

highlands in Kiambu district by the Smallholder Dairy (R & D) Project in 1998 reveal that farmers are prepared to pay relatively high prices for manure (KSh 12500 per 7 Ton lorry) from traders purchasing it at lower prices from pastoral areas of Maasailand (KSh 3000 per 7 Ton lorry). Another study in the Kenya highlands by Lekasi *et. al.* (1998) indicate that the value of manure produced in a smallholder dairy farm may be approximately 30% of the value of milk produced, based on the market values for both. This value is captured on farm through the increased value of crop production, by applying manure to crops on farm. Direct manure sales either through formal or informal channels in most areas do not exist, hence the value of manure production is not included in the valuations of livestock contribution despite its importance.

In addition to the direct contribution of manure to plant nutrients, it provides important organic matter to the soil, maintaining its structure, water retention and drainage capacity. In other countries such as Ethiopia and India, cow dung is used as fuel for cooking and heating, reducing expenditures for fuel wood or fossil fuels. It also has specific uses in the homestead including decoration of houses and granaries (Sansoucy *et. al.*, 1995).

#### **2.4 Cattle as a Source of Draught Power**

Most animal power activity is concentrated in the semi – arid zones. In other zones barriers such as population density, effects of animal disease such as trypanosomosis and hilly topography among others retard the use of animals for traction. In Kenya, McIntire *et. al.* (1992) observes that working animals, mainly zebu oxen are used in areas such as Machakos where 80 percent of farmers use draft animals. There is a strong pull from the urban labour market (Nairobi) resulting in relatively high labour costs and some absentee farming. Therefore, the use of oxen for draught power as opposed to hand labour proves to be time

and labour saving. In the Maasai rangeland, no cattle are used for cultivation (Starkey, 1986).

Nearly all the draught cattle of Africa are indigenous breeds and either come from the small herd of the farmer or purchased from other farmers or pastoralists. In either case, the animals are primarily bred for their draught qualities since the cattle are an integral part of complex farming and social systems. In Ibrahim (1999) there is a case for the use of cross – breeds of indigenous and exotic breeds in Ethiopia for draught purposes provided the cross – bred animals are adequately adapted and sufficient feed resources are available. In most cases, farms are small and draught power is required for relatively short periods each year and farmers may not be in a position to continue maintaining draught oxen specifically for work purposes. Therefore, the use of multipurpose dairy draught cattle is seen to provide several advantages apart from milk production. In addition, research has shown that crossbred cows can perform draft work and still efficiently produce milk and calves (Zerbini and Wold, 1999). In Kenya, the use of cross – bred dairy animals for draught purposes is not common.

## **2.5 Cattle Production Systems in Kenya**

Agroecology plays a significant role in determining the cattle breeds kept, the objectives of production and consequently the production system. There are three major land - based systems producing milk in Kenya; crop – livestock pastoralism and agro – pastoralism systems. First, the crop – livestock system is common where farms and herd sizes are small. Cattle are used for traction, subsistence milk, manure and as a risk diversification strategy (Omore *et. al.*, 1999). Within this system, farms can be divided by level of intensification. At low population density, crop and animal production is extensive, that is, they use more land per unit of output than do intensive techniques. Extensive agriculture allows few crop – livestock interactions. The distinction between extensive and intensive agriculture refers to the amount and type of productive factors used in a given agroclimate (McIntire *et. al.*,

1992). Agroclimate refers to the complex of factors that constitute the agricultural resource base and determine the potential productivity of farming. Agriculture intensifies in response to population growth and changes in markets; and where new markets or technologies create opportunities for growth, intensive agriculture is stimulated further (*ibid.*).

The smallholder dairy systems of the Kenya highlands are an example of intensive small – scale production systems in which crops and livestock are closely integrated and where market factors have been crucial to dairy development. In this system, high population growth has resulted in reduction in land – holding sizes and farmers have adopted a dairy enterprise (mainly upgraded dairy breeds), which is closely integrated into multi – objective farming system that also relies on cash crops. The most intensive dairy producing areas are found within 150 Km of the capital, Nairobi (McDermott *et. al.*, 1999). The proximity to the large urban market where there is large demand for liquid milk encourages production.

