4.3.2.4 Socio-economic value of cattle

Estimates of the socio – economic value of cattle are derived from their estimated values in the Tobit model. The estimated values for each cattle category for different cattle keeping systems are then used to compute the shilling/dollar value of the socio – economic functions of cattle. These socio – economic functions include the value of cattle in insurance, finance and status display. However, since the farmers cannot clearly distinguish the value of each function, they are all lumped together as one value.

4.3.3 Relative Weights of Cattle Keeping Objectives

The cattle enterprise is a multi - objective enterprise. In this study, the relative importance of the various objectives is sought by using the Analytic Hierarchy Process (AHP). Farmers are asked their objectives of cattle keeping and relative weights of the objectives derived. The Analytical Hierarchy Process is a decision approach designed to aid in the solution of complex multiple criteria problems in a number of application domains. This method has been found to be an effective and practical approach that can consider complex and unstructured decisions. The AHP is an analytical tool, supported by simple mathematics that enables people to explicitly rank tangible and intangible factors against each other for the purpose of setting priorities. The process was developed by Saaty in the 1970s and has been used in a large number of applications to provide some structure on a decision making process involving many kinds of concerns including planning, setting priorities, selecting the best among a number of alternatives, and allocating resources. The AHP is conducted in the following steps:

a) Pairwise comparisons
b) Computing the relative weights

4.3.3.1 Pairwise Comparisons

AHP enables a person to make pairwise comparisons of importance between decision elements (e.g., milk income versus manure) with respect to the scale shown in Table 4. The AHP accommodates pairwise comparisons verbally, numerically, or graphically. The verbal mode uses a nine-point scale consisting of five words; equal, moderate, strong, very strong and extreme. There are also four intermediate levels (e.g. between moderate and strong).

Table 4: Scale of comparative importance

Comparative Importance	Definition	Explanation
1	Equally important	Two decision elements equally influence the decision.
3	Moderately more important	One decision element is moderately more influential than the other.
5	Strongly more important	One decision element has stronger influence than the other.
7	Very strongly more important	One decision element has significantly more influence over the other.
9	Extremely more important	The difference between influences of the two decision elements is extremely significant.
2, 4, 6, 8	Intermediate judgment values	Judgment values between equally, moderately, strongly, very strongly, and extremely.
Reciprocals		If v is the judgment value when i is compared to j, then 1/v is the judgment value when j is compared to i.

Source: *Adapted from Dyer and Forman (1992)*

4.3.3.2 Computing the relative weights

AHP computes a weight for each decision element based on the pairwise comparisons using mathematical techniques such as Eigenvalue, Mean Transformation, or Row Geometric Mean. In this study, the Eigenvalue technique is employed for computing the weights under

AHP. Priorities are derived by calculating eigenvalues and eigen vectors of reciprocal matrices representing pairwise comparisons (Dyer and Forman, 1992). The pair-wise comparisons generate a matrix of relative rankings for each level of the hierarchy. The number of matrices depends on the number of elements at each level. After all matrices are developed and all pair-wise comparisons are obtained, eigenvectors or the relative weights (the degree of relative importance amongst the elements) and the maximum eigenvalue (λ_{max}) for each matrix are then calculated.

4.3.4 Optimal Livestock Sales Age

Selling an animal for urgent cash needs may not coincide with the optimal moment from a meat, milk production or breeding perspective. However, using part of the flock for specific purposes at a desired moment is observed by Bosman *et. al*., (1997) to have advantages over disposing of animals at the optimum biological moment and subsequently keeping the money or goods received until required. The study hypothesises that livestock producers consider cattle as capital goods and keep them after their economic period as long as utilities in socio – economic functions are derived and the benefits outweigh the costs.

In order to test this hypothesis, an optimal age for disposal (sales) of cows with marketed benefits is predicted. The difference between ages of cows still in the herd and optimal age is computed. This is done for a selective sample of cows still in the herd but exceeding the optimal sales age. A similar approach as that followed by Jarvis (1974) in the determination of the optimum slaughter age for steers using the discounted profit function is adopted for cattle. The decision depends upon the animal's milk production, the interest rates, price of milk and the cost of inputs such as feed, concentrates, veterinary costs and hired labour. The criterion becomes maximisation of the present discounted profits function following the agricultural household models, which in perfect markets is the price of milk.

$$\pi(\phi) = \{(py(i, \phi, B_M) - ci\}e^{-r\phi} \tag{16}$$

Where B_M is a vector of marketed goods

ϕ = age of the animal

p = unit price of milk in KSh

y = annualised milk production in litres

i = vector of input quantity to the animal, independent of age

c = cost of the input bundle

r = interest rate

The first order condition for profit maximisation of the profit function requires that the producer select the optimal sales age ($\hat{\phi}_1$) of the animal. This is the age beyond which the enterprise returns start declining. This is obtained by getting the first derivative of the profit function and setting it to zero. At $\hat{\phi}_1$, the change in value due to changing output is equal to the current interest rate foregone plus the cost of feeding.

$$(\pi'_M = (p\frac{\partial y}{\partial \phi}) - rpy - cie \Rightarrow (p\frac{\partial y}{\partial \phi}) = rpy + ci) \tag{17}$$

The dependent variable is the difference between the actual and optimal disposal age of the cows. Given the conditions for optimal disposal age of cows in equation 16, a linear multiple regression model using ordinary least squares is fitted to obtain estimates of factors that influence the length of holding cows longer than the optimal age. The general linear regression model with *k* explanatory variables can be presented as:

$$Y = b_0 + b_1X_1 + b_2X_2 + ... + b_kX_k + \mu \tag{18}$$

The model assumes that the random error term μ_i, is normally and independently distributed with mean = 0 and constant variance σ^2. It further assumes a zero covariance between the error term and the explanatory variables. Explanatory variables are assumed not perfectly, linearly correlated.

