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Costs and benefits of livestock systems and the role of market and nonmarket relationships

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Abstract

In developing countries livestock are kept not only for their physical products, but also for insurance, financing, and to display status. Though this range of purposes is acknowledged, livestock policies nevertheless often emphasize physical production: a limited perspective that hampers the formulation and implementation of effective livestock policies. This article presents a comprehensive appraisal of costs and benefits of livestock systems that takes into account the institutional environment of livestock keepers. Indicators are developed that capture, quantify, and organize not only the benefits resulting from the physical production, but also those from the intangible functions. The method is illustrated by an analysis of cattle in the Western Province of Zambia. The results indicate that the perspective on livestock systems developed more closely reflects the observed decisions of the livestock keepers.

JEL classification: O13; O22; Q18

Keywords: Markets; Nonmarket relationships; Livestock; Policy analysis; Appraisal

1. Introduction

Millions of agrarian households in developing countries keep livestock as their main agricultural enterprise or as an enterprise linked to crop production. The roles livestock play in these households are manifold: the production of milk, meat, hides, manure, draught power, etc. as well as the accumulation of wealth, security against contingencies, and display of status. These various roles are acknowledged, with animal scientists usually concentrating on physical production, and social scientists additionally including aspects of financing, insurance, and status display in their analysis (Baker and Bhargava, 1974; Bosman and Moll, 1995; Doran et al., 1979; Low, 1986; Moll and Heerink, 1998; Rosenzweig and Wolpin, 1993; Udo and Cornelissen, 1998).

Livestock development policies, including research policies, generally focus on the physical production of livestock systems, often with an emphasis on marketed production (Behnke, 1985), and thereby neglect the multiple functions of livestock. One of the ways in which this restricted perspective on production becomes apparent is in the issue of the productivity of "traditional" livestock systems, such as cattle grazed on communal land or free-roaming goats. Policy analysts generally describe these systems as "low productive," because the off-take rate is well below potential levels. Livestock keepers, however, seem to be much less concerned with productivity in this narrow sense, and are prepared to keep low productive animals in

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their herds. The apparently divergent perspectives on livestock by policy analysts (and policy makers) and by livestock keepers hampers the formulation of effective livestock policies that take into account both the government's and livestock keepers' viewpoints.

The difference in perspectives on livestock arises largely because policy analysts exclude the institutional environment of livestock keepers, whereas livestock keepers include it. In developing countries this institutional environment is characterized by ill-functioning, absent, or nonaccessible markets for products, production factors, finance, and insurance. This means that the values of resources used for and products derived from livestock are not necessarily reflected in market prices, and that livestock attains roles in insurance, financing, and display of status. The latter was clearly demonstrated by Bennison et al. (1997) in a study of cattle keepers in The Gambia where the primary production objective proved to be the generation of savings, security, and asset protection. In this situation the standard cost–benefit analysis has serious shortcomings and the results rarely reflect the perspectives of livestock keepers. It should therefore come as no surprise that livestock keepers often use production methods that deviate from the "optimal" methods envisaged by policy analysts.

This article presents an appraisal of costs and benefits of livestock systems that aims to make policy analysis and resulting livestock policies more effective by focusing on the total complex of market and nonmarket relationships of the livestock system within the broader context of the institutional environment of livestock keepers. The approach is based on: (a) a distinction between recurrent production and embodied production to deal separately with regular income streams and irregular income from the sale of animals; (b) a distinction between marketed and nonmarketed resources and production, which leads to a discussion of prices and values for individual livestock keepers; and (c) recognition and estimation of the services livestock provide in insurance, financing, and status display. The approach is applicable to all types of animals, either individually or in herds. In this the analysis deviates from the approach followed by Crotty (1980) who developed separate models for various types of animals. The approach builds on the discussion of measuring the benefits of livestock by Behnke (1985) and expands the economic analysis to include the consequences of the institutional environment of livestock keepers. The outcome is a combination of cash income, noncash income, and intangible benefits instead of profitability as a single parameter. The appraisal complements biophysical livestock and crop–livestock models (Devendra and Thomas, 2002a, 2002b; Thornton and Herrero, 2001) that primarily focus on the relationships between livestock and crop enterprises and their physical environment as these quantified biophysical relationships form the starting point for the valuation and assessment of resources and products.

Section 2 deals with the method in four steps. In Section 3 the approach is applied to cattle grazed on natural pasture in Western Province, Zambia. Conclusions about the method are given in Section 4.

2. The method

The appraisal starts with the organization of the quantified resources used for a livestock system and the physical production obtained. Thereafter follows the valuation of resources and physical production within the farm household system, taking into account the presence or absence of markets for resources and production. The benefits derived from the functions of livestock in insurance, finance, and status display are discussed in the third stage, and in the final appraisal the total benefits of the livestock system are related to the household's production factors utilized, thereby taking into account their options and preferences. The analysis is depicted in Fig. 1.

