial period, though still important as a criterion for social differentiation, farmers began to think of livestock in terms of its economic value and, with the encouragement of the government, began to integrate them into local farming systems. Motivation for this change emerged from a redefinition of individual rights. Most important were ownership rights over land and livestock, which were placed in the hands of individual farmers, the government, or the community. The patron-client system was abolished during this time (Maquet, 1961). More recently, the post-independence period has witnessed even closer integration of crop and livestock production. Sustainable agriculture has been emphasized by the government and there is now widespread recognition that the future of livestock production in Rwanda will need to be "land-efficient," particularly for the growing numbers of farmers operating exceptionally small holdings (Rwamasirabo, 1990).

While reliable figures on the history of livestock production at the national level are scarce, the country's first National Agricultural Survey, fielded during the 1983-84 agricultural year provides a bench mark estimate of the current overall magnitude of the industry (SESA, 1988). Animal husbandry in Rwanda is now practiced by 76% of the country's farm households and goats are found on over half of Rwanda's farms (56%). The total goat population has reached 1.9 million, an average of 3.1 head among households raising goats (SESA, 1985). This total production figure represents nearly a 100% increase over previous estimates published by the Ministry of Agriculture based on a conservative extrapolation of results from earlier studies. In other words, growth in Rwanda's goat industry over the past 10-15 years has far exceeded the Ministry's often optimistic expectations. While at the same time, cattle production has declined in relative importance.

A guiding hypothesis of this research is that the recent increase in goat production has occurred in large part as a function of fundamental change in the structure of Rwanda's small farm agriculture, which itself is a response to rapid population growth and the pressure this growth places on the country's limited land resources. Rwanda's population is growing at an annual rate of 3.7% (one of the highest in Africa) and as a consequence landholdings are becoming increasingly small and fragmented. Farm families have learned to adapt to this pressure on the land in many ways -- perhaps most notably through a restructuring of land and

labor use. Two aspects of this restructuring are that marginal lands once set aside for pasture are now being brought into production (Clay and Lewis, 1989), and the need for more intensive use of scarce land resources is placing greater demands on the household labor pool.

Specifically, this research addresses the following set of fundamental, interrelated questions:

1. What are the underlying market, demographic and household characteristics and changes associated with, and responsible for, the recent changes in goat and other livestock production?
2. How is goat production integrated into other aspects of Rwandan agriculture at the household level?
3. Based on analyses of the structural causes and of the importance of goat production to Rwandan farm households (questions 1 and 2 above), what are the implications of technological innovations (breeds, feeds, practices, etc.) and/or potential policy changes on the future development of the country's livestock industry?

The present study is uniquely structured to assess the potential for future development of the Rwandan goat industry based on a thorough empirical analysis of how farm households of many different types participate in, and depend on, this pervasive industry. As such, this study is especially timely given current national resource limitations and the associated constraints to economic growth faced by Rwanda's ever-increasing population. The need for a concerted policy orientation to the development of small agriculture-related industries has never been stronger. The present study works to meet this need in considering the policy implications and potential for developing the small ruminant subsector of the economy.

Analyses presented below permit us to highlight recent trends in goat (and other livestock) production in Rwanda, and to assess the degree to which variations in goat production are linked to other household and farm characteristics. The focus of these analyses is on variables such as farm size, land use (e.g., crops versus pasture), household labor availability, and variations in agro-ecology, all of which will help us define the underlying structure of animal husbandry in Rwanda. These important structural variables will contribute a great deal to our understanding of the important role goat production plays in the day-to-day subsistence of Rwanda's farm population. Moreover, it is only through this kind of "grass roots" analysis that alternative technologies and policy changes affecting goat production can be adequately evaluated.

Sources of Data

The analyses presented in this working paper focus on all four of Rwanda's major types of livestock: cattle, pigs, sheep and goats. Key variables such as farm size, household labor,

education of the head of household, and animal mortality, are introduced in order to help understand and explain variations in livestock ownership.

The first attempt to systematically report livestock estimates was made by the Belgian colonial administration in 1953. Livestock estimates for 1963 and 1973 are drawn from the annual reports of Rwanda's Ministry of Agriculture. A third data source is the 1984 National Agricultural Survey conducted on a nationwide, stratified random sample of farm households. These 1984 data provide the basis for the analyses presented in this working paper. Weighting factors for the 1984 survey are based on a count from the Rwanda national population census of 1978 and were updated by complementary field work in 1983. Technical aspects of the sample design have been described in more detail elsewhere (SESA, 1988).

A fundamental question in the analysis of livestock trends involves the accuracy of the available historical data. The 1984 Rwanda National Agricultural Survey and later follow-on surveys utilized scientific sampling procedures and undoubtedly yield the most accurate estimates to date. The estimation method used in 1953 by the colonial administration, as well as those utilized by the Ministry of Agriculture for the estimates in 1963 and 1973, are for the most part undocumented, but are believed to have been systematically compiled and to be reasonably accurate, at least in terms of their general orders of magnitude.

Growth and Decline of the Livestock Population over Time

Figures presented in Table 1 indicate that there was a relatively small drop in the cattle population from 1953 to 1963, a decline that can be attributed to political events (revolution and independence) occurring between 1959 and 1961. Up to 1973 the cattle population increased by 35 percent. During the period 1973 to the present, cattle increased in numbers albeit at a slower rate to 1984, but has since declined rather significantly.

We also observe from Table 1 that the sheep population decreased from 1953 to 1963 by 1.8% per year, and then increased from 1963 to 1973 by 1.2% per year. Since 1973 the sheep population has increased by almost threefold.

The goat population also declined from 1953 to 1963 (by 3.7% per year). As is the case for sheep, there is no apparent explanation for this decrease except possibly inaccurate statistics (low estimates) in the earlier years. In the next decade, the decline was slight at only 0.6% per year. Since 1973 there has been an important increase in the goat population by a factor of about three.

Overall, the increase since 1973 in the population of both sheep and goats is perhaps questionable; we suspect that the sheep and goat populations were underestimated before the adoption of more refined scientific sampling and measurement techniques in 1984 and 1989. Since cattle are comparatively easy to enumerate, and have always had a more concentrated economic focus, the likelihood that they were under-enumerated prior to 1984 and 1989 is relatively low, at least when compared to sheep and goats.