The rationale behind the least squares method is the minimization of the sum of squares of the deviations of the actual observations from the regression line. The smaller the deviations from the line, the better the fit of the line to the scatter of observations. The ordinary least squares estimators possess some optimal desirable qualities of estimators (unbiasedness, consistency, efficiency and minimum variance) according to the Gauss-Markov least squares theorem (Koutsoyiannis, 1977). The linear multiple regression model is specified as follows;

$$\begin{aligned} DIFFAGE = {} & \beta_0 + \beta_1 URBKM2 + \beta_2 LSIZE + \beta_3 SYST + \beta_4 BREED + \beta_5 NONMKT + \beta_6 TOTINC \\ & + \beta_7 HRDSZE + \beta_8 DEPRAT + \beta_9 HHS + \beta_{10} GENDER + \beta_{11} EDUCYRS \\ & + \beta_{12} CREDIT + \beta_{13} HEAD\_AGE + \beta_{14} SMALLKM2 + \beta_{15} ACCESS \\ & + \beta_{16} POPDENS5KM + \beta_{17} CALV\_YEAR + e_i \end{aligned} \tag{19}$$

The dependent variable, DIFFAGE is the difference between the actual age of the animal and optimal sales age with marketed benefits, β_0, and β_I 's are parameters to be estimated and e_i the disturbance error term. The exogenous variables include market access variables, feeding system and household characteristics. Table 3 gives a description of the exogenous variables.

4.4 Scope and Limitations

In calculating the difference in age between old cows and the optimal age, the study only utilised details of old animals still in the herd, not considering those sold beyond optimal age. The reason behind this is that information could only be obtained for those animals still existing in the herd and not those sold. The consequence of this is that it was not possible to estimate total costs arising from keeping cattle for non – market benefits, since this estimation would require estimation of the full benefit cost stream until disposal (sales). This is noted in the literature review as a possible approach to estimating the cost of keeping animals beyond the optimal age as opposed to the approach used by Slingerland (2000).

CHAPTER FIVE

5. RESULTS AND DISCUSSION

This chapter is divided into three sections. The first section discusses the results of the descriptive analysis, which includes an overview of the socio-economic characteristics of farm households in Rachuonyo and Kisii districts and a description of the socio – economic roles of cattle. The second section discusses the results of the econometric estimation of the socio – economic, non – market valuation of cattle keeping as well as the results of the econometric estimation on the factors that influence the probability of holding cows longer than the optimal sales age with marketed benefits. The third section discusses the results of the cattle enterprise budget analysis to assess the competitiveness of the cattle systems.

5.1 Descriptive Analyses

5.1.1 Household Characteristics

Some of the household related characteristics are presented in Table 5. The average household size across the entire sample is 5.1 adult equivalents. This is comparable to the average Kenyan household size of 5.2 reported by the Ministry of Planning in the Welfare Monitoring Survey report (1996). Households practising extensive grazing have an average household size of 5.2 adult equivalents compared to 4.9 for those practising zero - grazing and semi – zero grazing. This compares with the average household size of 4.8 in Kiambu district where zero – grazing is practised (*ibid.*). However, the mean household size for the two groups of farmers is not significantly different ($p > 0.1$).

Households practising extensive grazing have larger land sizes compared to those practising semi – zero and zero grazing. The average land size is 2.2 and 1.4 ha for the extensive and semi-zero/zero grazing system households respectively and is significantly different (p

< 0.01). This finding compares to that made by Bebe *et. al* (2002), for low – intensity (extensive grazing) households where the average farm size is reported to be 2.2 ha and 0.6 ha for medium/high intensity (semi – zero and zero – grazing system) households. The main land tenure systems found in the study area include freehold, communal and rentals from individuals (Waithaka *et. al.*, 2002). The land tenure systems have an important influence on the cattle production systems. The freehold system tends to promote security, investment and consequently agricultural growth as opposed to the communal systems.

Table 5: Household related characteristics, by cattle production system

	Cattle production system	
Parameter	Extensive grazing (n = 132)	Semi – zero and zero grazing (n = 123)
Average household size	5.2	4.9
Average land size (ha)	2.2	1.4
Average monthly off –farm income (KSh)	3534.1	5198.4
Average total monthly household income (KSh)	5186.8	8595.1

Source: *Survey results, 2002*

The average monthly off – farm income for the semi – zero and zero grazing system households is significantly higher than for extensive system households ($p < 0.01$). This is also the case for total monthly income where the average for the intensive and semi–intensive system households is significantly higher than the extensive system households ($p < 0.01$).

Cash crop production (tea and pyrethrum) is found in the intensive and semi – intensive systems due to the favourable agroecology. This boosts farm income in comparison to subsistence food crop production in the extensive system. On average, the national monthly off – farm income was estimated at KSh 4,941 per household in 1994 (Ministry of Planning, 1996).

Table 6 shows the characteristics of the household head in the study area. The household head is defined as the senior member of the household who makes key decisions in the household and whose authority is acknowledged by other members. The results indicate a predominance of households headed by males as opposed to females. Eighty three percent of the households interviewed were male headed while seventeen percent were female headed households.

Table 6: Household head characteristics

	Male	Female
Sex of household head (%)	83	17
Average age (years)	51.4	53.2
Average number of education years	8.9	3.8

Source: *Survey results, 2002*

The average age of the household head in male and female headed households is 51.4 and 53.2 years respectively. The female headed households have lower education levels compared to their male headed counterparts. The mean number of years spent in school is significantly different between the male and female headed households ($p < 0.01$). Generally, women are less educated and handle fewer employment opportunities as compared to their male counterparts. They therefore do not have alternative avenues for off – farm income, to meet household needs. From the survey, 61 percent of the male headed households are involved in farming, 31 percent are primarily involved in off – farm activities and another 3 percent retired with pension. On the other hand, 93 percent of female headed households are primarily involved in farming, 5 percent in off – farm income and 2 percent undertaking petty businesses.