The focus of the analysis is on the livestock system, but this livestock system is part of the farm household system that may comprise crop and care systems, as well as other on-farm and off-farm enterprises. The possible relationships between livestock and crop systems are included in this analysis. The position of the livestock system *vis-à-vis* other on-farm and off-farm enterprises will be briefly outlined at the end of this section.

2.1. Resources and production

Biophysical input–output data of the livestock system form the starting point of the analysis. These data are generally annual averages per herd in a steady-state situation, or averages per type of animal over

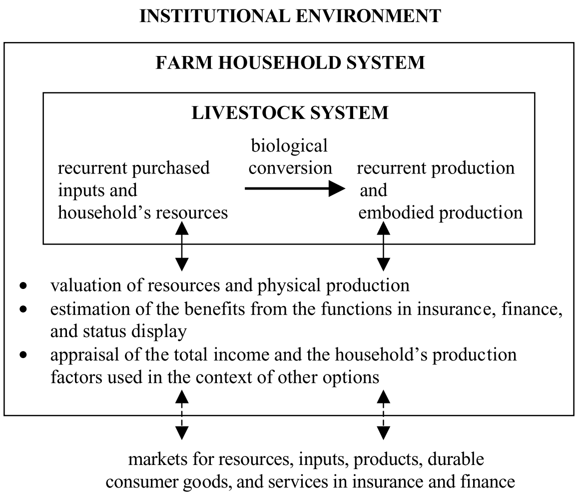

Fig. 1. The livestock system in the wider context.

its lifetime. The input–output data are thus the interface between, on the one hand, the complex biophysical processes that deal with reproduction, growth, and mortality, and on the other hand the valuation of inputs used and outputs obtained that result in an *ex post* assessment of the benefits of the system (Bosman et al., 1997).

In this method, the resources used in livestock production are split into recurrent purchased inputs and the household's production factors directly employed, such as family labor, land, and capital invested in animals and stables. Examples of recurrent purchased inputs are medicines and drugs, feed supplements and fodder, hand tools, hired labor, and veterinary services. The reason for this distinction lies in the valuation of the resources, which is dealt with in the next sections.

Livestock production is separated into recurrent production and embodied production. Recurrent production becomes available according to the livestock's type, sex, age, and the season. Examples are products and services such as milk, wool, manure, and draught power. Embodied production refers to changes in body weight, pregnancy (as proof of fertility), and change in capabilities through training, or to changes in numbers of animals if the analysis is at herd level. Embodied production is thus production that is not consumed but that is kept in animals as an investment. This investment results in future recurrent production or it becomes available when animals are slaughtered, sold, or given away. The embodied production per period is usually measured by subtracting the embodied production at the end of period $t-1$ from the embodied production at the end of period t.

2.2. *Prices and values of resources and production*

To assess the contribution of livestock to the income of the livestock keeper the resources used and production obtained must be valued. This valuation is not a straightforward process, as markets for resources and products are imperfect or even absent and thus do not provide prices. Moreover, livestock keepers may have differential access to markets, which means that the price obtained by farmer x may differ from the price obtained by farmer y, while for farmer z, who has no access to that market, neither price is relevant.

Some of the resources and products are valued through markets where supply and demand conditions result in prices. The nonmarketed resources and products are valued within the households, using as a yardstick the combination of resources, options for using these resources, and preferences specific to that household.

For the analysis of the recurrent production, the distinction between marketed and nonmarketed outputs, the former with market prices and the latter with estimated prices (both at farm gate level), is maintained in the following two indicators.

The net recurrent cash income in period t, Y_t^c, is defined as

$$Y_t^c = \left(r_{jt}^m p_{jt}^m\right) - (a_{it} p_{it}), \tag{1}$$

with

- r_{jt}^m the quantity of recurrent marketed production j in period t, with $j = 1, \ldots, l$;
- a_{it} the quantity of recurrent purchased input i used in period t, with $i = 1, \ldots, n$;
- p_{jt}^m the price for recurrent marketed output j; and
- p_{it} the price of recurrent purchased input i.

The net recurrent cash income is a partial indicator, but a major one for farm households, as they usually strive for cash income to pay for school fees, medical treatment, and the purchase of consumer goods.

The recurrent income in kind in period t, Y_t^k, is defined as

$$Y_t^k = \left(r_{jt}^n p_{jt}^n\right), \tag{2}$$

with

r_{jt}^n the quantity of recurrent nonmarketed production j in period t, with $j = 1, \ldots, l$;
p_{jt}^n the estimated price for nonmarketed output j.