The semi – intensive systems are characterised by a lower human population density compared to the intensive systems, the dairy animals rely mainly on grazing and the breeds are the same as those in the intensive areas though with a higher local zebu content: In the extensive systems, more land and less labour is used per unit of output. Livestock mainly rely on grazing and are mainly local zebus. The land sizes are also relatively large compared to the other two systems (McIntire *et. al.*, 1992).

Secondly, an example of the pastoralism system is that practised by the Maasai community in Kenya, in the sparsely populated semi – arid range - lands. They have large herd sizes averaging 100 – 170 cattle and many sheep and goats (Grandin, 1983). The livestock holdings represent a close approximation of wealth, though the potential milk off - take is low. The word used is “emali”, meaning property but most commonly used with specific reference to livestock holdings (de Leeuw *et. al.*, 1999). The amount of milk and meat

produced from the pastoralists' herd has continually become inadequate to feed the families as it used to in the past (Laswai *et. al.*, 1999). As a result, they are forced to take up other economic activities in order to spread risks and reduce the need to sell livestock for purposes of food purchases.

Some of the coping strategies taken against the risky environment are crop cultivation (agro – pastoralism), subsistence sources of income such as migrant wage labour and petty business. This characterises the agro – pastoralism system. Cultivation is mainly for subsistence production of food crops such as maize, beans and sweet potatoes. This has resulted into changes in their eating habits from meat and milk to grain foods for survival and to a more sedentary type of livelihood. However, livestock still plays a major role in the agro – pastoralists' livelihoods both in terms of wealth, status display and insurance against crop risks.

Kenya has a cattle population of 13,976,000 of which 2,174,000 are exotic dairy animals (Peeler and Omore, 1997). The smallholder dairy cattle herd comprises 20 percent of the cattle population in Kenya and produces an estimated 56 percent of the milk from cattle. The dairy and indigenous cattle production systems in Kenya have been sub - divided into four broad classes (two large and two small scale systems) reflecting the genotype, the major product(s) or objectives of production and the physical (climate), biological (flora and fauna) and socio – economic (market orientation and management input classified as intensive, semi – intensive and extensive) environments (*ibid.*).

The large - scale systems are: (i) intensive and semi – intensive dairy production with *Bos taurus* cattle that is entirely market oriented. (ii) extensive dairy – meat or pastoralism with *Bos indicus* (East African Zebu) cattle. The small scale systems are: (i) intensive rural dairy – manure production with *Bos taurus* and crossbred dairy cattle that is mostly market –

oriented. This system has the majority of dairy cattle and the highest concentration is found in the Central and Rift valley provinces. (ii) semi – intensive dairy – meat – draught – manure production with *Bos indicus* and a few crossbred dairy cattle that is mainly subsistence oriented.

Small - scale production is dominant particularly where exotic cattle and their crosses are adopted. Production is based on the close integration of dairy cattle into the crop – based enterprises. An important element of small - scale production systems is the use of manure to fertilize food and cash crops, allowing sustained multiple cropping on the small land holdings (McDermott *et. al.*, 1999). Factors such as climatic potential, population density and market incentives influence the cattle breed types and cattle distribution in an area.

## **2.6 Conclusion**

The above studies generally focus on the marketable and intermediate contributions of cattle keeping. They qualitatively describe the socio – economic functions that cattle assume on the livelihoods of smallholder farmers. However, they do not go a step ahead to estimate the value of these socio – economic functions. From the literature reviewed, only Bosman *et. al.* (1997) and Moll *et. al.*, (2001) have attempted to value these non – market functions using a cost benefit approach based on opportunity costs. Slingerland (2000) has added both short term as well as long – term cost components into the model, making it very complex and difficult to operationalise. Both approaches however, do not take into account, the livestock keepers' perception, behavioural function or other factors such as available resources or household factors that may influence the valuations. Models that can be used to describe these behavioural functions include the discrete choice models, which mainly include probit, logit, and tobit. This is the gap that this research intends to fill.