5.1.2 Cattle Production Systems Characteristics

Table 7 summarises some of the cattle systems characteristics based on the survey results. In the extensive grazing system, the predominantly kept cattle breed is the local breed. 95 percent of the cattle kept in this system are local breeds and 5 percent dairy crosses. High – grade dairy cattle and dairy crosses are mainly kept in the intensive and semi – intensive systems. 75 percent of the cattle kept in this system are the upgraded breeds with a few occurrences of local breeds comprising 25 percent. The agro – climate of a region influences the type of cattle breeds kept, their productivity and their susceptibility to diseases. Much of the extensive grazing is practised in the lowlands of Rachuonyo district, where there are occurrences of tick infestation (RoK, 1997). The local breeds are predominant in the region because they are adaptable to the harsh climatic conditions. The upgraded cattle, mainly kept under semi – intensive and intensive systems are found in Kisii and the upper midland zones of Rachuonyo district, where they are adaptable and climatic conditions favourable for fodder production.

As farmers intensify their systems, they keep smaller herds, which allows them to use more of the planted fodder to achieve higher milk productivity per cow. The survey results indicate that extensive grazing households have an average herd size of 3.6 Tropical Livestock Units (TLU) compared to 1.9 TLU's from the semi – intensive and zero grazing households. This is significantly different between the two systems ($p < 0.01$). A similar finding has also been made by Bebe *et. al* (2002) for the Kenya highlands where the average herd size for a high – intensive system household is 1.8 TLU's compared to 3.2 TLU's for low – intensive system.

Table 7: Characteristics of cattle production systems in Rachuonyo and Kisii districts

Production parameter	Extensive grazing (n=132)	Semi – zero and zero grazing system (n = 123)
Cattle breed types	Predominantly local zebu	High – grade and Crosses
Herd size (TLU)	3.6	1.9
Milk price (KSh/Lt)	27.8	27.1
Households selling milk (%)	33	38
Proportion of milk sales per household (%)	32	33
Households using cattle draught (%)	51	13
Milk offtake (lts/cow/day)	1.6	5.3

Source: *Survey results, 2002*

Milk production is mainly used for home consumption. Only thirty six percent of the households interviewed indicate sales of some portion of milk produced. In the extensive grazing system, 33 percent of the households sell milk in comparison to 38 percent in the intensive/semi – intensive systems. The households involved in milk sales sell an average of 31 percent of the milk produced. Milk therefore plays a significant role in provision of household food security. The farm gate price of milk is higher in the extensive systems compared to the intensive and semi – intensive systems. On average, the farm gate price is KSh 27.8 in the extensive systems compared to KSh 27.1 in the intensive and semi – intensive systems. However, this is not significantly different ($p > 0.1$).

Milk production is low for the extensive grazing system compared to the semi – zero and zero grazing systems. This can be attributed to the genotype of the cows kept in the different systems. Upgraded breeds, commonly found in the semi – zero and zero – grazing systems have a higher milk potential compared to the local breeds found in the extensive systems.

Utilisation of cattle for draught power is common in the extensive systems where 51 percent of surveyed households report the use of cattle for draught power compared to 13 percent in intensive and semi – intensive systems. The main tasks include land preparation and planting during two planting seasons in a year. On average, the draught cattle work for 3.5 hours per day for 135 days a year. The cattle types utilised for draught power are mainly oxen (26 %) and bulls (71%). However, there are reported cases of use of cows (2%) and heifers (1%) in the sample. The animals are joined together to form a work span; these may consist of two or four animals yoked together. They may come from the same owner or several owners may combine their animals to form a work span. The animals are also hired out to farmers without draught animals at an average fee of KSh 420 per day per work span, which translates to KSh 105 per animal. The use of cattle for draught power is common in the extensive system compared to the semi – intensive and intensive systems due to the large land sizes existing in the extensive systems.

5.1.3 Socio – Economic Roles of Cattle keeping

Farmers keep cattle for various purposes. Figure 9 shows the proportion of households and their objectives for cattle keeping by system type. The results indicate that households keep cattle mainly to obtain milk for home consumption, calves, milk income, manure and security. In the low intensive systems, draught power is also an important aspect of cattle keeping. 96 percent of the households from the low intensive system keep cattle as a store of wealth compared to 65 percent from medium and high intensive systems. In addition, 90 percent of farmers from low intensive systems view cattle keeping as a way of improving one's social standing in the community. This is in contrast to the intensive and semi-intensive systems where only 25 percent of the farmers interviewed view cattle rearing as a way of improving one's social status. This finding corroborates observations made by de Leeuw *et. al* (1999) for the Maasai pastoralists where, wealth is measured by the size of the herd. The larger the herd size, the wealthier the owner and respect accorded him.

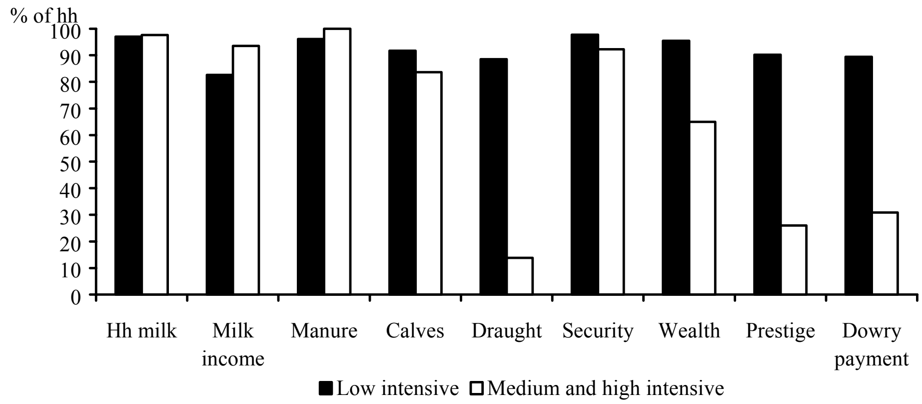

Figure 9: Objectives of cattle keeping, by cattle production systems

Cattle are also regarded as assets that can be used to pay bride price, creating ties between families in the community, resulting in acquisition of a respectable status in the society. In the low intensive systems, 90 percent of the interviewed households view dowry payment as one of the roles of cattle rearing in comparison to only 30 percent in the medium and high intensive systems. The results of the Analytic Hierarchy Process (AHP) to determine the relative importance of the diverse cattle rearing objectives are presented in the subsequent tables and figures for different cattle types and systems.