The nonmarketed recurrent production is consumed, exchanged, or invested and as such is observable by farm households and implicitly valued. The valuation through estimated prices is for analytical purposes.

The aggregate value of the various types of embodied production is reflected in the sale price of an animal. For slaughter animals the sale price is usually just the total weight times the price per kg live weight. For dairy or draught animals the sale price normally reflects the expected capability for future production. Markets for slaughter animals are usually present, but markets for animals in their productive period may be thin, and in such cases, prices must be estimated. The value of the embodied production in year t, V_t^e, is calculated by subtracting the sale price of the animal(s) at the end of period t, P_t, from the sale price at the end of period $t-1$, P_{t-1}:

$$V_t^e = P_t - P_{t-1}. \tag{3}$$

The embodied value in a year can be negative due to loss of body weight, or reduced production prospects.

The combination of the net recurrent cash income, the recurrent income in kind, and the embodied production, all over period t, gives the *gross margin* for period t:

$$GM_t = Y_t^c + Y_t^k + V_t^e. \tag{4}$$

The gross margin is the comprehensive indicator for the value of the net on-farm physical production of the livestock system obtained by using the households' production factors. Combining the three components into one indicator facilitates the analysis, but for livestock keepers this one indicator is not observable. However, as the components each are observable we may assume that farm households take them all into account in their assessment of livestock systems.

The valuation of the household's production factors labor, land, and capital directly employed in the system is discussed in the final analysis in Section 2.4.

2.3. The functions of livestock in insurance, financing, and status display

The functions of livestock as security against contingencies, as a means of financing, and in the display of status are significant in communities where it is difficult or impossible to fulfill these functions by other means. The absence or ill-functioning of markets for finance and insurance in developing countries, especially in rural areas, has been widely documented by, for example, Von Pischke et al. (1983), Binswanger and Rosenzweig (1986), Adams and Fitchett (1992), Bosman and Moll (1995), and Hoogeveen (2000). The consequence of the absence or restricted presence of finance and insurance institutions is that to cope with the vagaries of life, people in rural areas search for alternatives within their sphere of command. Among the possibilities are keeping livestock, hoarding gold and jewelry, and investing in tree crops.

The insurance function of livestock results from the potential of being able to sell the animals in case of emergencies. Having animals is thus comparable with having insurance, and the absence of the need to pay a premium can be considered the average intangible benefit. Sieff (1999) analyzed the relationship between wealth and livestock dynamics of the marginalized Datoga pastoralists in Tanzania and showed that the poorest households were forced to sell more animals than were replaced by reproduction, and thus were faced with dwindling herds. This reflects an extreme situation: the households are not only too poor to keep low productive animals as insurance, but they are also forced to sell their productive animals. The insurance function is important not only in situations where no other means of storing wealth are available, but even when there are other insurance options, because animals are easily convertible assets.

Insurance premiums provide cover to a specified limit for a determined period, and the benefit of insurance, B_t^s, is therefore related to the average value of animals for period t:

$$B_t^s = b^s(P_{t-1} + P_t)/2, \tag{5}$$

where b^s is a factor indicating a proportion of the average sale value. To estimate the factor b^s, the alternative insurance options must be assessed. In their analysis of dwarf goats in Southern Nigeria, Bosman et al. (1997)

used an informal life insurance system described by Ibe (1992), with an annual premium of around 0.10 as reference. Ayalew (2000) has discussed informal group insurance in the Ethiopian highlands and estimated the insurance benefit of goats to be 0.083 of the average value of the stock. If alternative options are not present a guesstimate is required, and a range from 0.05 for stable situations without major weather risks to a factor of 0.20 for situations with severe risks, seems justifiable.

The function of livestock in financing is noticeable in three phenomena: the purchase of animals when income exceeds consumption requirements (Dercon and Krishnan [1996] discuss income portfolios in rural Ethiopia and Tanzania); the investment of embodied production; and, the sale of animals predominantly for immediate consumption or investment requirements. The latter phenomenon is recognized in different circumstances. Behnke (1985) states in a discussion on the price of camels, "richer Bedouin continued to sell a *limited* number of animals in order to meet their perceived essential rice requirements"; Low (1986) formulated the "sale for specific cash needs" hypothesis in the context of cattle marketing in Swaziland; and Moll and Dietvorst (1999) found in the Western Province of Zambia that livestock keepers just sold cattle in case of a substantial and urgent requirement of cash. Selling livestock to meet specified requirements has a number of advantages:

- hedge against inflation, as the real value of livestock generally remains fairly stable;
- there is no need to keep cash safe (this is difficult in rural circumstances);
- the presence of cash is avoided, thereby averting possible claims from others that are difficult to refuse for social reasons;
- avoidance of storage losses if animals are exchanged for goods;
- avoidance of the cost involved in borrowing for consumption or investment purposes.

