A Socio-Economic Analysis of Technology Adoption in an African Livestock Industry

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ABSTRACT

The study examines the Tanzanian livestock industry to explain low levels of improved management and commercial sales. Level of technology adoption and two perceived economic values by producers are estimated in 792 herds. Communal grazing and depressed government regulated prices of cattle are determined as factors causing low levels of technology adoption.

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INTRODUCTION

The rising demand for food in the Less Developed Countries (LDC's) increases the responsibility for these governments to achieve self-sufficiency in agricultural production as a prerequisite for economic growth[1]. Agricultural policies are important in creating producer incentives to expand commercial production as well as in removing bottlenecks in the marketing system[2]. To be effective, government policies for increasing commercial production of foodstuffs must take into account the economic and sociological conditions under which small scale producers operate.

In many of the major livestock areas of Africa, for example, Mali, Niger, Ethiopia, Kenya, Botswana, and Tanzania, production systems are similar with communal grazing of livestock and the structure of the industry being mainly subsistence type small herds operating at low levels of productivity[9]. The role of cattle in the lifestyle of African livestock owners is complex, involving both economic and sociological factors which affect the rate of adoption and commercialization of producer's herds[3].

The objective of this study is to examine the livestock industry in Tanzania as typical of African livestock production systems to determine the level and effect of improved livestock management on commercial sales and suggest some approaches for increasing adoption of technology and the supply of meat.

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The Tanzanian Case.

The livestock industry in Tanzania has the potential, with approximately 11 million head of cattle, to supply not only its own domestic meat requirements, but also that of the surrounding meat-deficit countries of Uganda, Zambia and Zaire as well as the opportunity to export canned beef to countries in the European Economic Community (EEC). Despite this potential, the cattle industry remains underutilized and inefficient, characterized by low productivity, high mortality and low commercial offtake. Only minimal benefits are being received by the non-livestock sector.[1]

Current government livestock development plans emphasize subsidized livestock improvement, e.g. veterinarian services, dips, and water facilities based on the assumption that producers will readily adopt improved practices, become better managers and more market oriented. Specifically, this study attempts to: first, measure technology adoption in Tanzanian herds; second, test the relationship of technology adoption with herd size, family size and age of respondent; and third, test market incentives for technology adoption and commercial sales.

METHODOLOGY

To measure the level of technology adoption (level of improved management) for 792 livestock producers field surveyed in 1975, an adoption quotient index is developed to score each respondent on the number of selected practices adopted out of the total potentially available to him.[2] The twenty-two livestock management practices chosen are weighted by difficulty of adoption on a scale of 0-10 by seven individuals familiar with production and marketing conditions for livestock in Tanzania.[3]

$$A.Q.= \frac{\sum_{j=1}^{n} Y_j W_j D_j}{\sum_{j=1}^{n} W_j C_j} \times 100 \qquad (1)$$

where:

n = 22 improved livestock management practices judged important in increasing productivity and quality of herd.

Y_j = 0,1 variable for each n practice indicating whether j'th practice was adopted.

W_j = degree of difficulty in adoption of i'th practice, range 0-10.

D_j = coefficient indicating distance traveled to perform activity increases level of management.

C_j = 0, 1 variable indicating whether i'th practice is available for adoption. No penalty if not.

In equation 1, the adoption quotient scale has a relevant range from 0 to 100 with 100 indicating adoption of all available improved practices.

Because of the strong dependence upon livestock for family subsistence, adoption of improved management practices is analyzed in the context of the economic value which the livestock owner perceives from his herd. Two value systems are assumed perceived by all producers: a traditional value, valuing the cattle in terms of the family's dependence upon the herd for subsistence; and a commercial value, valuing cattle in the herd which can be sold for cash in the marketplace. The net difference between the two value systems is hypothesized to be important in understanding the producer's adoption of improved practices and his commercial orientation to the marketplace.

In Table 1, an expected annual traditional value (T.V.) is estimated on a per cow basis from the probability of obtaining milk and by-products

