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Economic Evaluation of Smallholder Subsistence Livestock Production: Lessons from an Ethiopian Goat Development Program

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SUMMARY

Conventional productivity evaluation criteria are inadequate to evaluate subsistence livestock production, because 1) they fail to capture non-marketable benefits of the livestock, and 2) the core concept of a single limiting input is inappropriate to subsistence production, as multiple limiting inputs (livestock, labour, and land) are involved in the production process. As many of the livestock functions as possible (physical and socio-economic) should be aggregated into monetary values and related to the resources used, irrespective of whether these "products" are marketed, home-consumed or maintained for later use. A broad evaluation model involving three complementary flock-level productivity indices was applied to evaluate subsistence goat production in eastern Ethiopian highlands. The results showed that indigenous goat flocks generated significantly higher net benefits under improved than under traditional management, which challenges the prevailing notion in countries like Ethiopia that indigenous livestock do not adequately respond to improvements in the level of management. It is then concluded that the evaluation model not only allows a broad aggregation of benefits from subsistence livestock, but also provides a more realistic platform to propose sound improvement interventions.

Keywords: Evaluation, indigenous animal genetic resources, Unit Net Benefits

NON TECHNICAL SUMMARY

An aggregated productivity model involving three complementary flock-level productivity indices was developed to evaluate subsistence goat production in the eastern Ethiopian highlands. Results show indigenous goat flocks generated significantly higher net benefits under improved than under traditional management, which challenges the prevailing notion that indigenous livestock do not adequately respond to improvements in the level of management. Furthermore, it is shown that under the subsistence mode of production considered, the premise that crossbred goats are more productive and beneficial than the indigenous goats is wrong. The model thus provides a more realistic platform upon which to propose sound improvement interventions.

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1. Introduction

The vast majority of Farm Animal Genetic Resources is kept by smallholder farmers under traditional management systems. Unfortunately, improvement of these traditional production systems was too often taken to mean commercial level intensification of production to increase the output of marketable products (e.g. Delgado et al., 1999). Thus, the focus of development policies initiated in developing countries in the last century has been on the introduction of higher-yielding exotic breeds that were developed for high-input, comparatively benign production environments, where adaptive traits nearly play no role. This policy has certainly contributed to the erosion of local breeds adapted to the lower input mixed farming and pastoral production systems found throughout the developing world (ILRI, 1999).

The recognition of the need for sustainable development and conservation of these animal genetic resources demands methodologies for economic valuation, of which determining the actual economic importance of the breed is an important part (Drucker, et al., 2001).

Unlike market-oriented commercial farmers, subsistence livestock producers follow broad production objectives that are driven more by their immediate subsistence needs rather than demands of a market. While monetary returns are the driving force in a high-input and free-market economy, biological survival and established cultural traditions may define the essential values of a subsistence community (Ørskov and Viglizzo, 1994). An increasing wealth of evidence shows that subsistence agriculture follows low-input and risk-averse strategies, and the producers make rational decisions to maximize overall benefits from limiting resources, or in broader terms, to maximize total system output (de Ridder and Wagenaar, 1984, 1986; Cossins, 1985, Behnke, 1985, Scoones, 1992; Ørskov, 1993; Ørskov and Viglizzo, 1994). As a result it is not justified to base the economic evaluation of subsistence livestock production on the conventionally recognized (marketable) yield attributes, because the non-conventional utilities of subsistence livestock including manure, asset, security, traction, employment generation, farm integration and socio-cultural relevance can be as important depending on the value systems of communities. Because the reasons for keeping livestock, i.e., the breeding objectives, are economic rather than biological, evaluation of the production process should consider as many of their uses as possible (physical and socio-economic), and relate these aggregated benefits to the resources used.

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This paper proposes a concept for the economic evaluation of subsistence livestock production to capture the multiple utilities of livestock as well as the multiple limiting resources employed. It uses the smallholder goat production in eastern Ethiopian highlands as the example, where a Dairy Goat Development Programme (DGDP) had been implemented for nine years with the specific objective of improving the contribution of goats to household welfare. This model of aggregating net benefits is then applied to test the concept that indigenous goats can be made economically more rewarding to the smallholder farmers by improving traditional husbandry practices based on the experiences with the DGDP.