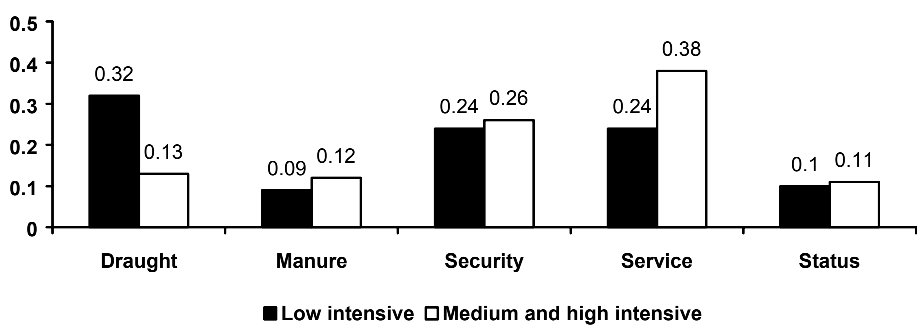

Figure 10: Relative importance of keeping bulls, by system type

Figure 10 indicates that draught power is the most important objective of keeping bulls in the low – intensive systems. Bull service and security provision (savings and insurance) are also in the top three ranks. However, for the medium and high intensive systems, bull service is the most important objective, with security, draught power and manure also in the top four ranks on the list. The social status acquired from keeping a bull obtained equal weights across the systems and ranked last in the medium and high intensive systems and second from last in the low intensive systems.

Table 8: Relative importance of keeping cows, by system type

	Low intensive		Medium and high intensive	
Objective	Relative weight	Rank	Relative weight	Rank
Calves	0.16	3	0.15	3
Dowry payment	0.22	1	0.18	2
Home consumed milk	0.13	4	0.18	2
Manure	0.07	6	0.07	6
Milk income	0.11	5	0.12	4
Security (savings and insurance)	0.20	2	0.23	1
Social status	0.11	5	0.07	5

Source: *Survey results, 2002*

Dowry payment and the role of cows as security assets are the most important objectives of keeping cows in low intensive systems as indicated in Table 8. The offsprings are relatively more important than milk and manure in this system. Social status acquisition from keeping cows is relatively more important than manure in both systems. The relative importance of manure across the systems is the same though it ranked last in both systems. In the medium and high intensive systems, the role of cows as security assets, milk production for home consumption, dowry payment and offsprings were in the top four ranks.

The heifers and immature males are mainly important for dowry payment purposes in the low intensive systems as indicated in Figures 11 and 12. In the medium and high intensive systems, the role of heifers and immature males as a form of security was relatively more important than other objectives. Manure is also highly valued in the medium and high intensive systems compared to the low intensive systems for both heifers and immature males. Acquisition of status from owning heifers is equally valued in both systems. However, it acquires more importance in the low intensive systems than high and medium intensive systems for the case of immature males.

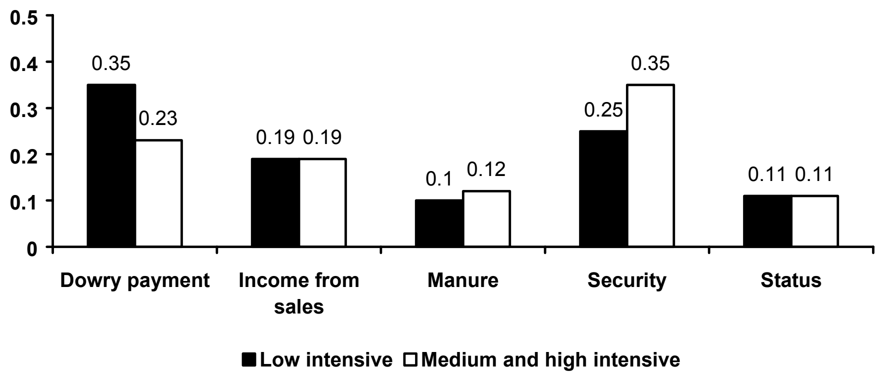

Figure 11: Relative importance of keeping heifers, by system type

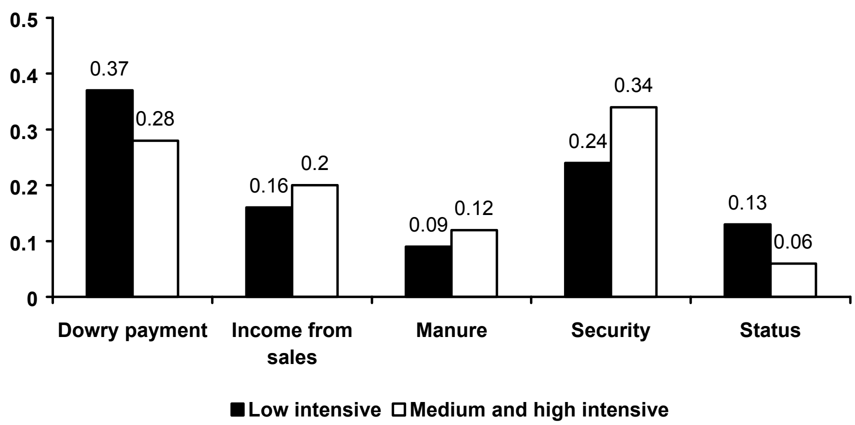

Figure 12: Relative importance of keeping immature males, by system type

Farmers use cattle to cushion against unexpected shocks as well as offsetting planned expenditures. This is because other alternatives such as insurance and credit facilities are not available. From the survey, fifty percent of cattle sales occurring between the years 2000 to early 2002 are primarily to offset unexpected expenditures, while another 30 percent is used to finance planned expenditures. Other reasons for sales include old age (4%) and poor performance (6%). The types of cattle sold are presented in Table 9.

Table 9: Type of cattle sold to finance expected and unexpected expenditures

Cattle type	n	Percent sold
Bulls and oxen	79	25
Immature male	50	16
Cows	52	17
Heifers	56	18
Calves	8	3

Source: *Survey results, 2002*

The highest proportion of animals sold for financing planned and unplanned expenditures are bulls and oxen, comprising 25 percent. The proportion of immature males, cows and heifers sold range between 16 and 18 percent. Apart from sale of cattle, other ways in which households cope with emergency needs include fundraising, borrowing from friends/relatives, sale of small stock, sale of farm produce and off – farm income. Less than 1 percent of the households record the use of credit to offset emergency needs.