TABLE 1. ESTIMATED ANNUAL TRADITIONAL VALUE FOR A COW IN TANZANIA - A CONSTANT HERD INVENTORY, 1975

By-Product from Cow[a]	Annual Probability in Receiving By-Product[k]	Estimated Liveweight	Estimated Home Consumption	Litres of Milk/yr.	Home Consumption % Milk/yr.	Retail Value[d]	Unit Value/Cow	Expected Annual Value[f]
	(percent)	(kg)[b]	(kg)	(litres)[c]	(litres)	(TSH/kg)	(TSH)[e]	(TSH)
Meat	10	155	62	---	---	1.50	93.-	9.30
Milk	54[g]	---	---	570[h]	210[h]	1.-/ltr.	210.-	113.40
Bull Calf[i] (0-12 mo.)	21	---	---	---	---	no value	no value	no value
Meat from Bull Heifers-1-3 yrs.	4	100	40	---	---	1.50	60.-	2.40
Meat from Bull Heifers-3-5 yrs.	4	170	85	---	---	1.50	127.60	5.05
Sell Bull (over 5 yrs.)	17	250	---	---	---	1.55	387.50	65.88
Cull Cow[j]	10	185	---	---	---	1.50	277.50	27.75
TOTAL								223.78

a. Manure is not included since portion of respondents were semi-nomadic and did not place a value on this by-product. Calculated expected annual value was TSH 1.- for respondents farming.

b. Conversion to pounds is 1 kg = 2.2#.

c. Conversion to gallons is 4.2 litres = 1 gallon.

d. Retail value is the shadow price for product if purchased in market place.

e. Conversion rate to U.S. currency is Tsh. 8.50 = U.S. $1.00.

f. Expected annual value - (unit value/cow) x (annual probability in receiving by-product).

g. Derived from annual probability of cow living (90%) times annual probability cow with calf (60%).

h. Zebu cows produce approx. 570 litres/yr. Calf receives approx. 360 litres.[7]

i. Live bull calves produced per cow per year = .21 = .30 - [(.60)(.50)(.30)]. Probability of bull calf (50%), probability it will die before weaned (30%). Approximately 10 months to wean.

j. Assume all heifers retained as replacement stock, no direct value until they become cows.

k. Probabilities derived from field survey interviews. [8]

from a cow in a twelve month period. An economic value is assigned to each by-product in the form of an imputed price if the product had to be purchased in the marketplace. In equation 2, a traditional value for each respondent's herd is determined by the number of cows in the herd multiplied by the expected annual value per cow.

$$T.V. = \text{cows in herd} \times \text{Tsh.}223.13 \qquad (2)$$

If a social value for the status and prestige in keeping cattle is calculated and included, the traditional value for a herd would be even higher.

A commercial (market) value for a herd is based on the total number of bulls, steers, and cows (potential culls) in the herd if sold in the marketplace. In Table 2, an annual market value is derived for each class of animal from an estimated market weight and the established government market price. The annual commercial value for each type of animal sold is equally proportioned over the number of years required for the animal to reach selling age to allow for comparison with T.V. on an annual basis. A commercial value (C.V.) for each herd is estimated by summing the total expected annual value for each class of animals.

$$C.V. = (\#\ \text{bulls} \times \text{Tsh.}93.62)+(\#\ \text{steers} \times \text{Tsh.}106.90)+ (\#\ \text{cows} \times \text{Tsh.}49.29) \qquad (3)$$

The commercial value closely approximates a producer's net returns from cattle sales because in Tanzania, like other African nations, fixed and variable costs to producers are negligible due to such factors as public ownership of land, labor for herding provided by family children not in school, and government subsidized improved technology; for example, dips and veterinarian services.

TABLE 2. ESTIMATED ANNUAL MARKET VALUE BY TYPE OF LIVESTOCK IN TANZANIA, 1975

Type	Average Commercial Liveweight (kg)[d]	Price/kg of Liveweight[a] (Tsh.)[e]	Unit Market Value (Tsh.)	Average Age when Sold[b] (years)	Expected Annual Value[c] (Tsh.)
Bull	350	1.55	543.-	5.8	93.62
Steer	400	1.55	620.-	5.8	106.90
Cow[f]	230	1.50	345.-	7.0[g]	49.29

a. Government price based on weight of animal.

b. Derived from field survey data. [8]

c. Expected annual value is unit market value times the average age of animal sold which proportions the value for the animal over the years required to raise it to its commercial value. This provides a basis for comparison with traditional value for herd in Table 1.

d. Conversion rate is 1 kg = 2.2 lbs.

e. Conversion rate is Tsh 8.50 = U.S. $1.00.

f. Assume all heifers held as replacements. Cows are potential culls from the herd and would be sold for cash.

g. From field interviews, livestock owners generally sell cows at later age. [8]