2. Materials and Methods

2.1 Conceptual framework

The concept of productivity indices is commonly applied to livestock production in characterising production operations, comparing or ranking alternative options of production and even measuring improvements. The term 'productivity' is generally defined as a ratio of output to input; it embodies a connotation of rate of production in which the scale of the rate can be set in terms of the resources utilized, including time. The numerator reflects the desired objective and the denominator the most limiting constraint (Spedding *et al*., 1981; Upton, 1989; de Leeuw, 1990). The time horizon of evaluation should capture major events of the production process; e.g., periods of seasonal body weight losses of animals in times of scarcity (Ørskov and Viglizzo, 1994).

In an economic evaluation of subsistence production all the reasons for raising the livestock (i.e., the breeding objectives) have to be accounted for, irrespective of whether the "products" are marketed, home consumed or maintained for later use (stock). For analytical purposes the multiple roles of livestock, in this case goats can be categorized from the perspective of functions into physical, socio-economic and socio-cultural (Jahnke, 1982; Devendra, 1992; Bosman and Moll, 1995). The evaluation then involves broad aggregation of the benefits that these functions generate. Such an aggregated benefit can be expressed either in monetary value (Behnke, 1985), in dietary energy equivalents (Upton, 1985), or in a combination of monetary value for traded items and protein and energy values for subsistence produce (Cossins and Upton, 1987). However, for practical purposes, it is reasonable to accept Behnke's (1985) proposition of assigning monetary values to both subsistence and marketable products. Actual prices are taken for marketed products, and estimated prices are applied to subsistence transactions. The relevant seasonal market price to attach to home consumption is the price that farmers would have to pay if the produce were to be purchased (Kaufmann, 1998). The inputs applied for production can also be divided into two: the household resources of animals (capital), land and labour, and those inputs purchased from outside the household.

Following this concept of aggregate benefits, "meat" production has to include the net change in body weight of the flow and stock of goats in a given time, in buying and selling of the goats and in transferring them in and out of the flocks. Again the meat so produced can be sold, consumed, transferred or maintained. Meat in these communities is, therefore, not only a product for home consumption or sale, but also a medium of frequent value transaction. The monetary value of the meat can be estimated by applying the average current market prices of inward transfer (purchase, transfers), outward transfers (sales, slaughters, transfers) and average stock (net inventory). The hidden costs of mortality, morbidity (weight loss, reduced production) and other losses (predator,

theft, etc.) are accounted for when the aggregation is done at the flock level for a specific observation period. Obviously, the quantified benefit from "meat" production can well be negative.

The benefits from milk production come in the form of milk off-take as well as growth of suckling young. Milk suckled by the offspring is accounted for in ´meat´ production. The milk consumed, marketed or preserved during the observation period can be quantified by multiplying estimated milk off-take by its current market price.

Goat manure, as is habitually applied to the soil, serves a vital input function to the subsistence farmers. However, the utility of manure has often not been considered in the calculation of the total benefits from livestock. This is perhaps because manure is not widely marketed, or there has not been a practical quantitative procedure to estimate the monetary value of manure. Because the influence of manure on soil is both in augmenting its chemical composition as well as in improving its physical structure (Stangel, 1995), it is theoretically possible to develop a two-stage valuation (Ayalew, 2000). First key soluble nutrients in manure are selected to relate with same nutrients in commonly applied inorganic fertilizers; then the composition and solubility of the same nutrients in manure are estimated from available empirical evidence to establish the chemical equivalence of manure with the inorganic fertilizers with respect to the selected nutrients (Tisdale *et al*., 1985; Fernández-Rivera *et al*., 1995; Somda *et al*., 1995; Schlecht *et al*., 1997). Secondly the contribution of manure to soil physical properties is estimated from known residual effects that relate to improved water holding capacity, pH etc. as well as slower release of nutrients (Onim *et al*., 1990; Williams *et al*., 1995). Such an indirect valuation of manure makes it possible to estimate the benefits from manure along with meat and milk.