Table 1. Rwanda's Animal Population and Animal/Human Population Ratios Over Time

Year	Cattle	Sheep	Goats	Pigs
1953				
Animals	619,000	258,000	836,000	N/A
Animals/Human	.29	.12	.40	
1963				
Animals	555,000	215,000	664,000	N/A
Animals/Human	.19	.07	.22	
1973				
Animals	740,000	243,000	628,000	N/A
Animals/Human	.18	.05	.15	
1984				
Animals	837,000	560,000	1,919,000	223,000
Animals/Human	.14	.09	.31	.04
1989				
Animals	728,000	711,000	1,895,000	282,000
Animals/Human	.10	.10	.26	.04

Human Population and Source:

1953: 2,101,900 (Ministry of Colonies, Brussels 1986)

1963: 2,971,000 (Estimated by the U.N.)

1973: 4,053,000 (World Population Census)

1984: 6,130,000 (World Population Census)

1989: 7,400,000 (World Population Data Sheet, PRB)

Animal Population (Source):

1953: Administration Coloniale Belge

1963: Ministère Rwandais de l'Agriculture

1973: Ministère Rwandais de l'Agriculture

1984: Service des Enquêtes et Statistiques Agricoles (SESA)

1989: Service des Enquêtes et Statistiques Agricoles (SESA)

Earlier statistics on the pig population are not available, although the data available for 1984 and 1989 indicate the relatively minor role they play overall in Rwanda's livestock industry.

The general trend in animal-to-human ratios shows that while the cattle population has remained more or less stable over the years, but with a slight increase overall, the rapid growth of the farm population means that on a per capita basis cattle are only one-third as numerous as they once were. The same is true for goat production though to a lesser degree as the per capita production has declined from .40 in 1953 to .26 in 1989. The sheep population seems to have

kept pace with human population growth on the whole, as the ratio has differed little from earlier estimates. Insufficient data on pig production at earlier periods in time prohibits comparable analysis for the pig population. In summary, two important trends emerge from these data. The first is that human population growth has made it more difficult for farmers to own livestock, and second, overall the industry is shifting from large to small ruminants. These trends are examined more closely in sections that follow.

Livestock Distribution by Prefecture

As shown in Table 2, farmers in Rwanda own an average of .75 head of cattle, .50 pigs, .20 sheep and 1.73 goats (note: these averages are for all households, not just for those who own livestock). This table also shows a heavy regional concentration of cattle in Kigali, Gikongoro and Gitarama, where the household average is 1.17, 1.08 and 1.07, respectively. This concentration may be explained by the fact that the king's court was historically located in the region, the country's first livestock research center was established there, and a small dairy industry was set up in the nearby community of Nyanza, Butare.

Beginning in the 1950s, to relieve mounting population pressure, the government organized resettlement schemes (*paysannats*) in some of the less populated southern and eastern provinces, notably in Butare, Gitarama and Kigali. As two hectares of land were allocated to each *paysannat* household, pasture was not a major constraint under this system. The number of cattle per household is the lowest in Cyangugu, Kibuye and Kibungo. Even though the average farm size in Kibungo is one of the highest, later analysis will show that exceptionally high cattle mortality rates there are one reason why households in Kibungo do not own more cattle. In the other two prefectures, we hypothesize that small landholdings account for the low level of cattle production.

The pig population is particularly large in Rwanda's southern provinces. Gikongoro has the highest per household average of all at .69, followed by Butare with .57 pigs per household. This region is historically unique from others in that pigs were introduced there for the first time anywhere in Rwanda by the Fathers of Save, located in a parish in Butare. Over the years, farmers have acquired management experience, and a market has developed in the vicinity of the church school, which maintains a steady demand for pork products. Results from the national agricultural survey (SESA, 1985) show, perhaps not coincidentally, that Gikongoro and Butare are the country's top producers of sweet potatoes, an excellent fodder crop for pigs.

The sheep population is more concentrated in the northern provinces. Ruhengeri has the highest number of sheep per household at 1.15 head while the national average is .20. The second prefecture is Byumba with an average of .86 head, followed by Gisenyi with .52 head of sheep per household. These three prefectures have in common their high altitude and shared borders with Zaire where a market for sheep appears to exist, yet additional research is needed to confirm this observation.

Table 2. Livestock: Ownership by Prefecture in 1984

Prefecture	Cattle			Pigs			Sheep			Goats		
	Total Number	Mean # Owned (all HHs)	% HHs Owning	Total Number	Mean # Owned (all HHs)	% HHs Owning	Total Number	Mean # Owned (all HHs)	% HHs Owning	Total Number	Mean # Owned (all HHs)	% HHs Owning
Butare	130,811	.96	31.4	77,892	.57	35.6	51,089	.38	14.3	201,583	1.48	57.2
Byumba	71,954	.59	17.0	8,703	.07	1.7	105,845	.86	28.3	226,946	1.60	52.4
Cyangugu	15,965	.20	10.4	13,679	.17	10.5	15,296	.19	10.2	131,750	1.85	57.4
Gikongoro	88,140	1.07	40.5	56,611	.69	44.3	42,185	.51	19.4	176,327	1.53	52.4
Gisenyi	121,978	1.05	23.5	10,997	.09	5.9	60,432	.52	22.7	203,582	1.80	59.4
Gitarama	142,408	1.08	39.3	15,098	.11	8.6	44,981	.34	12.0	188,483	2.43	52.9
Kibungo	36,466	.40	10.7	13,604	.15	12.6	4,961	.05	3.7	257,542	2.82	71.5
Kibuye	32,085	.35	12.6	2,531	.03	2.0	26,940	.29	12.0	185,523	2.02	63.8
Kigali	157,777	1.17	30.7	7,168	.05	3.1	64,368	.29	18.5	255,391	1.89	57.6
Ruhengeri	39,518	.31	12.8	16,432	.13	7.1	143,717	1.15	53.6	136,239	1.09	49.4
Rwanda	837,102	.75	23.7	222,714	.50	12.6	559,814	.20	20.6	1,919,366	1.73	56.2

Source: ENA 1984

Goat production is more evenly distributed among the different prefectures. The largest share of goats is found in Kibungo where households raise an average of 2.82 head. As observed above, this prefecture also has the fewest cattle per household, probably because of its high rate of mortality. The large goat population may be at least partially explained by the absence of cattle, but also by the availability of large pastures where acacia, an appropriate feed for goats grows naturally. Research shows that savannah, which plays the same role as acacia, can still be found in parts of Kibungo. Goats also proliferate in Kibuye, where households raise an average of 2.02 head. This may be explained by extensive informal trade between that prefecture and neighboring Zaire.

Livestock are raised in various combinations. Some households raise several types at once while others raise only one or none. In 9 of 10 prefectures, goats alone are the most prevalent form of livestock ownership. This pattern is broken only in the mountainous region of Ruhengeri where sheep exceed goats in importance. Clearly, the majority of the farmers in Rwanda lean toward goat production, as suggested earlier in Table 2. Possible explanations for this general tendency are: the low initial investment required compared to cattle production, low mortality rates, the high productivity rate of 1.4 kids/year/doe, no special fodder plants required for feed, rapid market development in the urban sector, and low competition for crop land. Goat meat is gaining acceptance in the diet of Rwandans, replacing beef in terms of cost and perhaps even taste preferences.