Credit plays an important role in reducing binding capital constraint. Generally, there is minimal use of long – term credit. The survey results indicate that only 36 percent of the households interviewed have ever obtained credit in the last fifteen years. The main sources of credit include the Savings and Credit Co – operative Societies (SACCO) (67%) and farmer groups (19%). Others are government banks (5%) and micro finance institutions

(2%). Twenty two percent of the farmers have obtained credit in kind. Of this, 80 percent have obtained it in the form of fertilizer from Kenya Tea Development Authority for the tea enterprise, 7 percent have obtained cows/bulls from projects with development components such as the Livestock Development Project's (LDP) Cow From Cow Rotation Scheme (CFCRS), and 13 percent have obtained goods on hire purchase. The reasons for not obtaining credit is summarized in Figure 13.

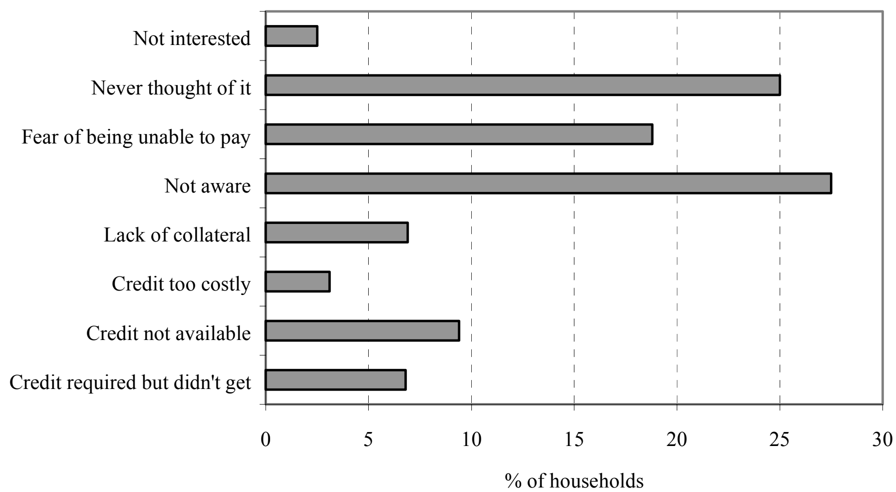

Figure 13: Reasons for not obtaining credit

The common reasons cited by the farmers include lack of awareness and fear of being unable to pay. A few (7%) indicate that credit is required but could not be obtained.

5.2 Econometric Analyses

5.2.1 Econometric Results on Socio – Economic Non – Market Valuation

A Chow test is done to test whether the coefficients estimated over Kisii data are equal to those estimated over Rachuonyo data. The results of the test indicate that the two sites are similar and therefore data was pooled. A Tobit model was estimated with the dependent variable being the proportion of the socio – economic value of cattle keeping (WTP amount) over the farmer's total perceived value of the animal. The objective was to assess factors that influence the probability of demand and magnitude of the proportion of the non – market, socio – economic value of cattle. Independent variables consisted of production system characteristics, household related characteristics, climate potential indicator and market access indicators derived from measures of location by Staal *et al* (2002), which includes GIS-derived variables. The description of the independent variables is presented in Table 3. The results are presented in (Table 10). Standard errors of β estimates were examined to assess possibilities of multicollinearity and the Pearson correlation coefficient (ρ) was also used to examine linear associations between pairs of explanatory variables. High sample correlation coefficients between cattle breeds and the cattle feeding systems led to the introduction of the variables as interaction dummy variables. The statistical significance of the model is examined by using a Wald test of the null hypothesis that all slope coefficients ($H_0 = \beta_j = 0$) are zero except the intercept term. The χ^2 statistic of 74.4 is statistically significant ($p < 0.01$) indicating a rejection of the null hypothesis. Results from McDonald and Moffit's decomposition, are also presented. $F(Z)[\ \delta E(Y^*)/\delta X_i$ represents the change in proportion of WTP among farmers already willing to pay, $\delta F(Z)/\ \delta X_i$ indicates the change in probability of WTP (being above zero) and $\delta E(Y)/\ \delta X_i$ is the total change in the WTP proportion.

Table 10: Estimated Tobit model for factors influencing the share of socio – economic value of cattle

Independent variables	Maximum likelihood coefficient	Robust Standard Error	Total change $\delta E(Y)/\delta X_i$	Change among farmers WTP $F(Z)[\delta E(Y^*)/\delta X_i$	Change in probability of WTP $\delta F(Z)/\delta X_i$
			Animal related characteristics		
HEIFERS	1.604	1.415	1.359	1.347	0.012
BULLS OX	-5.407***	1.426	-4.528	-4.487	-0.040
CALVES	-5.029***	1.967	-4.258	-4.220	-0.038
UPGSTSEM	-0.054	1.697	-0.046	-0.045	-0.000
INDSEMI	4.403**	2.227	3.682	3.649	0.033
ANAGE	0.357	0.541	0.272	0.290	0.002
ANAGE2	0.001	0.035	0.003	0.003	0.000
HRDSIZE	-0.123	0.169	-0.146	-0.103	-0.001
			Household characteristics and resource availability		
LSIZE	-0.054	0.092	-0.028	-0.028	0.000
DEPRAT	3.628***	1.279	3.028	3.001	0.027
HHS	0.573**	0.254	0.536	0.531	0.005
GENDER	-2.476*	1.410	-2.158	-2.139	-0.019
EDUCYRS	0.086	0.126	0.068	0.067	0.001
CREDIT	-0.675	1.064	-0.482	-0.478	-0.004
OFFINC	0.000	0.000	0.000	0.000	0.000
			Market access indicator and resource availability		
INFKM2	-0.112*	0.061	-0.110	-0.093	-0.001
PPE	2.911	3.724	2.331	2.311	0.021

Log likelihood function = -2399.1

Number of observations = 637

$H_0 = \beta_j = 0$, Wald χ^2 (17) = 74.4

F(z) = 0.96, z = 1.75 f(z) = 0.0863 σ= 11.59

***, ** and * = significance at 1%, 5% and 10% respectively

The maximum likelihood coefficients from the Tobit estimation indicate that the cattle type, the interaction between the cattle feeding system and the animal breed, dependency ratio, household size, sex of the household head and distance to the nearest informal milk collection centre on murram road have a significant influence on the probability of demand and the magnitude of the proportion of the socio – economic value of cattle.