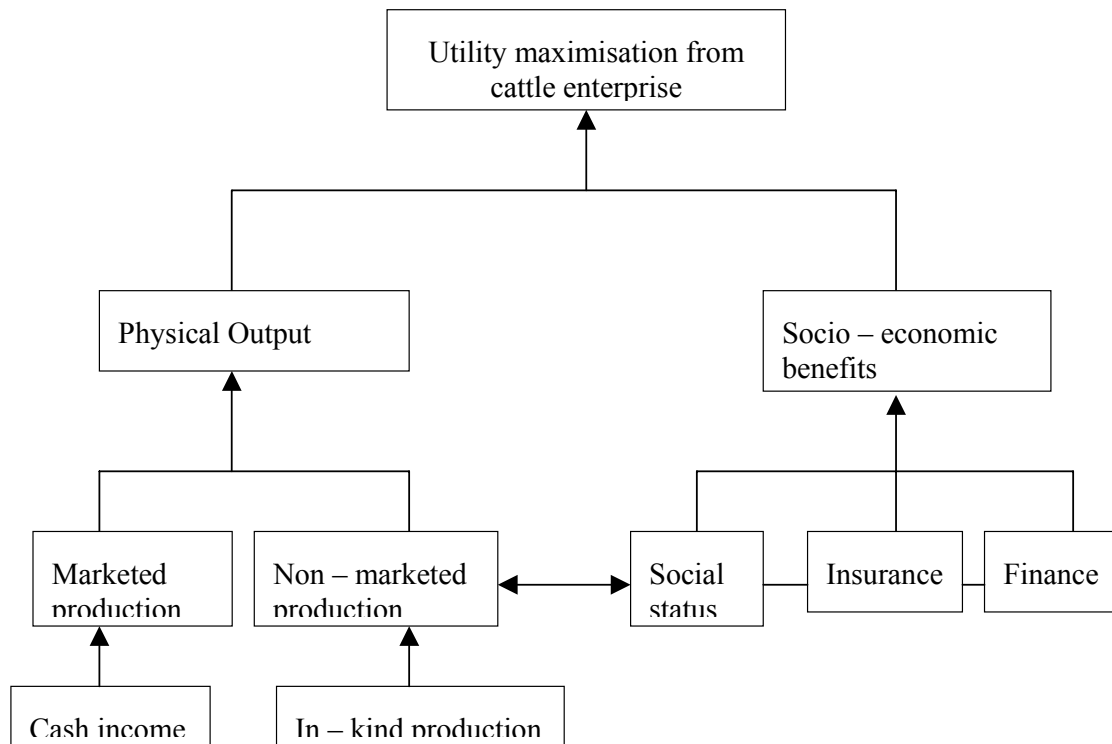
## CHAPTER THREE

### 3. CONCEPTUAL FRAMEWORK

This section contains discussions on the conceptual framework of the study. The framework derives from the agricultural households model. Second, an overview of the available approaches for assessing non – market goods demand is also presented.

#### 3.1 Utility Maximisation and the Cattle Enterprise

The framework explains the contribution of market and non-market benefits to utility maximisation from the cattle enterprise by cattle keeping households. The household's objective function is utility maximization. Agricultural household models have been developed over the years to study smallholder agriculture (Singh *et. al.*, 1986).



**Figure 5: Conceptual framework of utility maximisation from cattle enterprise**

These models assume that households maximise utility subject to constraints on total income,

time available, production technologies, and available land and capital. In addition, an implicit production function for the non – market benefits is conceptualised in this study. These benefits enter positively into the household’s utility function. The household have a demand for the non-market benefits in a manner similar to its demand for other goods such as food and leisure. The mathematical expression of the model can be presented thus;

$$\begin{aligned}
 & \text{Max } U = U(C^a, C^m, C^l, C^{nm}; Z^h), \text{ utility function} & (5) \\
 & \text{s.t.: } Q^a = Q^a(x, l; z^q), \text{ production function,} \\
 & \sum p^m q^m + \sum p^x q^x + w^{\text{hired}} L^{\text{hired}} \leq P^a (Q^a - C^a) + w^{\text{Non-farm}} L^{\text{Non-farm}} + E, \text{ income constraint} \\
 & L = L^{\text{Family}} + L^{\text{hired}}, \text{ labour allocated to agricultural activity} \\
 & T = C^l + L, \text{ time constraint} \\
 & C^{nm} = C(\text{manure, insurance, finance, social status}), \text{ non – market benefits}
 \end{aligned}$$

Where:

$C$  is consumption of goods ( $a$  = agricultural e.g. milk;  $m$  = not produced by hh;  $nm$  = non-market benefits from cattle enterprise)

$Z^h$  is a vector of household characteristics

$Q^a$  is the production function of an agricultural good

$x$  and  $l$  are two variable factors with price  $p^x$  and  $w$  respectively

$Z^q$  represents the fixed factors and firm characteristics

$w$  is the wage rate

$E$  is exogenous income (e.g. gifts and remittances)

This model provides a framework, as to the variables that influence household utility maximisation. Utility is realised from consumption of bundles of goods, which are either produced on farm, such as milk or non - agricultural goods such as manufactured products. In addition, the household derives utility from the non – market benefits from cattle. The non – market benefits from cattle is a function of manure produced and utilised on – farm, and the

socio – economic benefits of cattle. The socio – economic functions of cattle is realised in the role of cattle in financing, insurance and display of social status (Figure 5).