Overall, among the more than 1.1 million farm households in Rwanda, 73.1% own livestock, 56.2% own goats. Of the households owning goats, about 55% own goats alone, while the remaining 45% own goats as well as other livestock (Table 3). Among households that do own goats, the average number of animals per household is 3.1 head. Across prefectures, Gikongoro has the largest percentage of households owning livestock at 80.2%, followed by Kibungo at 79.4%, Butare at 78.2%, and Ruhengeri at 77.2%.

These figures suggest that livestock do not necessarily compete with crop production. Indeed, the most densely populated prefectures of all, Ruhengeri and Butare, have among the highest percentage of households owning livestock. These are also areas settled long ago, and that maintain strong traditions and cultural attachments vis-a-vis animal husbandry. An alternative explanation is that a certain complementarity exists between livestock and crop production. The need to intensify crop production on small farms is obvious; increasing manure application is one way to achieve this goal. Small ruminants, which have less demanding grazing needs, may be especially well-suited for those who cannot afford to increase pasture if it means keeping land out of crop production.

The issue of animal population density was raised in 1951 when, in the preparation of the five year plan, a recommendation was made to reduce livestock production. It now appears that such a blanket recommendation did not fully consider the possibilities for integrating crop and livestock (particularly small ruminant) production.

Table 3. Goat and Other Livestock Ownership by Prefecture in 1984

Prefecture	Total Number of Households	% With Any Livestock	% With Goats	% With Goats Alone	% With Goats and Other Livestock	Average Number of Goats: (HHs Owning)
Butare	136,218	78.2	57.2	27.1	30.1	2.6
Byumba	122,473	66.2	52.4	26.8	25.6	3.5
Cyangugu	79,109	67.0	57.4	41.9	15.7	2.9
Gikongoro	82,307	80.2	52.4	17.0	35.7	2.9
Gisenyi	16,628	71.5	59.4	32.5	26.9	3.0
Gitarama	132,027	71.7	52.9	25.8	27.1	2.7
Kibungo	91,201	79.4	71.5	55.7	15.9	3.9
Kibuye	91,745	69.6	63.8	48.0	15.8	3.1
Kigali	135,333	71.1	57.6	30.7	26.9	3.3
Ruhengeri	127,866	77.1	49.4	12.9	29.5	2.6
Rwanda	1,111,897	73.1	56.2	30.7	25.5	3.1

Source: ENA 1984

Livestock and Farm Size

As a major constraint to livestock development is the availability of land, especially where technology is limited, this factor is likely to be associated with livestock ownership. National figures on farm size show operational holdings to be an average of 1.2 ha per household (SESA, 1987). An estimated 26.2% of households are in the farm size class of less than a half a hectare, while 16.6% operate more than 2.0 hectares.

Looking at the relationship between type of livestock and farm size, we find that households without livestock tend to be those with the smallest holdings (Table 4). Among the smallest farms, 47.1% own no livestock at all while only 11.7% of the large farms, those with operational holdings in excess of 2.0 hectares, raise no livestock. This finding is consistent with the hypothesis that declining land availability is a constraint to livestock production. The second important figure in this table is the percentage of households in the smallest farm size category that own goats only (25.4%). This indicates once again the importance of goats in Rwanda, particularly for the small holder. Any policy affecting the goat industry will have implications for a quarter to a third of households operating .50 ha or less. The same generalization holds true for other small ruminants as well. Pigs and sheep, when raised alone, are more likely to be found on small and medium sized farms than on larger farms.

Large holders, on the other hand, tend to raise cattle alone or to raise various combinations of livestock. This reflects the relative advantage of larger farmers in terms of the

Table 4. Percent of Households Owning Livestock by Farm Size in 1984

% of households	Farm Size (in ha)				
	.00-.50	.51-1.00	1.01-1.50	1.51-2.00	2.00+
% of households in category	26.2	30.3	15.5	11.4	16.6
% of households without livestock	47.1	27.3	19.2	11.2	11.7
% of households with cattle only	3.9	5.1	4.2	3.4	5.6
% of households with goats only	25.4	34.0	33.7	36.7	26.0
% of households with pigs only	3.6	3.0	4.1	1.3	2.0
% of households with sheep only	6.2	6.7	3.4	4.3	1.8
% of households with two types	11.3	17.6	25.6	32.0	33.6
% of households with three types	2.4	5.3	13.1	9.1	17.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: ENA 1984

principal factors of production (land, labor and capital) and their ability to apply these factors in the livestock market. Despite their lack of access to these factors of production, small holders do engage in livestock production, albeit on a smaller scale.

Livestock and Pasture

The availability of pasture can be important for livestock production, particularly for cattle. Where pasture is not available, the need for fodder crops grows in importance. In Rwanda, pasture is scarce due to the pressure of population growth. Only in certain areas where ranches or communal land exist is pasture, in the traditional sense, maintained. Pasture represents only 9.3% of the total land operated by farm households in Rwanda or approximately

Table 5. Mean Holdings in Pasture and Percent of Holdings in Pasture by Prefecture in 1984

Prefecture	Mean holdings in pasture (ha)	% of holdings in pasture
Butare	.18	16.0
Byumba	.08	6.0
Cyangugu	.02	1.8
Gikongoro	.21	16.0
Gisenyi	.01	1.7
Gitarama	.16	11.2
Kibungo	.12	7.8
Kibuye	.07	5.7
Kigali	.25	15.4
Ruhengeri	.04	4.0
Rwanda	.11	9.3

Source: ENA 1984

.11 hectares per household (Table 5). Across prefectures, there is significant variation. Butare and Gikongoro, the highest, each have 16.0% of their total land area in pasture, whereas pasture represents only 1.7% of operational holdings in Gisenyi. It is rather surprising to find that Butare, the most densely populated area in the country, has such a high proportion of its land resources in pasture. It should be noted that communal lands and those of commercial ranches (very small in number) are not figured into these estimates as the present study focuses exclusively on holdings operated by households.

Prefectures with large numbers of farms established under *paysannat* resettlement schemes have among the highest percentage of land in pasture. These include: Butare, Gikongoro, Kigali and Kibungo, and with the exception of Kibungo they also have in common the highest concentration of the cattle at the household level. Farmers in Gisenyi own 17% of all cattle but place only 1.7% of their land in pasture. This may be explained at least in part by the fact that pastures located in the natural forest in Epa, Gisenyi, were not measured in the 1984 survey.