The benefit of financing through animals thus results from the avoidance of cost involved either in storing money or goods, or in borrowing. However, the sale of animals when there is a need, and not at the optimal moment as determined by the physical production or prices, implies a trade-off between the benefit from financing and the maximal cash returns.

The measurement of the function in financing must focus on the sale (or direct consumption) of animals because this forms a clearly identifiable event, and because measuring the outflow covers previous investment behavior through the accumulation of embodied production and the purchase of animals. The benefit of financing, B^f, is related to the sale price:

$$B_t^f = b^f P_t, \tag{6}$$

where b^f is a proportion of the sale price. The factor b^f can be estimated by considering the cost or loss incurred in alternative ways of financing, such as: having a savings account; storing grain; obtaining informal credit; or, pawning jewelry or durable consumer goods. In the studies by Bosman et al. (1997) and Ayalew (2000) the estimates are based on the avoidance of inflation for Nigeria, and on commercial interest rates for short- and medium-term credit for Ethiopia, respectively, resulting in values for b^f of 0.06 and 0.10.

The function of livestock in providing status to their owners is related to the presence or absence of other means to display wealth, such as durable consumer goods and building materials. Status may not be an entirely intangible benefit, as it may play a role in acquiring influence, and subsequently increasing access to resources. The benefit from providing status is, as in insurance, related to the average value of an animal (or animals) over period t:

$$B_t^p = b^p (P_{t-1} + P_t)/2, \tag{7}$$

where b^p is a proportion of the average value. For an estimate of factor b^p a value below the value for insurance seems appropriate as insurance, which may mean survival, generally has a higher priority than status.

At best, estimating the factors b^s, b^f, and b^p determining the benefits in insurance, financing, and status display is guided by alternatives that vary in relevance. Actual estimates thus require subjective judgments, and so are open to debate. Yet in situations where markets are absent or ill-functioning, debatable estimates are unavoidable.

2.4. The analysis

The total benefit derived from livestock production is composed of the gross margin plus the benefits from insurance, financing, and status display. The benefit in financing is measured over animals sold (or consumed, or given away), whereas the benefits of insurance and status display are measured over animals kept. The distinction between stock and flow leads to a separation between the analysis for an individual animal and the analysis at herd level.

The analysis of an individual animal over its lifetime results in two indicators: the annual benefits of keeping the animal

$$B_t^k = Y_t^c + Y_t^k + B_t^s + B_t^p, \tag{8}$$

composed of cash, products consumed, and the benefits in insurance and status display; and, the one-time benefit of selling the animal:

$$B_t^s = P_t + B_t^f, \tag{9}$$

the sale price plus the benefit of financing. One could argue that the total benefit of selling an animal is reflected in the sale price. The sale price, however, does not play a pivotal role in the decision to sell when markets are partially absent: it is not the sale price that triggers the sale of an animal, but the purpose for which the sale price received is required. The benefit of selling an animal, B_t^s, thus reflects the benefit of having the sale price in hand at the right time.

The expression of the benefits of a single animal into two indicators parallels the distinction between "production value" and "liquidity value" used by Baker and Bhargava (1974) in their theory on liquidity management, but in our analysis both terms have a wider definition.

The total benefit of keeping an animal during n years, followed by sale, is

$$B^n = \sum_{t=1}^{n} B_n^k + B_n^s. \tag{10}$$

Dividing by n results in the average total benefit per year, $\bar{B}$.

The analysis at herd level is usually carried out for a period of 1 year. At herd level no separate indicators for keeping and sale are required, as in an average situation both apply. The gross margin captures the total physical production in a year, while the benefits in insurance and status display and in financing are measured over the average herd and the proportion of the herd sold, respectively. The total benefit in an average year is

$$\bar{B} = \overline{GM} + \bar{B}^s + \bar{B}^f + \bar{B}^p. \tag{11}$$

The addition of all income components into one parameter $\bar{B}$ should not obscure the trade-off among the components. This trade-off stems from both biophysical and socioeconomic factors. For example, keeping low-productive animals in the herd on a limited area reduces overall biological productivity, but increases the benefits from insurance and status.

The total benefit, either for a single animal or for a herd, results from the utilization of the household's production factors—labor, land, and capital (L, G, and C, respectively). Allocating the total benefit over the production factors to determine the respective returns requires prices for the production factors:

$$\bar{B} = (L \times p_l) + (G \times p_g) + (C \times p_c), \tag{12}$$

with p_l, p_g, and p_c the prices for labor, land, and capital, respectively. These prices are either (partly) absent, or not relevant for all livestock keepers, and this precludes a general statement on the returns per production factor. However, the formula shows that, given the total benefit and the amounts of labor, land, and capital used, there is a trade-off among the returns per production factor.