As subsistence goats are a low-cost and inflation-proof alternative of saving, their value provides asset (financing) and security (insurance) benefits at times of difficulty. They help to adjust the consumption and savings of the household's income over time, by balancing the current cash needs against anticipated or unexpected cash needs of the future (Jahnke, 1982; Winrock, 1992; Sansoucy *et al.*, 1995). These socio-economic benefits effectively increase a household's income and improve its purchasing power, thereby providing further economic stability to the household economy. The financing benefits can be estimated based on the concept proposed by Bosman and Moll (1995) that in a subsistence economy the opportunity of using the value in animals for specific purposes at the desired time without having to pay in the form of interest rate or insurance premium confers measurable benefits. Hence, the benefit in financing during an observation period is calculated as a product of the monetary value of flock outflow (slaughter, sales, outward transfer), and the financing factor of the study area, estimated from the opportunity cost of credit. In the present study, the cost of alternative sources of credit was estimated by the current interest rates of the formal credit market (10%), although formal credit was effectively not available to the subsistence farmers. The informal credit market operates without stated interest rates, and the calculated working interest rates were very variable (Ayalew, 2000). The insurance (security) benefit can be estimated by assuming that the whole stock is available to provide household security through liquidation at any one time when the need arises (Bosman and Moll, 1995). It is quantified as a product of the insurance factor (estimated from the opportunity cost of insurance) and the monetary value of the annualised current stock (weighted average body weight of the whole flock). The opportunity cost of insurance was estimated from the informal insurance market (8.25%), because none of the

study households bought insurance from the formal market during the study period. Details are discussed elsewhere (Ayalew, 2000).

There are also other relevant socio-economic and socio-cultural roles of goat, namely provision of employment opportunities for otherwise low-opportunity cost household labour, integration and resource use (land, labour, feeds) and fulfilment of various socio-cultural obligations of their owners (Jahnke, 1982; Steinfeld, 1988), which are not accounted for in this study.

Under subsistence production of, for instance, Ethiopian highlands, it is not always realistic to select one limiting input to constitute the denominator of the productivity index, when all the major factors of production (land, labour, livestock) are commonly used for several production functions (Ruthenberg, 1980). Land is a critical resource in the densely populated highlands with an average holding of cultivated land of just under half a hectare. The opportunity costs of labour of especially smaller children and those who are unable to help in other farm operations may be low or zero (Ørskov and Viglizzo, 1994), but the labour input of women and elderly children is shared with other habitual duties. As it would be difficult under these conditions to put a market value on the labour cost, the absolute amount of labour time can be estimated and standardized on the scale of Labour Equivalent (LE) to account for differences in age and sex (Abdulahi, 1990). The reasoning behind using the animal itself as the limiting input is its consumption of feed and other inputs. Because of the difficulty of quantifying total feed input under extensive production, the total maintenance energy requirement can be indirectly estimated from the metabolic body size of the animals (Morand-Fehr, 1981; Schmidt-Nielson, 1984). These arguments led to the simultaneous application of three productivity indices in relating aggregated net benefits to the three factors of production (land, labour and animals).

Total physical net production is arrived at as the sum of net ´meat´ production, value of milk off-take and value of manure. Purchased external inputs are accounted for using the technique of Value Added: deducting the sum of external inputs from total physical net production yields the Value Added of flocks. The net benefits realised from raising goats during the observation period are then calculated as the sum of Value Added of flocks, benefit from financing and benefit from insurance. These are then divided by the size of cultivated land, or the estimated household labour input in hours, or the metabolic body size of the average flock, to arrive at the three indices of Unit Net Benefits from the flocks for the resources employed.

2.2 Study area and experimental flocks

This model was applied to evaluate a goat development project in Ethiopia (Ayalew, 2000). The Dairy Goat Development Programme (DGDP) had been implemented between 1989 and 1997 in selected sites of Ethiopian highlands to improve overall household welfare through improved management and crossbreeding of indigenous goats with imported Anglo-Nubian goats. The basis for introducing exotic breeds of goats for crossbreeding has been the general prejudgment that indigenous goats do not adequately respond to improvements in level of management, which can be tested by comparing the overall contribution of goats under the improved and the traditional management.