Given that larger farms own more livestock, it was expected that these farms would also have greater holdings in pasture. Table 6 confirms this hypothesis, showing that while the largest farms have an average of 1.38 ha of land in pasture, those in the smallest farm size category hold only .02 ha in pasture. Undoubtedly small holders see the use of land for crops and for pasture as competing demands. On the very largest farms there is relatively little

competition between crops and livestock; crop production on these farms tends to be constrained principally by the limited family labor supply (SESA, 1987). Land not cropped is generally placed in pasture or woodlot.

Table 6. Mean Holdings in Pasture and Percent of Holdings in Pasture by Farm Size in 1984

Farm Size (ha)	Mean Holdings in Pasture (ha)	% of Holdings in Pasture
.00 - .50	.02	6%
.51 - 1.00	.16	22%
1.01 - 1.50	.31	25%
1.51 - 2.0	.46	26%
2.01 +	1.38	43%
Total	.11	9%

Source: ENA 1984

Animal Population Density

To develop sensible policies regarding livestock production, we must know how many head of livestock farmers raise in relationship to their holdings and management systems. This section deals with the question of animal population density and the future of the livestock industry given declining land resources and competing land use demands. The ratio accepted by most researchers as the minimum amount of land required under an extensive system is one hectare for one head of cattle, and .3 to .4 ha for one head of cattle under an intensive scheme (ISAR, 1974). Based on these generalized assumptions, Rwandan farmers appear to be producing livestock beyond their means.

Because cattle, goats, sheep and pigs are different types of livestock with varying sizes and weights, a standard unit of measure is needed in order to examine the overall animal-land relationship. This unit is the Tropical Livestock Unit (TLU). The TLU standard is 250 kg, or the equivalent of one head of cattle. For present purposes, one TLU is also considered to be the equivalent of six goats, six sheep, or four pigs. ISAR likewise estimates that one hectare of pasture may be enough to support one cow and its calf. Krueger (1981) estimated that under normal conditions in Rwanda, one head of cattle should be considered equivalent to six goats or six sheep. Others suggest that cattle in Rwanda may not need an entire hectare each, but

when the quality of local pastures is taken into account, it can be argued that even one hectare is insufficient.

Livestock management systems are known to vary between two extreme types. First there is the *intensive* scheme, where animals are kept in permanent stables most of the time; under this system, raising livestock is done specifically for the purposes of milk or meat production. Animals often receive supplements and concentrates in order to enhance productivity. The second is the *extensive* livestock system in which animals are grazed outside and watered in or out of the stable. Animals are milked either a small amount or not at all. Generally speaking, neither pasture nor forage is viewed as a constraint where this system is practiced.

Assuming the average farmer in Rwanda is willing to devote one third of his holdings (.40 ha) to livestock (either pasture or fodder crops), then, under an intensive system, researchers tell us that he should be capable of supporting approximately 1.0 TLU. Under an extensive system, however, which is the predominant practice in Rwanda, only .40 TLU can be supported on this same amount of land. Farmers in Rwanda currently raise an average of 1.20 TLU, or roughly 3 times the amount of livestock recommended for adequate animal nutrition and ecological sustainability.

This situation will ultimately have negative consequences for the ecological system. Deforestation and soil erosion are known to be connected to uncontrolled expansion of agricultural and livestock systems. Animals will be affected by a lack of adequate feeds, which in turn can affect the quality of animal products. Crop production can likewise suffer from weak manure production. Animals can be transformed from a resource that generates income and helps improve nutrition to a destroyer of natural resources. Skilled resource management is needed to ensure that livestock remain a resource for, and not a threat to, future development in Rwanda.

Rates of Animal Mortality

Findings from the National Agricultural Survey show substantial differences in mortality by type of animal and by agro-ecological region. Examination of these differences can be instructive not only from a causative, or epidemiological standpoint, but also as the basis for decision making and long term veterinary planning and investment.

In general the annual percentage of animals lost due to mortality is quite high in Rwanda: 31.5% for sheep, 27.9% for pigs, 18.2% for goats and 14.9% for cattle (see Table 7). A regional breakdown shows the highest mortality for cattle to be in the eastern part of the country. This has been confirmed by Pellemon International (1987), the reason being a high incidence of east coast fever in that area. There are two regions in which the mortality of pigs is equally high: the South-Central (35.7%) and the North-Central (35.0%). Pellemon International estimated the total mortality for pigs raised under traditional methods to be 50%.

Table 7. Rates of Animal Mortality by Agro-ecological Zone During the Twelve-month Period Ending October 1983

Zone	% of Cattle	% of Pigs	% of Sheep	% of Goats
North-West	12.5	20.3	21.7	21.4
North-Central	14.8	35.0	37.4	24.5
South-West	10.4	15.6	16.6	15.1
South-Central	10.2	35.7	19.0	12.3
East	22.1	22.9	56.4	17.5
Rwanda	14.9	27.9	31.5	18.2
(Estimated Deaths during 12 month period)	(123,780)	(62,088)	(176,228)	(349,739)

Source: ENA 1984

Two regions show high rates of mortality for sheep; these are the East region which lost 56.4% of its sheep in 1984, and the North-Central region which lost 37.4%. Pellemon International reported a 32% loss on-station. Why sheep mortality is so high in the East is not entirely clear, but certainly such a finding warrants special attention and perhaps some form of intervention.

The overall annual rate of mortality for goats is 18.2%, which is confirmed by similar findings reported by Pellemon International. The two northern regions of the country suffer from the highest rates of mortality of all, at 24.5% and 21.4%, respectively. Comparing the four types of animals, regional variations in mortality rates appear to be the lowest for goats and cattle. Goats and cattle also have the lowest overall rates of mortality.

The North-Central region seems to be especially weak in terms of animal health. Across the four types of animals, the North-Central suffers from high mortality in every case. At the prefectural level the major problem is found in Ruhengeri and Byumba for small ruminants and in Kibungo for cattle. One suspects that the high population density in the northern provinces and reports of water contamination (MINAGRI, 1979) may be a contributing factor in the exceptionally high mortality in that region.

According to annual reports of the Ministry of Agriculture from 1972 to 1975, Kibungo lost 10,411 head of cattle, representing 28.5% of the total cattle population in that prefecture. Another report (Pellemon International, 1987) presents figures showing that Gisaka, in Kibungo, had the highest incidence of east coast fever. Our analysis shows precisely the same pattern. Given that Kibungo has the second largest farm size per household, the largest holdings in

pasture, and a relatively low livestock population density, it is likely that once the spread of east coast fever is controlled, mortality rates for cattle in Kibungo will decline significantly.