Livestock keepers will assess the livestock system in terms of the types of income derived from keeping and selling on the one hand, and the household's production factors used on the other hand (Staal, 2000), and will do so bearing in mind their possibilities for using their production factors in other on-farm and off-farm enterprises; see Fig. 2.

The outcome of this assessment may differ by household according to their particular objectives and values for the different income components, their factor endowments, and their access to institutions. Analysts lack these individual and subjective references, but the comprehensive appraisal of costs and benefits presented above offers a framework for combining estimates with observed data. Sensitivity analysis of the estimates allows the analyst to relate the total benefit of a livestock system to a range of circumstances experienced by different groups of livestock keepers.

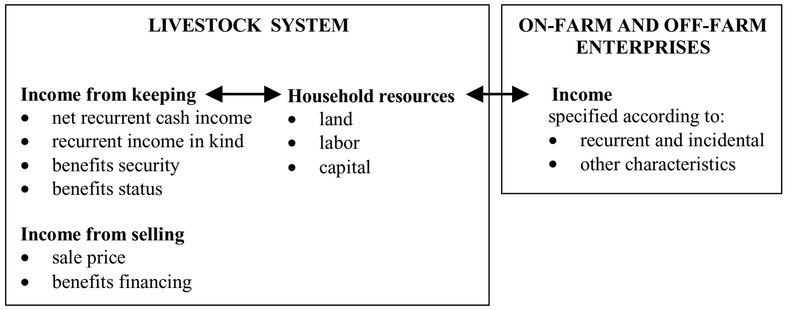

Fig. 2. Appraisal of the livestock system.

3. An assessment of cattle in Western Province, Zambia

The method is illustrated by applying it to cattle production in the Western Province of Zambia. Cattle are kept in combination with crop production and this combination is widespread in Southern Africa. The data on the physical production were collected through herd monitoring over a period of 5 years (Brouwer et al., 1992; Corten, 1988; van Klink, 1990). Prices and values were collected and estimated during an overall assessment of the crop and livestock subsectors (Mwafulirwa and Moll, 1991). The analysis below refers to an average individual animal, a cow, over a lifetime of 15 years, the lifetime covered in the herd monitoring.

Approximately 30% of the households in the Western Province keep cattle. The animals, of the Barotse type, are kept in herds of 30 to 100 head, owned by a number of people. During the daytime the animals graze on natural pasture, under the control of a herdsman. At night they are kept in enclosures, *kraals*, that are shifted frequently to spread the manure over the fields where maize and millet will be grown. Meat production is the main purpose of the system, but cows are milked (leaving enough milk for the calf), and bullocks are used for transport and ploughing.

3.1. Resources and production for one cow

Labor is used for herding, shifting *kraals*, and for milking. The capital embodied in the animals is substantial: it forms 90% of the total assets of the cattle-keeping households (Moll and Dietvorst, 1999). Minimal amounts of working capital are used to buy medicines. There is ample scope for more cattle in the Western Province, so land (natural pasture), is not scarce and access is free. The resources used and the production obtained over the lifetime of a cow are shown in Table 1. On average the reproductive period of the cow starts in year 4, with some cows giving birth in year 3 and a larger proportion as late as in year 5; this distribution is reflected in the table. The average number of calves per cow is approximately 3.5, with an average calving interval of 1.6 years. The weight gain becomes close to zero from year 7 onward.

3.2. Prices, values, and indicators

The prices refer to the average prices during 1990. The price for milk in the provincial capital, Mongu, was 10 K/liter, but in rural areas the price was substantially lower, so an average price of 5 K/liter has been used to value the milk.[1] Most of the milk is consumed by the household or exchanged in the community, but an estimated 25% of the milk is sold for cash. Purchased inputs refer to veterinary drugs and medicines sold by the Western Province Cooperative Union. There is no market for manure, so the value of manure has been estimated as the total price of an amount of fertilizer with equivalent nutrient components. This is a conservative estimate, as crops on the sandy soils benefit from the organic matter as well. In a more commercially oriented situation in Kenya, Lekasi et al. (1998) found that the market value of manure was about five times

[1] Kwacha, the currency unit in Zambia; the average rate of exchange in 1990 was K 29 = US$1.