The study was conducted in the highland agricultural districts of Gursum and Kombolcha in eastern Ethiopia. A total of 33 traditional and 29 improved flocks were used. The overall annualised flock size of these households was 3.0 goats. The control (traditional) flocks were sampled from adjacent villages. Improved management was taken to mean the actual level of care provided by those households who had participated in the DGDP for at least 5 years and received indigenous goats on credit. These farmers were introduced to, and assisted in, improved feeding, basic health care and controlled breeding practices promoted in the DGDP technology package. Some of these households went further to receive crossbred goats, but these were not considered in this paper.

Data was collected on the management, performance and utility of 185 indigenous goats (95 under traditional, 90 under improved management) during the one-year observation period from July 1998. Purchased external inputs were recorded. The three major inputs (goats, labour and land) were also accounted for at flock level, and the corresponding three flock level unit net benefits were quantified as measures of aggregate benefits. There were no significant differences between the study groups in average family size, holdings of cultivated land, total livestock holdings (TLU) annualised flock size and total number of goat-days. The slight differences in the initial goat flock sizes at the start of the study period disappeared later as the annualised average flock sizes stabilised.

A fixed linear model of SAS (1989) was used to represent the variation in unit net benefits between the improved and the traditional management. Management and district were considered as fixed effects. The stratum of management (weak, medium, strong) was included as a nested fixed effect within the improved and traditional management.

3. Results

The improved management of indigenous goats resulted in a significantly ($p < 0.05$) higher composite productivity on land and labour than those under traditional management: the added net benefits generated were 80% higher per unit of land and 73% higher per hour of labour input (Table 1). Furthermore, farmers in Kombolcha district generally produced 60% and 51% higher net benefits per unit of land and labour, respectively, than those in Gursum district. This was explained by the relative land scarcity in Kombolcha, and the general association of higher productivity with declining land holdings (Ayalew, 2000).

[Table 1]

Average holdings of cultivated land were 51% less in Kombolcha than they were in Gursum; at the same time farmers in Gursum spent 28% longer time on goat husbandry than those in Kombolcha, with the result that the average labour input per kg body weight of the average flock was significantly ($P < 0.05$) higher in Gursum. The goat enterprise being a low-input and labour intensive economic activity, 63% of its total labour input went to feeding, including grazing (Ayalew et al., 2000). When land is scarce as in Kombolcha, more of household labour appears to be used in other income-generating activities including petty trading and engagement in casual labour. Thus farmers in Kombolcha tend to spend less time on goat husbandry, but for the actual labour spent they generated more unit net benefits per unit of land and labour. The study also showed that more labour is spent on crossbred than indigenous goats, and because farmers in Kombolcha generally had less time for goat

husbandry, the indigenous goats proved to be more beneficial than crossbred goats under the improved management (Ayalew, 2000).

The non-significance of differences on net benefits per unit metabolic body weight of the average flock can be explained by the fact that this parameter measures biological productivity and that the genetic constitution of flocks in the improved and traditional flocks is essentially similar. The improved management produced higher benefits from a larger biomass.

The differences in unit net benefits mainly came from the markedly higher meat production under improved management (Table 2). Value of gross meat output represented 60% and 45% respectively of total physical production for the improved and traditional management (Figure 1). This higher production was partly because of the greater number of goats sold and kids born. Besides, there was a significantly larger flock size (stock) at the end of the study. Similarly, improved management appeared to have produced higher net body weight gains and reduced total losses over the year, though the differences were not statistically significant (Table 2). Improved flocks have received less number of goats by way of in-ward transfer, but they have gained by giving out more goats in temporary transfer to invest in their social relations. The slaughter rates were nearly equal with those of the controls. They purchased larger number of goats, but that was compensated by greater sales rates. Yet by taking advantage of changing prices, these households had opportunities to generate higher benefits.

[Table 2]

[Figure 1]

The traditional flocks lost about 29.4% of the average flock size in the form of death (due to disease, snake bite, plant poisoning) and predator attack, compared to 15.5% in the households with improved management. The losses due to predators, plant poisoning and snakebite relate to the significantly higher frequency of free grazing practiced throughout the year in the traditional households. Following recommendation of the DGDP, the improved flocks tended to practice more of tethered management by feeding goats around homestead.