Table 8. Number of Household Members Aged 15-64 by Farm Size (ha) in 1984

Farm-size (ha)	Number of household members aged 15-64					Total
	0	1	2	3-4	5+	
.00 - .50	47.8	32.5	33.9	13.6	3.7	26.4
.51 - 1.00	33.7	36.1	30.6	28.0	26.4	30.4
1.01 - 1.50	7.1	13.3	14.6	19.1	17.8	15.6
1.51 - 2.00	5.2	7.0	10.2	14.0	17.0	11.1
2.00 +	6.3	11.2	10.7	25.3	35.1	16.4
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
(Number of Households)	(37,394)	(139,780)	(553,425)	(293,426)	(87,872)	(1,111,897)

Source: ENA 1984

Livestock and Labor

The distribution of economically active household members (those between the ages of 15 and 64) across farm size categories shows a high concentration of active members on larger farms, particularly those of 2.0 ha or more (Table 8). Similarly, this table shows that a large percentage of households with two or fewer active members fall in the smallest farm size category of 0-.5 ha. The acquisition of farm land in Rwanda is closely linked to the family life cycle (Clay *et al.*, 1990). This means that the young families begin with a small amount of land and accumulate holdings over time as their families expand and their parents further subdivide the family holdings.

An examination of household labor availability by type of livestock ownership reveals two general patterns. The first is that an increase in household labor is associated with increased cattle and goat ownership (Table 9). This may be a case of concomitant variation with farm size, as shown in previous tables, but also it is likely that the increased income generated by large families facilitates investment in livestock, notably cattle, and that the labor demands of cattle-raising can be easily met by large families. The second is that no significant relationship exists between household labor and the ownership of pigs, and that sheep tend to be disproportionately concentrated on farms where labor availability is lowest of all. Overall, these findings confirm that small ruminants, and especially sheep, are less demanding in terms of labor than are cattle.

Table 9. Percent of Households Owning Livestock by Number of Household Members Aged 15-64 in 1984

Type of Livestock	Number of Household Members Aged 15-64					Total
	0	1	2	3 - 4	5 +	
% Owning cattle	13.3	16.4	15.6	25.3	32.4	23.7
% Owning pigs	9.5	5.3	12.2	10.4	14.1	12.6
% Owning sheep	24.1	22.0	17.9	17.9	15.9	20.6
% Owning goats	34.2	47.4	53.2	65.0	68.8	56.2
(Number of households)	(37,394)	(139,780)	(553,425)	(293,426)	(87,872)	(1,111,897)

Source: ENA 1984

Age of Head of Household and Livestock Ownership

An extension of the life cycle hypothesis alluded to earlier is that livestock ownership is likely to be related to the age of the head of household. Along with age comes the accumulation of capital through inheritance, management of household labor and landholdings, and capital investments. These accumulating factors of production place older farmers in a favorable position vis-a-vis the purchase, pasturing and maintenance of livestock, but especially of cattle. By contrast, we would expect to find that younger farmers, being owners of smaller farms and not yet in control of large amounts of capital or family labor, raise fewer livestock overall but especially fewer cattle.

Looking at the relationship between age of the head of household and livestock ownership in Table 10, it is found that young families do indeed raise fewer cattle. Among heads of households aged 46 years or more, approximately 30% own cattle, compared to only 8.9% of household heads aged 30 years or less. Our hypothesis that the accumulation of capital, land, and labor necessary for long-term investments such as cattle raising is given strong support by these data. Contrary to our expectations, however, is the finding that small ruminants are not disproportionately owned by younger household heads. There appears to be no relationship between age of head and ownership of goats and pigs, and in the case of sheep, older heads of households are more likely to be owners than are the younger heads. In short, though many young household heads lean toward small ruminants when they invest in livestock, probably because there is less required in terms of start-up costs and maintenance, their older counterparts are equally invested in these small ruminants, and even more so in the case of sheep. It is likely that the reason that older heads are more apt to be involved in sheep production is because of their ownership of cattle. As discussed earlier, the tradition in Rwanda is that cattle and sheep are raised together. We note however that although age and livestock ownership are closely related, ownership begins to drop off for all types of livestock among the very oldest group of farmers (those aged 65+ years).

Table 10. Percent of Households Owning Livestock by Age of Head of Household in 1984

Type of Livestock	Age of Head of Household				Total
	15 - 30	31 - 45	46 - 65	65 +	
% of households owning cattle	8.9	23.2	34.8	26.7	23.7
% of households owning pigs	9.7	14.0	13.7	11.7	12.6
% of households owning sheep	14.2	18.2	27.8	21.4	20.6
% of households owning goats	48.9	45.7	64.0	52.7	56.2
Mean Farm Size (ha)	.85	1.28	1.44	1.20	1.21
Mean Holdings in Pasture (ha)	.09	.11	.11	.12	.11
(Number of households)	(273,826)	(369,929)	(354,215)	(113,927)	(1,111,897)

Source: ENA 1984

Multivariate Analysis of Livestock Production

Previous sections have examined the connections between livestock production and various correlates such as landholdings, land in pasture, household labor, age of head, and agro-ecological region. This section analyzes the multiple and independent effects of these variables through a set of multivariate regression models. Each of the four major types of livestock plus an overall measure of livestock production in Tropical Livestock Units (TLU) are regressed across a set of key independent variables. Variations in agro-ecological region are reflected in measures of altitude and rainfall. Table 11 reports the zero-order correlations and betas for each of the five models.

Looking first at the cattle population, Table 11 shows a positive and significant correlation (beta = .07) between the number of cattle owned and regional population density, likely a reflection of the historical importance of cattle in the southern provinces. Because cattle need relatively large amounts of pasture, the influence of farm size on cattle ownership is moderately strong and positive (beta = .34). Equally important is the number of economically active household members (beta = .23) confirming our earlier observation that the labor

Table 11. Regression Models for Cattle, Pigs, Sheep, Goats and Total Tropical Livestock Units (TLU)

Independent Variable	Cattle		Pigs		Sheep		Goats		TLU	
	r	beta	r	beta	r	beta	r	beta	r	beta
Altitude	-.03	.01	-.01	.10*	.23*	.28*	-.07*	-.01	.00	-.04
Rainfall	-.06*	-.06*	.08*	.12*	.08*	-.08*	-.08*	-.01	.03	.05
Population Density	.01	.07*	.06*	.06*	.10*	.03	-.11*	-.07*	.03	.04
Farm Size	.31*	.34*	.05	.03	.20*	.19*	.27*	.22*	.14*	.12*
Household Labor	.32*	.23*	.12*	.11*	.11*	.06*	.18*	.12*	.16*	.13*
Age of Head	.18*	.13*	.02	.00	.10*	.08*	.08*	.04	.04	.00
Education of Head	.02	.03	.03	.02	-.03	-.01	.00	-.01	-.01	-.04
R ²		.17		.03		.11		.09		.04

Source: ENA 1984

*Significant at $p < .05$

requirement for cattle is considerable. The zero-order correlation between age of head of household and cattle population ($r = .18$) drops off to .13 when other variables in the model are introduced. This indicates that part of the influence of age is indirect, through farm size and family size. In other words, age is important because the accumulation and inheritance of wealth grows over time, but also, indirectly, by virtue of the fact that older farmers operate larger farms and have a larger family labor pool. Rainfall has a negative and significant relationship probably because in the south-east region of the country, in parts of Butare prefecture and in the southern portion of Gikongoro, rainfall is relatively low, yet due to the large holdings found in the paysannats established in these regions, the cattle population is still relatively large.