Table 1
Cattle in the Western Province, average production data of one cow over a lifetime of 15 years

Type	Unit	Year														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Recurrent production																
Milk[a]	Liter	0	0	24	108	133	133	133	112	53	14	0	0	0	0	0
Manure[b]	Ton	0.10	0.15	0.18	0.21	0.23	0.24	0.24	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Calves	Head	0	0	0.12	0.53	0.65	0.65	0.65	0.55	0.26	0.07	0	0	0	0	0
Embodied production																
Weight gain	Kg	109	60	40	28	19	13	8	6	5	2	0	0	0	0	0
Bodyweight end year	Kg	109	169	209	237	256	269	277	283	288	290	290	290	290	290	290
Recurrent purchased inputs																
All[c]	K	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Household's production factors																
Land[d]	Ha															
Labor	Md	6	4	8	10	10	10	10	10	4	4	4	4	4	4	4
Capital[e]	K	813	1,946	2,646	3,122	3,451	3,675	3,822	3,920	3,997	4,046	4,060	4,060	4,060	4,060	4,060

[a]Milk production for human consumption.
[b]The quantity of manure dropped in the kraal.
[c]The value of all purchased inputs together is given in Kwacha. The average exchange rate in 1990 was US$1 = K 29.
[d]Free access to natural pasture.
[e]The average value over the year.

the value of the equivalent nutrients in fertilizer. Productive cows are generally not sold, as a cattle keeper will exchange such a cow for an ox from another cattle keeper if cash is required. As a result, no prices were available for cows in the reproductive phase, and in this analysis the price of a cow is based on the farm gate price of 14 K/kg live weight paid for slaughter animals by iterant traders (Table 2). The net recurrent cash income from a milked cow is small, around 150 K (US$5) annually. The recurrent income in kind during the productive period was equivalent to 31 kg of maize in year 3, 118 kg in year 5, and to 17 kg from year 11 onward. The annual added value reached 1,063 K in year 5 and thereafter dwindled to close to 75 K (US$2.6).

3.3. Benefits in insurance, financing, and status display

The Zambezi floodplain, where most of the cattle in Western Province are kept, is marginally suitable for crop production. In average-to-good years the production of maize and millet might just be sufficient to meet the household's consumption requirements, but in years with below average rainfall, staple food must be purchased. In these circumstances cattle form the major insurance against famine, as there is no formal insurance. A factor of 0.05 to 0.10 would reflect a range of relatively favorable to unfavorable local circumstances.

Most of the cattle keepers had no access to financial institutions, and even if they had had access to one of the two banks in the provincial capital Mongu, a savings account would have been unattractive as interest rates on savings were negative in real terms due to inflation. In principle, it is possible to store wealth in the form of maize, but rodents and pests take a heavy toll. In these circumstances the most attractive option in financing is to keep animals until a substantial amount of cash is required (Moll and Dietvorst, 1999). A benefit factor of 0.10 has been taken to reflect the unattractive potential alternative modes of financing.

Cattle offer a major opportunity to express status in the rural communities, and people are known for the size of their herd. A benefit factor of 0.03 has been taken to value the status aspect. The benefits in insurance, financing, and status display are shown in Table 3.

Table 2
The prices and values of the average production of one cow over its lifetime in the Western Province

	Price	Year														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Net recurrent cash income																
Milk, 25% sold	5 K/liter	0	0	30	135	166	166	166	140	66	18	0	0	0	0	0
Purchased inputs (K)		20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Total (K)		−20	−20	10	115	146	146	146	120	46	−3	−20	−20	−20	−20	−20
Recurrent income in kind																
Milk, 75% consumed	5 K/liter	0	0	90	405	499	499	499	420	199	53	0	0	0	0	0
Manure	380 K/t	38	57	68	80	87	91	91	95	95	95	95	95	95	95	95
Calves[a]	100 K/h	0	0	12	53	65	65	65	55	26	7	0	0	0	0	0
Total (K)		38	57	170	538	651	655	655	570	320	155	95	95	95	95	95
Gross margin																
Value embodied prod.	14 K/kg	1,526	840	560	392	266	182	112	84	70	28	0	0	0	0	0
Total (K)		1,544	877	740	1,045	1,063	983	913	774	436	180	75	75	75	75	75
Additional indicator																
Sale price end year (K)		1,526	2,366	2,926	3,318	3,584	3,766	3,878	3,962	4,032	4,060	4,060	4,060	4,060	4,060	4,060

[a]Estimated price, calves are not sold.

3.4. Analysis

Having valued the physical production and estimated the benefits in insurance, financing, and status display, the total benefit of a cow can be expressed in the two indicators: the benefit derived from keeping a cow per year; and, the benefit of selling the animal at the end of the year, Table 4. The benefit derived from keeping an animal declines after the reproductive period, but due to the benefits in insurance and status display it does not become negligible. The mere fact of having an animal thus results in benefits.