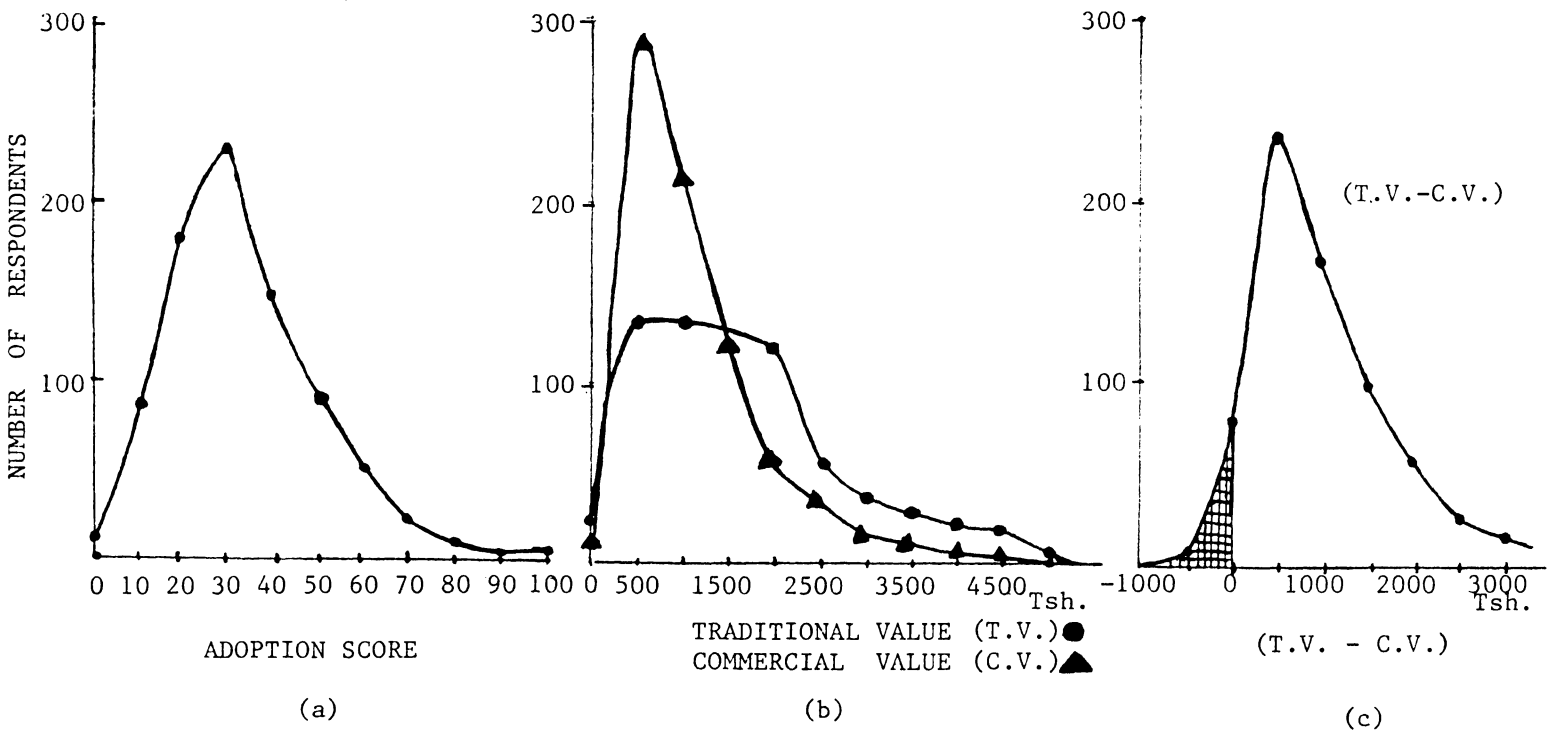
RESULTS

The level of improved livestock management by respondents is low. Figure 1a shows that the distribution of livestock owners' rate of adoption of improved practices is skewed toward a low level; approximately 33 percent of the respondents have scores of less than 20, and 80 percent with scores less than 40. The average adoption score for the total sample is 29. If producers had adopted just the basic disease control practices in the scale, they would have a score of 31. From field survey data adoption of health practices was less than 25 percent indicating some additional improved practices like castration and culling cows were responsible for increasing producers' scores[8].

Explanatory variables, similar to those used in other adoption studies, are tested to determine factors affecting technology adoption[3]. In the relationship between adoption score and the independent variables of herd size, family size and age of respondent, the correlation coefficients are less than .2; the r^2 for the equation is less than .1; and the F-value is insignificant. There is little change in the explanatory value of these factors within levels of adoptions scores. When the respondents are grouped by adoption scores; high (scores over 40), medium (scores 21-40), and low (scores less than 21), the resulting correlation coefficients of less than .15 and r^2's less than .01 indicate that these variables do not explain variation in adoption scores even within groups.