The regional concentration of pigs in Butare and Gikongoro that developed for historical reasons accounts for the finding that both altitude and rainfall are positively correlated with pig ownership (betas = .10 and .12). Because pigs are commonly raised in stables and fed fodder crops, they are the one type of livestock that is not correlated with farm size. Indeed, they have a positive correlation with population density. Though less demanding in terms of land, the results show that pig production does draw on household labor.

The concentration of sheep in the northern provinces, particularly along the border with Zaire where the market is strong accounts for the correlation with altitude (beta = .28). As sheep are traditionally raised along side cattle in Rwanda, it is not surprising to find that these two types of livestock are influenced by the same set of factors. In particular, farm size, household labor and age of head of household are the primary associated factors.

Because goat production in Rwanda is so dispersed, and is practiced by farms of all types, there is little correlation found between goat ownership and either altitude (beta = -.01) or rainfall (beta = -.01). The reason why the zero-order correlations with these two variables are significant is simply because the high altitude and rainfall areas tend to have very small farms and, consequently, fewer goats. In other words, these zero-order relationships are "interpreted" by the intervening effects of farm size. Again, the presence of household labor enables farmers to increase their production of goats (beta = .12).

When the model is run against an overall measure of livestock production, i.e., the Tropical Livestock Unit (TLU), only household labor and farm size show any net effect on production. While populations of cattle, pigs and sheep were all individually influenced by regional differences in rainfall and altitude, overall, these differences balance out. In other words while there is considerable regional specialization in the industry, it appears that no particular altitude or rainfall region has a real advantage over any other. As a policy matter, expansion of the livestock industry overall will benefit all regions of the country, yet if only certain types of livestock are promoted, certain regions will stand to gain more than other regions, with the exception, of course, of goats, which are found everywhere. Though there appears to be some regional equity to the livestock industry, it appears that both land and labor are the necessary conditions for successful animal production almost across the board. Only pig production does not seem to favor the large holders.

Goat Sales and Purchases

To illustrate the importance of goat production in Rwanda's rural economy, we refer to the rural component of the National Budget and Consumption Survey (MINIPLAN, 1988). These figures show that the net income from all sources including home production was 55,259 FRW/household/year or \$586/household/year at the official exchange rate of 94.34 FRW/\$. Of this total, crop production represented 54% and animal production 8%. Breaking down the gross value of animal production, we find that cattle contribute 40%, goats 30%, pigs 13% and sheep 7%. The data from the National Agricultural Survey in 1984 indicate that households sold on average 15% of their goats, while their own consumption was 8% and mortality 18% of the total population.

According to interviews with market participants, goat prices follow a bimodal pattern with one peak in June and the second peak in December. June is the period of the coffee harvest. Rural incomes increase from sales of coffee and other crops. Though animal owners are not in a hurry to sell their animals at this time, having other sources of cash to rely on, the demand for meat increases, presumably due to the higher incomes. Results from the 1983 Budget-Consumption Survey show that the income elasticity of demand for meat was 2.15. Thus, supply and demand factors combine to raise the price of goats. More businesses are created during the coffee harvest, with new restaurants appearing in rented buildings. Traders get special short-term loans to buy coffee, and this has an overall positive impact on the rural economy during this period.

The second peak is in December when traditional holiday feasts increase the demand for meat. Supplies will typically increase in September and October when crops begin to mature and animals must be tied or stabled to avoid crop damage. The same pattern appears at the beginning of the second season in February and March. At this time, the price of goats is low because of their high supply. Outside of these two periods, the price of goats is relatively stable. One suspects that the more serious buyers are those who have more or less regular incomes, but this hypothesis needs empirical confirmation.

The goat market is open and competitive. The skill of trading lies principally in one's ability to accurately assess an animal's value. Farmers, butchers, and restaurant and bar owners estimate the price of goats entirely by physical examination. There are no published guidelines on animal prices. Traders develop a market sense only by comparing animals and prices in different markets. Transportation costs are also an important factor in determining prices. The more isolated the marketplace, the higher the cost for sellers to take back their goats if they do not sell. Thus, isolated markets tend to have lower prices. Another element is the question of how urgently a particular seller needs money or a particular buyer needs goats. There are no special facilities at the goat market, which in most cases is located in the open air. Sometimes even slaughtering areas are without a roof or a concrete floor.

5.3 Estimating the Potential for Goat Marketing and Consumption in Rwanda

Pellemon International (1987) identifies the following production parameters for local goat breeds in Rwanda raised under a traditional management system:

- Litter size: 1.37
- Sex ratio: 50% male and 50% female
- Annual mortality rate: 18.2%
- Proportion of males kept after one year for reproduction: 20%
- Proportion of females kept after one year for reproduction: 55%

Karangwa (1981) has proposed a slightly different set of parameters:

- Litter size: 1.41
- Sex ratio: 51% male and 49% female.
- Annual mortality rate: 20%
- Sales as a percentage of adult herd: 25%

The following set of "average" parameters will be retained for analysis:

- Annual mortality rate: 18.2%
- Litter size: 1.4
- Sex ratio: 50% male and 50% female.
- Proportion of males retained for reproduction: 20%
- Proportion of females retained for reproduction: 55%.

By applying these parameters to a total goat population of 1,919,366 head in 1984, over a twelve month period, we estimate that there could be 981,716 goats in the market or consumed on the farm (for a comprehensive discussion of estimation techniques see Pellemon International, 1987, p. 1-37). However, our 1984 figures show that only 434,997 goats were actually marketed or consumed, which translates into just 51% of the theoretical potential. One can conclude from these findings that farmers are not maximizing their investment in the goat industry. Goat production is far from reaching its potential and is clearly responding to factors other than the market.