The cattle type variable is entered into the model in form of dummy variables. To avoid the dummy variable trap (perfect collinearity), the dummy for cattle type cow is excluded from the model to be the comparison group. The coefficients on BULLS_OX (-5.4) and CALVES (-5.0) have negative and significant ($p < 0.01$) influence on the probability of demand and the magnitude of the share of socio – economic value of cattle keeping. This implies that bulls/oxen and calves have a lower non-market value and demand compared to cows. This result has the implication that such cattle types are likely to be easily disposed off and thus have a more market integrating effect than other livestock types.

Interactive variables between the animal breed class and the cattle feeding system are also introduced in the model as dummy variables. The base group includes indigenous breeds on open grazing systems. The coefficient on INDSEMI (4.4) is strongly positive and significant ($p < 0.05$) in explaining the probability and level of demand. This implies that local breeds under semi – zero grazing system are perceived by farmers to be better assets than local breeds under the grazing system.

The coefficient on UPGSTSEM (-0.06) is negative, though not statistically significant. The mean of the dependent variable (WTPSHARE) is significantly different across the two main system types (grazing and zero grazing/semi-zero grazing) ($p < 0.01$).

Other animal related characteristic variables such as the age of the animal and herd size do not have a statistically significant influence on the probability and share of the socio –

economic value of cattle. The variables ANAGE and ANAGE2 are introduced to show how increases in animal age influence their share of the socio – economic value.

Three household related characteristic variables are significant in explaining the probability of demand and the magnitude of the proportion of the socio – economic value of cattle; dependency ratio (DEPRAT), household size (HHS) and sex of the decision maker (GENDER). Estimated coefficients on DEPRAT (3.6) and HHS (0.6) have strongly positive and significant ($p < 0.05$) influence on the probability of demand and share of the socio – economic value of cattle. This positive signs are expected since it is hypothesized that the number of dependants are positively related to the household financial needs. Similarly, the greater the household size the greater the risk probability and financial obligations, hence the need to have an insurance and financial strategy in the form of livestock to cope with this.

With respect to gender of the household head, those headed by males are hypothesized to have access to insurance and finance alternatives such as credit and off farm income, due to their access to collateral required for credit and higher education levels relative to women, giving them higher chances of enjoying off – farm income. From the results, the coefficient on GENDER is negative (-2.6) and statistically significant ($p < 0.1$) implying that, relative to female - headed households, male headed households are likely to place a lower value on the socio – economic roles of cattle, *ceteris paribus*. This is attributable to lack of alternatives for finance and insurance for female - headed households compared to their male counterparts. Past studies (Kabutha, 1999; Tangka *et. al*, 1999) have also documented the low access by women to capital and financial assets.

The coefficient on INFKM2 (-0.11) has a negative and significant influence on the probability of demand and magnitude of the share of the socio – economic value of cattle ($p < 0.1$). This variable is used as a market access measure. The further away a farmer is from an informal market, the lower will be the likelihood of demand for the socio – economic benefits. This result suggests that farmers far from market outlets are less likely to have a high demand for the socio – economic roles of cattle due to lack of markets for disposing livestock and livestock products when there is need.

Other variables such as land size, credit use, ppe and annual off –farm income do not have a significant influence on the probability of demand and the level of socio – economic value of cattle. Estimated coefficients on LSIZE and CREDIT are negative as expected, implying a negative influence on the share of socio – economic values of cattle. This is expected because credit is an alternative way of financing expenditures, so for farmers with access to this capital, the financing and insurance roles of cattle diminishes. Land can also be used as collateral to influence credit access.

Following McDonald and Moffit's decomposition, the Tobit coefficient is disaggregated into two effects; (1) effects on the probability of WTP (being above zero) and (2) effects conditional upon being above zero (those already above zero) as shown in Table 10. The results suggest that having a bull or an ox would decrease the likelihood of demand relative to cows by 4 percent and also decrease the share of the socio – economic value by 4.5 percent in the entire sample and among those already demanding. Similarly, having a calf would decrease the likelihood of demand relative to cows by 3.8 percent and also decrease the share of socio – economic value by 4.2 percent in the entire sample and among those demanding.

Having indigenous breeds of cattle under semi - zero grazing system would increase the likelihood of demand for the socio – economic functions relative to those under open grazing system by 3.3 percent and also increase the share of socio – economic value by a significant

3.6 percent in the entire sample and among those demanding.

On the other hand, an additional unit of dependants in the household would raise the probability of demand by 2.7 percent and increase the share of socio – economic value by 3.0 percent in the entire sample and among those already having a demand. Likewise, an additional adult equivalent in the household would raise the probability of demand by 0.4 percent and increase the share of socio – economic value by 0.5 percent in the entire sample and among those already having a demand.

A household that is male - headed would reduce the likelihood of demand by a significant 2 percent and reduce the share of socio – economic value by 2.1 percent in the entire sample and among those demanding. This finding seems to emphasize the variability in resource access based on gender of the decision maker.