In Table 5 the benefits derived from a cow over its lifetime are compared with the resources used. The value of the natural grassland used for cattle can be set at zero, as there are no alternative types of land use and there is sufficient grazing area for herd expansion. Cattle keeping is the major economic enterprise for the majority of the population in the Western Province and alternative uses for the total capital embodied in the provincial herd are not present. Neither are financial institutions present that offer a prospect of real positive interest rates in combination with acceptable transaction cost. For these reasons the average opportunity costs of capital invested in cattle are set to zero. The benefits can thus be attributed to the remaining resource: labor. The return from keeping a cow ranges from 106 to 222 K/manday from year 3 onward. To this must be added the benefit obtained when the animal is sold sometime within the period of 15 years. This return to labor per day is substantially above the return to labor from crop production, which has been estimated

Table 3
The benefits in insurance, financing, and status display of one cow over its lifetime in the Western Province (Kwacha)

Benefits	Benefit factor[a]	Year														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Insurance	0.10	81	195	265	312	345	368	382	392	400	405	406	406	406	406	406
Financing[b]	0.10	153	237	293	332	358	377	388	396	403	406	406	406	406	406	406
Status display	0.03	24	58	79	94	104	110	115	118	120	121	122	122	122	122	122

[a]See text.
[b]Benefit in case of sale.

Table 4
Benefits of keeping a cow and selling a cow in the Western Province (Kwacha)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Benefit keeping per year															
Net recurrent cash income	−20	−20	10	115	146	146	146	120	46	−3	−20	−20	−20	−20	−20
Recurrent income in kind	38	57	170	538	651	655	655	570	320	155	95	95	95	95	95
Benefit insurance	81	195	265	312	345	368	382	392	400	405	406	406	406	406	406
Benefit status display	24	58	79	94	104	110	115	118	120	121	122	122	122	122	122
Total	123	290	524	1,059	1,246	1,279	1,298	1,200	886	678	603	603	603	603	603
Benefit if sold end year															
Sale price end year	1,526	2,366	2,926	3,318	3,584	3,766	3,878	3,962	4,032	4,060	4,060	4,060	4,060	4,060	4,060
Benefit financing	153	237	293	332	358	377	388	396	403	406	406	406	406	406	0
Total	1,679	2,603	3,219	3,650	3,942	4,143	4,266	4,358	4,435	4,466	4,466	4,466	4,466	4,466	4,060

[a]After the animal has been kept for 15 years it must be sold at the end of the year; no additional benefit in financing is obtained in this case, as the moment of sale is not a matter of free choice.

at 20 K/manday (Mwafulirwa and Moll, 1991). The major economic enterprises for the rural households in the Western Province are cattle husbandry and crop production, and keeping a cow, with a milk production around 100 liters/year during her reproductive period, is thus an attractive enterprise. This is due to the combination of physical production and the benefits in terms of insurance, financing, and status.

The inclusion in the analysis of these intangible benefits has consequences for the decision to sell an animal as it affects both the benefit from selling an animal and the net present value of future production (Fig. 3). The lines a, b, and c represent the net present values of future production from the years indicated until the end of year 15, inclusive of the sale of the animal at the end of year 15. A discount rate of 0.10 represents the time preference. Because this analysis is based on average production data, mortality is not included. Inclusion would not change the analysis as the salvage value does not deviate substantially from the live weight value in the Western Province. Line a depicts a situation in which the benefits in insurance and status display are not relevant (b^s and b^p are both 0.00). Line b represents the present value of total future benefits in a low-risk situation with benefit factors for insurance and status display of 0.05 and 0.03 respectively. A higher risk situation is depicted by line c with a benefit factor for insurance of 0.10. The lines d and e depict the total benefit of selling an animal during the year, with benefit factors for financing of 0.00 and 0.10, respectively. Lines d and a show a hypothetical situation with fully functioning markets for insurance, financing, and status display (benefit factors all 0.00). The sale of an animal should be considered around

Table 5
Keeping a cow in the Western Province, the benefits and resources used over its lifetime

	Unit	Year														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Benefit of keeping per year	K	123	290	524	1,059	1,246	1,279	1,298	1,200	886	678	603	603	603	603	603
Benefit if sold end year	K	1,679	2,603	3,219	3,650	3,942	4,143	4,266	4,358	4,435	4,466	4,466	4,466	4,466	4,466	4,060
Resources in use per year																
Land[a]	Ha															
Labor	Manday	6	4	8	10	10	10	10	10	4	4	4	4	4	4	4
Capital	K	813	1,946	2,646	3,122	3,451	3,675	3,822	3,920	3,997	4,046	4,060	4,060	4,060	4,060	4,060
Return to labor	K/manday	21	73	66	106	125	128	130	120	222	170	151	151	151	151	151

[a]Free access to natural pasture.