Figures on hides and skins exports in 1984, are compiled and reported by two different sources (Salah, 1989). The Ministry of Agriculture reports exports of 1,021 tons of hides and skins, while the National Bank reports 922 tons. The first figure corresponds to 2,042,000 hides (or the same number of goats). Figures from the National Bank correspond to 1,844,000 hides. Assuming that the correct estimate is somewhere between these two figures, or around 2 million, we are left with a huge discrepancy between this figure and the ENA-1984 estimate of 282,285 goats marketed, an estimate which was based on scientific sampling methods and which is believed to be quite accurate. One explanation for the difference is found in accounts of transshipments (imports and reexports). A 1986 report by the Ministry of Finance and Economy

confirms the existence of imports of hides and skins (MINIFINECO, 1986). At the same time, the country had an overstock of 478 tons of skins which were exportable.

The low level of meat consumption in Rwanda is caused by a lack of purchasing power in the rural areas. The National Budget and Consumption Survey estimated the value of gross household income in rural areas (including own-consumption) at 54,360 FRW (\$573) per year. This translates into expenditures of \$0.32/person/day. By comparison, the average price of meat in the rural areas was about \$1.20/kilogram. The same study found all the income elasticity to be positive even for staple foods, with the smallest elasticity being .14 for sweet potatoes.

Laure (1980) compared the price of commodities to daily wages. He indexed the price per 1,000 kcal and per 100 grams of protein to be very cheap when its ratio was less than 1/16 for calories and 1/8 for proteins. The commodity was classified as very expensive when the price per 1,000 kcal was 2 times the daily minimum wage, and 4 times when measured in proteins. In 1968, the ratio for beans was considered to be moderate at .13, when the ratio for goat meat was 1.6, or extremely high. Ten years later, the ratio for dry beans was .13, and for goat meat 2.39. The ratio for 100 grams of protein in 1968 for dry beans was .21, and 1.41 for goat meat in 1970. In 1978 the ratio was .20 for dry beans and 2.17 for goat meat. This example illustrates the high cost of meat relative to the cost of beans and relative to purchasing power in rural areas.

Several important conclusions can be drawn from this discussion. We have found that the goat population is large because sales are far below their estimated potential. Meat is exceptionally costly, given farmers' low purchasing power. At the same time, the high cost of goat meat limits the production of hides and skins, a source of rural income.

Conclusion

Prior to independence, livestock ownership was a sign of wealth and prestige. But with growing population pressure, resources have become increasingly scarce over time. For many, particularly small holders, livestock production provides some security against the advent of a poor harvest or a family crisis. The value of livestock is now determined in the marketplace, rather than by the social status it conveys upon its owner. Though commercial interests now motivate livestock production, few farmers have adopted intensive livestock management systems. Fodder crops are not grown, and most farmers still permit their animals to graze wherever grass and other vegetation can be found. It is difficult to say whether milk production is anything more than just a minor consideration for those who raise livestock, as the average production rate for cows is no more than one or two liters a day.

A longitudinal analysis of livestock data shows a decline in the ratio of animals to humans over the period 1953 to 1984, largely because of growth in the human population. At the same time, the population of small ruminants has increased; only the number of cattle has decreased significantly over time.

The largest concentration of cattle is found in the country's southern provinces, where the king's court was located and where the first livestock research centers were established. Pigs, too, are concentrated in the south, where they were first introduced by missionaries. Sheep are found principally in the northern provinces where the existence of markets on the border with Zaire has stimulated production.

Goats are distributed throughout the country but have discernible concentrations in the southern and eastern provinces. High productivity, low mortality, low initial investment, and relatively low labor demand are some of the factors that make goats the most commonly owned animal in virtually every region of the country. There are almost 2 million goats in Rwanda, more than any other type of livestock, and they are raised on over half of the country's farms. For the small holder, goats are the most important animal among the four types of animals commonly raised in Rwanda.

Overall, livestock production is highest in Gikongoro, a prefecture with exceptionally poor soils and weak agricultural production. We surmise that farmers in Gikongoro have looked to livestock production in an effort to diversify and avert the risk associated with weak production, particularly in the advent of a prolonged drought. Additionally, more livestock means more manure, the use of which enables these farmers to cultivate holdings of marginal fertility. Two other prefectures in which livestock ownership is uncommonly pervasive are Butare and Ruhengeri. Though soil fertility in these areas is not poor, population density is exceptionally high and farms are concomitantly small. Historical circumstances are the most plausible explanation for these anomalous findings.

In general, one finds that farmers operating relatively large landholdings, and those with more land in pasture, are more likely to own livestock. This is particularly true for cattle, which require more pasture than do small ruminants. When small holders do raise livestock, small ruminants seem to be best suited to their resource levels and economic needs. At a certain point, however, farms can become too small even for the production of small ruminants. Currently in Rwanda most livestock are allowed to graze in pasture or wherever vegetation can be found. Few are raised under more intensive schemes that require the construction of stables and that fodder be grown and cut specifically for this purpose.

Given available pasture in Rwanda (9.3% of holdings), it has been estimated that farmers currently own roughly three times the amount of livestock that is commonly thought to be ecologically sustainable. Likewise, an analysis of turnover in the goat industry has shown that farmers are selling or consuming only half of their potential. In other words, Rwandan farms appear to be over-stocked with livestock. There are two factors that may account for the fact that farmers do not more actively market their animals. The first is that livestock have traditionally served as a mechanism for capital savings, which are "cashed in" only on special occasions or in times of need. Second, purchasing power in rural areas is very low and meat consumption is still viewed as a luxury, with per-calorie and per-protein costs upward of ten times that of traditional staple crops such as beans and sweet potatoes. Only in the urban areas,

where incomes are higher, has the consumption of meat and milk products seen an appreciable increase.

In supporting a very large animal population relative to their available resources Rwanda's farmers must face the dilemma of maintaining this animal population over the long term without negatively affecting their resource endowment. A growing demand for meat and milk along with the farmer's desire to maximize returns to his investment, and the government's insatiable demand for foreign exchange earnings through the export of hides, will place a heavy burden on the shoulders of agricultural planners and decision-makers to ensure the adoption of a sensible and effective long-term strategy. At the very least a comprehensive farming systems approach that minimizes farmer risk and simultaneously integrates crop and livestock production in an environmentally sustainable fashion must be given priority consideration.

The export of hides and skins from Rwanda far exceeds domestic production. Evidence suggests that hides and skins are imported into Rwanda for re-export. This export market has been a consistent source of foreign exchange in the past and should undoubtedly be maintained. How the flow of skins from other countries through Rwanda is constrained or promoted by current exchange rates is certainly a question that merits further study. By contrast, the fact that Rwanda exports skins and hides while simultaneously importing shoes and other high-cost leather goods is a source of some consternation.