There is, therefore, sufficient evidence to accept the hypothesis that indigenous goats maintained under improved management generate higher net benefits per unit of cultivated land and labour used, but not per unit of metabolic body weight of the average flock.

4. Discussion

The paper demonstrates that the concept of productivity can be adapted and applied to subsistence and market-oriented smallholder livestock production. The economic evaluation captured many of the realised benefits by at the same time accounting for the inputs that went into the production process. As the subsistence producers raise the animals mainly to meet their subsistence needs, and the individual products are often consumed, transferred or marketed, it would be inaccurate to project the economic value of the breed by estimating the expected revenue from marketable products alone, for instance in the market share procedure for estimating the economic value of a breed (Drucker et al., 2001).

The relative contribution of the physical products to the benefits revealed the comparatively high importance of meat and manure, which made up 57 and 33% of the benefits in the improved management and 45 and 44 % of the benefits in traditional management, respectively. The focus of the DGDP on dairy improvement did not lead to expected results, because milk even in improved mixed flocks of indigenous and crossbred goats constituted only 10 % of the marketable physical output. In recognition of this, the DGDP relaxed its emphasis on milk at a later stage of its implementation and promoted 'meat' as well. Interest on manure has always been low (Ayalew, 2000).

The application of the concept of unit net benefits showed that the indigenous goats responded significantly to improved management attainable at the level of smallholder farmers. This challenges the prevailing notion in countries like Ethiopia that indigenous livestock do not adequately respond to improvements in the level of management. The improvements in the level of care resulted in maintaining more goats per unit of land or labour used and produced greater unit net benefits in a given time. These improvements were made horizontally (by keeping more animals) and not vertically (from fewer animals). The added benefits were brought about by a combination of larger stock, higher off-take, reduced losses, higher net weight gains, and hence greater physical output. The additional external costs were accounted for in determining the net benefits. However, the sum of purchased external inputs incurred in the improved management was very small, and this was not significantly different from that of the traditional management, which is typical of the subsistence mode of production (Doppler, 1991; Schiere, 1995).

The improvement in management constituted of better feeding practices and greater attention to basic health care, that the DGDP participant households maintained after the DGDP phased out. The merit of improved level of care to goats is not disputed; previous work in Ethiopia (Galal and Awgichew, 1981; Abebe, 1996; Berhanu, 1997) or elsewhere (Devendra and Burns, 1983; Laes-Fettback, 1989); showed that goats respond to improvements in nutrition and health care. In a similar comparative study in Brazil, Padhila *et al*. (1980) reported that improved health care, feeding and housing resulted in increased reproductive performance and reduced mortality of indigenous goats under traditional management, and that improved health care was the most rewarding of the improvements.

Another part of the study revealed that the crossbred (indigenous x Anglo-Nubian) goats did not produce any more unit net benefits than did the indigenous goats, which is discussed in detail in a related forthcoming paper. The results indicate that, under subsistence mode of production, the premise in many donor-funded as well as regular rural development programmes that crossbreds are more productive and beneficial than the indigenous animals, might be often wrong. The evidence of superiority might have been based on a calculation of benefits, which had not been adjusted to smallholder conditions. Adding the additional costs of procuring the exotic animals, and the difficulties of maintaining the necessary stock of breeding animals to produce the crossbreds, the indigenous goats become even more worthwhile to the farmers. This stands without accounting for the societal level values of the indigenous animal genetic resources that relate to adaptation in the ubiquitous high risk and low external input agriculture typical of countries like Ethiopia, the existence value of the genetic diversity in individual breeds, which accounts for 30 to 50% of the total genetic variability in animal genetic

resource as well as the socio-cultural values associated with the breeds (Hammond and Leitch, 1999; Drucker et al., 2001).

The need for setting the evaluation at the flock level cannot be sufficiently emphasised, particularly when another breed is involved. Seasonal body weight losses of animals, which were accounted for in the calculation of the net benefits, often portray a negative image of the smallholder producers. But the fact that animals gradually lose part of the weight gained during the lush season to survive the long dry season is actually a biologically useful attribute that helps the smallholders to cope up with times of scarcity (Ørskov and Viglizzo, 1994). The consequences of feed inadequacy for the indigenous goats may not go beyond some live-weight loss, but introduced crossbreds (particularly non-F1 crosses) also suffer substantial loss of fertility, and hence the decline in the longer-term overall production. For instance in the present study, breeding crossbred does gave birth to an average of 0.62 viable kids per doe, compared to 0.75 for the local does over the one-year observation period. Such adaptive features of indigenous animals continue to be relevant even when additional labour and land resources are allocated to increase their contribution to household welfare, as demonstrated in the DGDP.