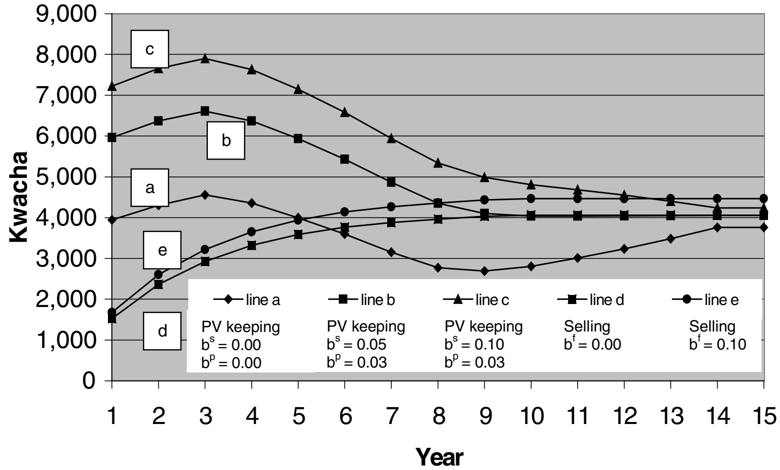

Fig. 3. Comparison of the sale value of a cow with the present value (PV) of keeping a cow, taking into account benefits for insurance, financing, and status display.

year 6, as the sale price (line d) rises above the present value of future production (line a). The combination of line e with lines b and c reflects the situation in the Western Province. The combination of lines e and b represents low-risk situation, and the combination of line e with line c represents the high-risk situation with sales around year 12. The three combinations show that with increasing importance of insurance, the moment of sale shifts toward the end of the lifetime of the animal.

Cows older than 11 years account for only 2% of the female animals in the Western Province and this indicates that lines e and c reflect the perspective of cattle keepers in an extreme situation, with high risk leading to substantial benefits of cattle in insurance.

Fig. 3 shows that the overall effect of the inclusion of the benefits for insurance, financing, and status is that the value of keeping animals increases relative to the value of selling animals. This finding is in line with the discussion by Low (1986) on the reasons for keeping and selling cattle in the context of nonmarket benefits of cattle ownership in Southern Africa. It also shows the limitations of herd simulation models that just focus on the interaction between herd size, herd composition, and voluntary dispatch.

This analysis of cattle at herd level in the Western Province would show the existence of herds with older animals than would be expected on the basis of an optimal physical production. In other situations, where total fodder availability is the limiting factor, these older animals compete with animals in the prime of physical production, the result being a total physical production below what is theoretically possible from the available fodder resources. Zemmelink (1995) did research in such a situation in East Java and compared total feed resources with the total herd of ruminants. He found that the total herd was substantially larger than the optimum size for physical production, and concluded that this could only be explained by taking into account the benefits from the insurance function. In East Java, and under similar circumstances, there is thus a trade-off between the benefits from physical production and the benefits from insurance, and status.

4. Discussion and conclusions

The method to analyze livestock systems described and demonstrated above first enables a number of income indicators to be formulated that capture, quantify, and organize the various benefits of a livestock system. Some of the income indicators are based on current market prices and are largely valid for all livestock keepers. However, the indicators "income in kind" and the intangible benefits are related to household characteristics that may differ substantially, such as household composition and access to financial institutions. The identification of separate income indicators, that together capture total income, thus allows a focus on different groups of livestock keepers. Second, for the overall appraisal of the livestock system, the summation of the various income indicators is related to the costs of the system in terms of the household's production factors employed, thereby taking into account opportunity costs. Again, livestock keepers usually differ in factor endowments and the appraisal can accommodate the various options open to different groups.

The relative importance of the indicators will differ with the livestock systems under analysis and the presence or absence of markets for resources, production, and services. The cattle production analyzed in Section 3 took place in a situation with almost absent markets for resources and services, a rudimentary market for milk, and with a functioning market for slaughter animals. The case reflects an extreme, but not uncommon, situation of restricted access to markets. In more market-oriented systems, such as dairy production near urban areas, the importance of the net recurrent cash income will be more prominent and more visible. However, the linkages with crop production (recurrent income in kind) and the benefits in financing and insurance may still contribute substantially to the total benefit of the system. Additionally, in more market-oriented livestock systems the household's production factors—labor, land and possibly also capital—usually have alternative opportunities in agricultural and nonagricultural enterprises that generally have clearly identifiable types of income. The application of the comprehensive appraisal of costs and benefits of livestock systems is therefore justified in a wide range of circumstances.

The inclusion of the markets for resources, production, and services in the analysis of livestock systems enables researchers and policy makers to assess these systems more closely from the viewpoint of the livestock keepers. This is highly relevant for the development of effective livestock policies, because livestock keepers will assess all proposed changes in the production system in the context of their objectives, factor endowment, and institutional environment.

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