Animal health is another area of concern. Diseases are so prevalent that helminths, ticks and theileriosis are now agreed to be the major constraints to livestock development in Africa. This study has found an exceptionally high rate of mortality among cattle in Byumba and Kibungo. It has been reported that the incidence of east coast fever in these areas is high, which may help account for our findings. In Ruhengeri and Kibuye, sheep have high rates of mortality, and in the north central region mortality among goats is high. The unusually high rates of mortality we have found in Rwanda's northern provinces should be seen as a priority need in terms of research and intervention.

Research on goats in Africa has stressed the notion that goats can provide immediate cash for the small holder and milk during the dry season, when the production of cow's milk is low. More needs to be known about the genetic characteristics of local breeds. Many regional cross-breeding experiments on goats have failed, the one exception being in the highlands of Kenya (Wilson, 1982). Constraints to the development of new breeds have been both environmental and management-related. The local breeds seem to be extremely well adapted and it appears that there exists adequate genetic material in the indigenous breeds for a significant increase in production (Rwamasirabo, 1990).

Goats have traditionally been allowed to feed on their own in the African system, but alternative feeds exist such as cassava, banana peels, corn bran, sweet potato vines, and agro-industrial byproducts (Smith *et al.*, 1989). Some legumes may also be added in order to upgrade basic feed. Little research has been conducted on-farm to determine how the local breeds fit into the overall farm production and consumption system. However, statistics in Rwanda have shown

that certain varieties of anti-erosion hedge produce on a one-hectare farm enough feed for two does and their four kids even without using supplements such as cassava and banana peels. The future of goat production in Rwanda will depend on the adoption of such varieties and on altering traditional management systems toward a more intensive, permanent stabling of goats and other livestock. Other management practices such as separating males and females, systematic vaccination and castration, providing adequate fodder plants and salt in the diet, and ensuring the intake of colostrum by kids will also be needed to improve goat production over the long term (Rwamasirabo, 1990).

The economics of goat husbandry are poorly documented in Africa. Despite the fact that goat's milk is more nutritious than cow's milk, that goat skins and hides generate sorely needed foreign exchange, and that goat meat is often preferred over other meats, development of the goat industry has had difficulty attracting public funds. Perhaps this state of affairs should not be surprising at all in the Rwandan context. Traditionally, cattle have been all-important. Small ruminants have never overcome their secondary status in the eyes of government officials and even of the larger development community. The market is not well organized, little information exists on market margins and price trends, and research on goat production in Rwanda is extremely limited. Goat husbandry would appear to have potential given shrinking farm sizes, low start-up costs and relatively low mortality rates. This study has tried to bring together historical reports and current data in an effort to broaden our understanding of goat husbandry in Rwanda, to illustrate how the industry intersects with key dimensions of local farming systems and to identify potential targets for related research and development in the future.

References

- Clay, Daniel C., J. Kayitsinga and J. McAllister. 1990. "Cycle de developpement familial, classe sociale et repartition des revenus en milieu rural au Rwanda." *Documents de Travail*, Division des Statistiques Agricoles, Ministère de l'Agriculture, de l'Elevage et de s Forêts, Rwanda.
- Clay, Daniel C. and L. A. Lewis. 1991. "Land use, soil loss and sustainable agriculture in Rwanda." *Human Ecology* (forthcoming).
- Dejaegher, Y., Daniel C. Clay, S. Rwamasirabo and J. L. Ngirumwami. 1988. *Aperçu Historique et Methodologique: Enquête Nationale Agricole, 1984*. SESA, Ministère de l'Agriculture, de l'Elevage et des Forêts, Rwanda.
- Gabriel, E. 1974. "Les routes d'exportation du bétail Rwandais," *Bulletin Agricole du Rwanda*, vol 7:1, pp. 22-29.
- Furnemont A. 1974. Comment Marier l'Agriculture et l'Elevage. Note Technique N° 15. ISAR. Rubona, Rwanda
- Karangwa, E. 1981. Elevage Caprin en Milieu Rural au Rwanda. Mémoire de fin d'études. Belgium.
- Krueger, W.D. 1981. Le Service Vétérinaire du PAP. Rapport de synthèse, Butare, Rwanda.
- Laure, J. 1980. Evolution des Prix de Bétail des Principaux Aliments a Kigali 1964-1978, *O.R.S.T.O.M., série SC.Hum.* Vol. XVII, No. 1-2, 85-115.
- Maquet, J. J. 1961. *The Premise of Inequality in Rwanda: A Study of Politics in Central Kingdom*. London, Oxford University: Press for International African Institute.
- Pellemon International. 1987. *Etude du Sous-Secteur Elevage, Volume 1*. Ministère de l'Agriculture, de l'Elevage et des Forêts, Rwanda.
- Rwamasirabo, Serge. 1990. Goat Production in Rwanda: Assessing the Potential for Future Development. Masters Thesis, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan.
- MINAGRI (Ministère de l'Agriculture, de l'Elevage et des Forêts). 1979. Rapport Annuel. Ministère de l'Agriculture, de l'Elevage et des Forêts, Rwanda.
- MINIFINECO (Ministère des Finances et de l'Economie). 1986. Situation Economique du Rwanda. Direction Générale de la Politique Economique, Rwanda.

- MINIPLAN (Ministère du Plan). 1988. Enquête Nationale sur le Budget et la Consommation, Volume 3. Ministère du Plan, Rwanda.
- Salah, E. S. 1989. L'assistance Préparatoire dans l'Etablissement d'une Industrie du Cuir et des Outils. Rapport final. Kigali, Rwanda.
- SESA (Service des Enquêtes et Statistiques Agricoles). 1985. *Résultats de l'Enquête Nationale Agricole 1984: Vol 1, Rapport 1*. Ministère de l'Agriculture, de l'Elevage et des Forêts, Rwanda.
- SESA (Service des Enquêtes et Statistiques Agricoles). 1987. *Description Sommaire des Principales Caractéristiques de l'Agriculture au Rwanda*. Ministère de l'Agriculture, de l'Elevage et des Forêts, Rwanda.
- SESA (Service des Enquêtes et Statistiques Agricoles). 1988. *Aperçu Historique et Méthodologique: Enquête Nationale Agricole 1984*. Ministère de l'Agriculture, de l'Elevage et des Forêts, Rwanda.
- Smith, O.B., O.A. Idowu, V.O. Asaolu, and M.O. Odulaniami. 1989. Comparative Rumen Degradability of Forage, Browse, Crop Residues and Agricultural Byproducts. Department of Animal Sciences, Obafemi Anolowu University, Ife Ife, Nigeria.
- Wilson, T.R. 1982. Husbandry, Nutrition and Productivity of Goats and Sheep in Tropical Africa. Joint IFS/ILCA workshop on small ruminant research in the tropics provision, Report No. 14. Stockholm, Sweden.