A logical extension of findings of this study is then the conceptualisation of sustainable improvement of indigenous livestock under subsistence mode of production. Working under the concept of unit net benefits developed in this study, improvements should be guided by the actual production objectives, in other words the aggregate benefits that accrue to the ultimate beneficiaries. The composition of the aggregated benefits (Figure 1) suggests that improvements in output of meat and manure could have greater impact on overall benefits than milk, or asset. As alluded to earlier in the broader definition of meat adopted in this study, these components of benefits are more appropriately evaluated at the level of the whole flock rather than at the level of individual animals. At the trait level, adaptation, viability and reproduction have strategic importance as they relate to all the physical outputs, and through these, to socio-economic benefits.

A major challenge to sustainable development of these livestock is the setting up and organization of long-term genetic improvement based on the economically important flock attributes. However, a more critical limitation is the poor control of the breeding process: genetic selection requires that the breeding process be fairly controlled at least through use of selected breeding bucks and retaining of superior breeding females. Patterns in flock dynamics suggest that the improved management did not exert any more control in breeding over that of the traditional management. With virtually no performance or pedigree records, the farmers do not have the means to acquire goats based on their genetic merit any more than can be established by way of visual appraisal. Two-thirds of the off-take (sales, slaughter, outward-transfer) records were observed to have been undertaken to meet immediate subsistence needs. The demand-driven rapid turn over of goats with an average stay of only 212 days per year and the small flock size clearly limits the scope for genetic selection. A practical short-term strategy would be to reduce the various losses in benefits in the form of mortality as well as morbidity (and associated body weight losses as well as reduced production), and to promote livestock marketing. The presence of a relatively large follower (replacement) flock that competes for feed and labour with reproducing females reduces the overall benefits. Availability of attractive market for livestock and livestock products could gradually transform the production process from one of subsistence to a market-oriented system, in which case producers would get the incentive to invest on improving output of desirable products.

The simultaneous application of multiple productivity indicators related to the key resources allowed to capture the interaction between land and labour in one of the districts without limiting depth of analysis on each of the inputs. Furthermore, association of the differences in unit net benefits with the resource endowments of the districts highlights the need for making location-specific valuation and improvement of animal genetic resources.

5. Conclusion

Unlike market-oriented commercial farmers, subsistence livestock producers follow broad production objectives that are driven more by their immediate subsistence needs rather than demands of a market. The conventional approach of evaluating subsistence livestock production based only on the common marketable yield attributes is inadequate, because these alone do not constitute the reasons for keeping the livestock. Not only that the evaluation should capture as much of the realised benefits as possible, but also the multiple limiting inputs that went into the production process should be accounted for. As demonstrated in this study, the concept of productivity can be adapted and applied to subsistence and market-oriented smallholder livestock production. This requires that the total system output should be aggregated from both physical (meat, milk, manure) as well as quantifiable socio-economic (asset and security) benefits, and these are then related to purchased external inputs as well as the major household resources of land, labour and livestock employed to generate the benefits. The resultant indices, referred to as Unit Net Benefits, can be applied to compare alternative production operations, or to measure the impact of improvement interventions.

When this evaluation model was applied, not only that a broad aggregation was made of the benefits from the indigenous goats, but the model also provided a more realistic platform to propose appropriate improvements for traditional subsistence livestock production system. Ideally, such an evaluation of the indigenous livestock genetic resources should also take account of the potential future uses of the resources and the societal level benefits emanating from maintaining the genetic diversity.