Similarly, an additional Km from an informal market would reduce the probability of demand by 0.1 percent and also reduce the share of socio – economic value by 0.1 percent in the entire sample and among those demanding. This shows that farmers far from informal markets place low values on the socio – economic values of their cattle. This result has implications on the influence of market access on the roles of cattle. Farmers far from markets do not have access to markets to dispose livestock products. They incur high market transaction costs due to the added transport costs, eventually lowering their perceived value of productive resources. This corroborates observations made by Jayne (1994) for crop production in Zimbabwe where farm to market transaction costs influences the import substitution relationship between cash crop and food crop production in the area. Cash cropping is deemed economically unviable despite providing higher returns to land and labor than grain crops because food marketing costs are high in rural areas. For grain deficit households, the opportunity cost of cash crop production is not the net returns to growing and selling food grains but, rather the cost of acquiring the grain foregone by cultivating cash crops, which is related to acquisition costs of grain rather than selling prices. As a result, cropping patterns are skewed away from those of comparative advantage. The predicted values of the WTP amount indicates that the socio – economic value of cattle in extensive systems is 19 % of the total perceived value of cattle compared to 21 % in semi – intensive and intensive systems. This is significantly different across the systems ($p<0.01$).

5.2.2 Influence of Non – Market Benefits on the Optimal Sales Age of Cows

The non – market benefits derived from cattle such as manure and the socio - economic benefits (finance, insurance, dowry payment) may lead farmers to retain cows beyond the age when milk production has declined (Moll *et al*, 2001), as long as the benefits still outweigh the costs. A locally weighted scatter plot smoothing (lowess) is done to assess the average optimal age range for milk production. The idea is to create a new variable such that, for each dependent variable observation y_i, contains the corresponding smoothed value. The smoothed values are obtained by running a regression of annual milk production on age of the cow using only point data (x_i, y_i) and a small amount of data near this point. In lowess, the regression is weighted so that the central point (x_i, y_i) gets the highest weight and points farther away, based on the distance $| x_j - x_i |$ receive less weight. The estimated regression is then used to predict the smoothed value $\hat{y}_i$ for y_i only. The procedure is repeated to obtain the remaining smoothed values, meaning that a separate weighted regression is estimated for every point in the data.

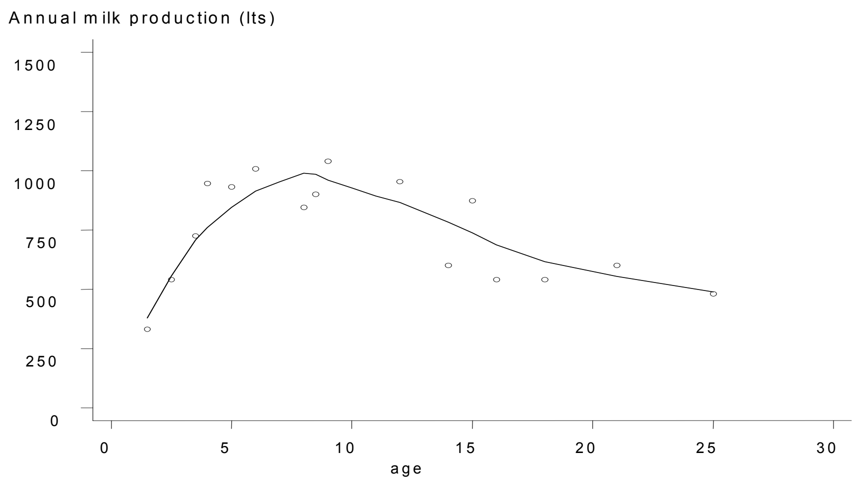

Figure 14: Annual milk production versus cow age

Figure 14, generated from lowess indicates that on average, milk production rises with age of the cow until the seventh year, after which milk production starts declining. Determination of the optimal sales age of cows following Jarvis (1974), indicate that this age is around 8 and 8.5 years for both improved and local breeds as is evident in Figures 15 and 16 respectively. To test the hypothesis that non – market benefits influence farmers' decision to withhold cows longer than the optimal period, a sub - sample of cows in the herd whose ages exceed the optimal period, was used.

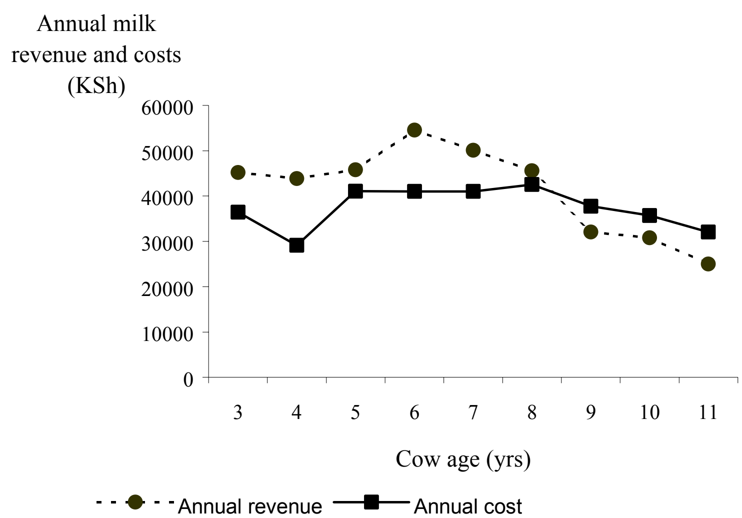

Figure 15: Annual milk revenue and costs versus cow age, for improved breeds

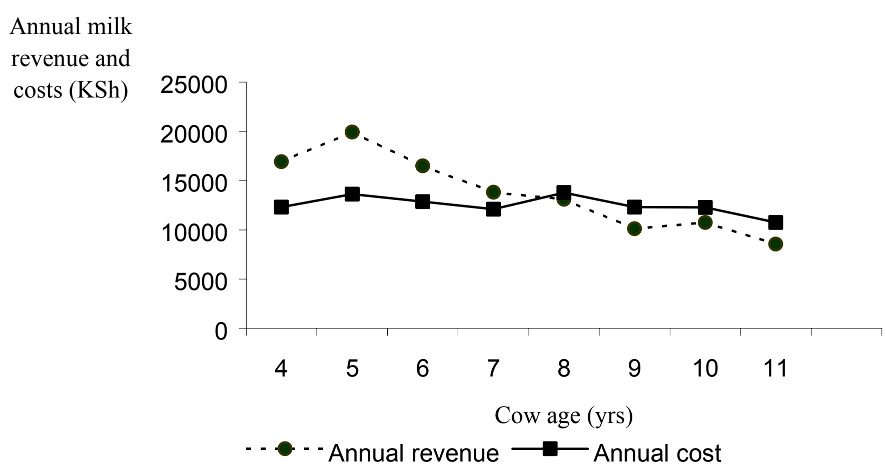

Figure 16: Annual milk revenue and costs versus cow age, for local breeds

5.2.2.1 Econometric Results on Factors that Influence the Decision to Keep Cows Beyond the Optimal Sales Age with Marketed Output

A linear multiple regression model using the ordinary least squares technique, with robust standard errors was estimated with the dependent variable being the difference between the ages of old cows still in the herd and the optimal age of cows.