Rate of adoption of improved practices does not significantly influence the commercialization of the industry. Livestock owners sell a small number of their cattle (an average 3.5 head per year) and the

FIGURE 1. DISTRIBUTIONS OF ADOPTION SCORES, TRADITIONAL VALUES, COMMERCIAL VALUES, AND NET DIFFERENCE BETWEEN TRADITIONAL AND COMMERCIAL VALUES FOR 792 LIVESTOCK OWNERS IN TANZANIA, 1975



number sold is positively correlated to the size of the herd as would be expected. On a percentage of inventory, however, sales are inversely related to herd size. For example, herd sizes between 50-100 sold 15 percent while herds between 11-15 sold 23 percent of their inventory in 1975[8]. This provides further evidence that the larger herd generally supports a larger extended family.

The distribution of the economic values for the herds is seen in Figure 1b. The commercial values of the herds are concentrated in the lower range with 38 percent of the herds having an annual average commercial value of less than Tsh.500 ($59), and 65 percent less than Tsh.1000 ($118). The higher traditional value for cows as perceived by the producer is indicated by the data on herd composition which show that cows comprise close to 50 percent of the animals in the herd[8]. This could explain why some producers said during field interviews they do not sell cows; and why many unproductive cows are retained in the herd.

The commercial values of the 792 herds are greater than or equal to the traditional value in only 11 percent of the herds. In 53 percent of the respondents' herds, traditional value exceeds commercial value by less than Tsh.1000. (Figure 1c) The average net difference in favor of the traditional value for the total sample is Tsh.1301. The difference is equivalent to the traditional value of six additional cows in the average herd.

Even the herds with higher comercial values (see shaded area in Figure 1c) do not show an increase in the rate of adoption. The eighty-eight respondents with herds of commercial value equal to or greater

than the traditional value are analyzed separately and found to have an average adoption score of 28.8, not significantly different from the average score for the total sample of 28.6. When the number of cattle sold for this group is regressed on total cattle in the herd and the adoption score, the equation has a significant F-value of 23.7 and a higher r^2 of .53; however, the adoption score is not significant in the equation.

A positive result is that 30 respondents in a small homogeneous production area (Arumeru District) with private ownership of their pasture because of tribal custom had an average adoption score of 50, which is significantly higher than for areas with similar production conditions near Lake Victoria but with communal grazing which had an average score of 21. Commercial value also exceeds traditional value in this district for cattle due to the higher price received in the "black" market for cattle to be smuggled across the border into Kenya. Other Districts near Kenyan markets but with poor range conditions and communal grazing had an adoption score of 40, apparently due to higher "black" market prices.

CONCLUSION

Rate of adoption among livestock producers is low despite the government's effort to increase productivity by investing in the livestock industry. Wide variability in adoption scores is not closely associated with the variables of herd size, family size, and age of respondent. Livestock producers having higher rates of adoption are not significantly more commerically oriented in selling their cattle in the market place except where there is a private ownership of land and/or a higher commercial value due to a "black" market. For most of the country, it appears that acceptance of improved practices for economic and social reasons are primarily related within the traditional value system where having healthier cattle means more milk, more calves, and a larger herd from which a

producer can provide food for his family or pay bridewealth for a wife.

Commercial market incentives do not appear as strong as subsistence incentives. Government's current policy of market control of meat and livestock prices has apparently dampened the incentive to adopt even subsidized technology which does require some investment of time and energy by the producer, e.g. trekking cattle to a dip or to the local veternarian's office. Increasing the level of livestock management and supply of meat will depend partly upon the relative positive magnitude between the commercial value and the traditional value (C.V. - T.V.).

Communal grazing causing range deterioration can dissipate the effect of subsidized improved technology, because in the long run, herd productivity and quality decline keeping the level of technology and commercial sales low [4,5]. An administered grazing fee or tax assessed on specific age groups of commercial stock in each herd would be effective in lowering the higher traditional value for livestock perceived by producers and removing the attractiveness to retain unproductive animals longer in the herd for social status.

Current livestock development programs emphasizing subsidized technology in the major livestock production countries of Africa have not achieved acceptable levels of adoption of technology or commercialization of the industry due to economic factors and communal grazing keeping productivity and quality of herds low. If higher meat output is to be achieved by LDC's in Africa, a set of policies is needed aimed at providing incentive for a wide range of food production and marketing practices; otherwise, the value of subsidized technology may be largely dissipated.

FOOTNOTES

1. Commercial marketed offtake of cattle in Tanzania is estimated to be a maximum of 13 percent.[8] This percent when compared to a 50% commercial marketed offtake in the U.S. illustrates the minimial benefits received by non-livestock owners in Tanzania.[10]

2. The adoption index was designed by Chattopadhyay and Pareek[2] to measure rate of adoption of improved farming practices in India. Slight modification in original model includes a distance coefficient for increased difficulty.

3. The correlation among seven judges in weighting the activities has a Standardized Alpha Coefficient for reliability of scale of .75.

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