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Table 1: Composite productivity indices on land, metabolic body weight of average flock and labour input of indigenous goats under improved and traditional management - least squares means (standard errors)

Descriptors	Net benefits (Birr*) per unit of		
	Land holding Birr/*Timad*** of land	Metabolic weight of average flock Birr/kg $^{0.75}$	Labour input Birr/hr of labour
Study groups:			
Improved	91.7 (13.6)	7.9 (1.5)	0.20 (0.03)
Traditional	51.0 (8.0)	5.6 (0.9)	0.11 (0.02)
α***	0.01	0.20	0.03
Districts			
Kombolcha	87.9 (14.1)	7.1 (1.6)	0.19 (0.03)
Gursum	54.8 (7.0)	6.4 (0.8)	0.12 (0.02)
α***	0.04	0.72	0.06

* Birr = Local currency (1US$ = Birr7.50 in June 1999).

***Timad* = Local unit of land, equivalent to one eighth of a hectare.

***$\alpha = P \mid (\mu_1 - \mu_2 \neq 0)\mid$

Table 2: Composition of gross output and aggregate benefits between study groups (in Birr)

Components	Improved management	Traditional management
Physical products		
Meat	138.8[a]	61.6[b]
Milk	20.7[a]	15.4[a]
Manure	71.6[a]	59.4[b]
Sub-totals	231.1[a]	136.4[b]
External inputs	16.8[a]	12.0[a]
Value Added	214.3[a]	124.4[b]
Socio-economic		
Asset	12.8[a]	10.4[a]
Security	5.3[a]	4.3[a]
Sub-total	18.1[a]	14.7[a]
Total net benefits	232.4[a]	139.1[b]
Changes in stock		
Total stock outflow	127.7[a]	104.4[a]
Forced stock outflow	63.7[a]	63.3[a]
Net weight gain	27.1[a]	17.8[a]
Price of goat losses	16.2[a]	35.8[a]

NB: Within rows, least squares means values of components with different superscripts are significantly different at $p < 0.05$ on a t-test.

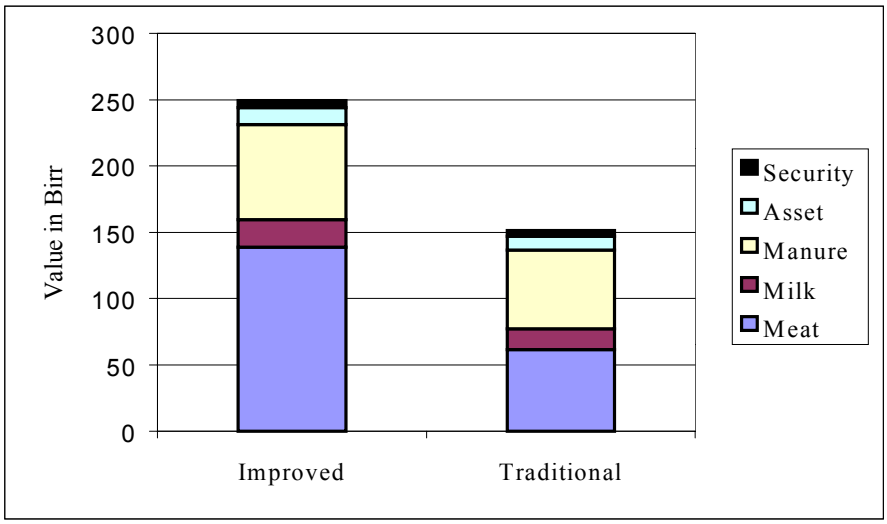

Figure 1: Comparison of benefits from indigenous goat flocks between improved and traditional management

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(xxxvii) This paper was presented at the Fourth Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei, CORE of Louvain-la-Neuve and GREQAM of Marseille, Aix-en-Provence, January 8-9, 1999

(xxxviii) This paper was presented at the International Conference on "Trade and Competition in the WTO and Beyond" organised by the Fondazione Eni Enrico Mattei and the Department of International Studies of the University of Padua, Venice, December 4-5, 1998

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(xl) This paper was presented at the conference on "Distributional and Behavioral Effects of Environmental Policy" jointly organised by the National Bureau of Economic Research and Fondazione Eni Enrico Mattei, Milan, June 11-12, 1999

(xli) This paper was presented at the Fifth Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CODE, Universitat Autonoma de Barcelona, Barcelona January 21-22, 2000

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(xlvi) This paper was presented at the Sixth Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Louvain-la-Neuve, Belgium, January 26-27, 2001

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