Table 11: Estimated Multiple Regression Model using OLS for factors influencing the decision to hold cows beyond the optimal age

Independent variables	Coefficient	Robust Standard Error	t
	Animal and system related characteristics		
INDGRAZE	5.417***	1.458	3.71
POPDENS5KM	-0.003	0.004	-0.61
CALV YEAR	7.164	5.294	1.35
HRDSZE	-0.049	0.143	-0.34
LSIZE	-0.046	0.041	-1.12
MILK LT	0.129	0.104	1.23
MLKPRC	-0.301***	0.088	-3.40
NONMKT	0.003***	0.001	4.44
	Household related characteristics and resource availability		
HHS	-0.368**	0.173	-2.13
DEPRAT	-2.173**	0.847	-2.56
GENDER	1.116	0.748	1.49
EDUCYRS	-0.165	0.103	-1.60
HEAD AGE	0.026	0.033	0.77
CREDIT	0.451	0.576	0.78
TOTINC	0.000	0.000	0.88
OFFINC	1.116	0.747	1.50
	Market access indicators		
URBKM2	0.043	0.039	109
INFKM2	0.100**	0.041	2.46
SMALLKM2	-0.024	0.043	-0.56
ACCESS	0.000	0.000	-0.40

Number of observations = 66	**R-squared = 0.540**
F(20, 55) = 8.01	**Prob > F = 0.0000**
Root MSE = 1.959	

***, ** and * = significance at 1%, 5% and 10% respectively.

The objective was to assess factors that influence withholding of cows longer than the optimal age. Independent variables consisted of animal related characteristics, household related characteristics, as well as market access indicators. Description of the independent variables is presented in Table 3. The results are presented in Table 11. The statistical significance of the model is examined by using the goodness of fit test of R-squared. The goodness of fit measure of 0.54 indicates that the model explains 54 percent of the total variation in the observed data.

The coefficients from the ordinary least squares estimation indicates that the interaction between the cow breed and the feeding system, milk price, socio – economic non – market benefits, household size, dependency ratio and the distance to the nearest informal milk collection centre on murram road, have a significant influence on holding of cows beyond their optimal age.

The coefficient on INDGRAZE is positive and statistically significant ($p < 0.01$) implying that relative to upgraded breeds of cows on semi – zero grazing system, indigenous breeds on open grazing systems are kept 5 years beyond their optimal milk production period. This can be attributed to the more market oriented nature of the upgraded breeds on semi – intensive systems relative to the indigenous breeds. The former requires higher investment costs and a market return is important in evaluating performance, as competition exists from alternative enterprises due to the favourable agroecology. It has better market opportunities because of the high population density of persons with a tradition of milk consumption. The latter is more subsistence than market oriented and investment as well as operational costs quite low. Milk production is relatively low as the agroecology is not favourable for rearing the high milk yielding upgraded breeds.

The coefficient on MLKPRC has a negative and significant ($p < 0.01$) influence on the decision to hold cows beyond the optimal age. This finding suggests that an additional shilling to the farm gate price of milk results in disposal before the optimal age by 0.3 years (3 months). Based on the price theory, high milk prices send positive milk supply signals, and consequently, producers may focus mainly on increased milk production for sales to obtain additional revenue or enjoy producer surplus. However, the degree of change in revenue will depend on the price elasticity.

The coefficient on socio – economic, non – market benefits has a positive and significant ($p < 0.01$) influence on the decision to hold cows beyond the optimal age. One-shilling increase in the value of non – market benefits results in delaying disposal by only 0.003 years. The results suggest that households deriving socio – economic non - market benefits from cows are more likely to hold cows longer than the optimal age albeit the short duration of withholding. The t – *statistic* presented on the non- market benefits coefficient indicates a rejection of the null hypothesis H_0: NON_MKT = 0 at 1 % level.

The other animal related characteristic variables are not statistically significant. Coefficients on CALV_YEAR, HRDSZE, POPDENS5KM, LSIZE and MILK_LT do not have a significant influence on the decision to hold cows beyond the optimal age.

The coefficient on HHS and DEPRAT are negative as expected and statistically significant ($p < 0.05$). Large households, especially those with a high number of dependants may rely more on the recurrent cash income from milk production to sustain the households and therefore may not hold cows after the optimal production period. An additional number of dependants would result in disposal before the optimal age by 2 years. Other household related variables that do not have an influence on the decision to keep cows beyond optimal age are EDUCYRS, GENDER and HEAD_AGE.

Distance from the homestead to the nearest informal milk collection centre on murram road is used as a proxy for measuring market access. Its estimated coefficient (INFKM2) is positive and significant ($p < 0.05$). This implies that farmers far from the informal market would delay disposal by 0.1 years (approximately 1 month). Transaction costs in the form of transfer costs tend to be higher for farmers far from market outlets. There is a tendency for them to adopt less market-oriented techniques since these transaction costs lowers their net returns.

The predicted values of DIFFAGE are presented in Table 12. The results indicate that on average, farmers hold their cows 3 years above the optimal age. In the open grazing systems, the length of holding cows above optimal is on average 3.7 years compared to 1.6 years in semi – zero grazing systems. The mean of the dependent variable (DIFFAGE) is significantly different between the two grazing regimes (grazing and semi-zero/stallfeeding) ($p < 0.01$).

Table 12: Predicted values of length of holding cows above optimal age

System type	Mean	S.D.
Open grazing	3.7	1.9
Semi – zero grazing	1.6	1.5
All	3.0	2.1

Source: *Survey results, 2002*