If perfect markets exist for all products and factors, then all prices are exogenous to the household and all products and factors are tradables with no transaction costs. Existence of perfect markets is not practical since the farm household is typically located in an environment characterised by a number of market failures for some of its factors and products. For instance, there are no markets for the socio – economic products of cattle. There is, therefore, the risk of excluding these benefits from the profit function on the part of the analyst, disregarding its importance to the producers. An extreme case of market failure is simply non – existence of a market. A market may also fail for a household when it faces wide price margins between the low price at which it could buy that product or factor. The magnitude of the price band may be increased by factors such as transaction costs which includes high transportation costs due to distances from the market and high marketing margins due to middlemen; shallow local markets, which imply a high negative covariation between household supply and effective prices; and price risks and risk aversion which influence the effective price used for decision making (Sadoulet and de Janvry, 1995).

With market failure, the corresponding good or factor becomes a non – tradable. Its “price” is no longer determined by the market, but internally by the household as a shadow price. If the market is not used for a transaction, the household behaves as if a market existed within the household for the non - tradable. Equilibrium of supply and demand on this fictitious market determines a shadow price that serves as the decision price for the household (Sadoulet and de Janvry, 1995). Determination of this shadow price, involves directly eliciting the value that the farmer places on his or her cattle. This requires a method for ascertaining the value of a service which has no market value or for which the market value does not reflect the true

value.

Economists have developed these methods, based on individual preferences criterion. These methods are either based on observed behaviour towards some marketed good or service of interest which has a relationship with the non – marketed good, termed “revealed preferences” or based on eliciting “stated preferences” in surveys concerned with the good or service of interest. Methods of observing revealed preference include the travel cost method, which elicits the cost incurred by a respondent in visiting and using a park for example. Stated preference methods, ask the respondents to state the value they put on a good or service, which they may or may not have used.

The stated preference valuation mainly uses direct elicitation methods, although there are also indirect methods. In the case of indirect stated preference methods, people are asked to respond to hypothetical markets, but their responses are only indirectly related to valuing the good of interest. The indirect methods include contingent ranking, indifference curve mapping, allocation games priority valuation technique and conjoint analysis. Direct stated preference methods can be less complex than indirect methods. The direct methods include spend more – same – less survey questions, allocation game with tax refund and contingent valuation (Mitchell and Carson, 1989). The contingent valuation method uses responses to questions posed to consumers to infer preferences and willingness to pay (WTP) for a product without a market price.

### **3.2 Non – Market Goods Demand and the Stated Preference**

Benefit cost analysis using the stated preference direct elicitation method, is the basis used in formulating the analytical framework for this study. It derives from welfare economics theory. Benefit cost analysis, the applied side of modern welfare economics, operationalises a

variant of the pareto criterion by trying to find ways to place a shilling value on the gains and losses to those affected by a change in the level of provision of a public good.

According to Mitchell and Carson (1989), there are two key assumptions of positive economics upon which welfare economics theory is based. The first one is that economic agents when confronted with a possible choice between two or more bundles of goods have preferences for one bundle over another. Secondly, through its actions and choices, an economic agent attempts to maximise its overall level of satisfaction or utility. Both assumptions have important implications for the contingent valuation (CV) approach. Contingent Valuation is a survey - based stated preference methodology that provides respondents the opportunity to make an economic decision concerning the relevant non - market good. Values for the good are then inferred from the induced economic decision (Carson, 2000).

Two basic characteristics of benefit cost analysis follow from the positive economics foundation. The first is the acceptance of consumer sovereignty, a principle embodying the belief that the consumer is a better judge of what gives him utility than anyone else, the second is a tendency of benefit cost analysis to emphasise on economic efficiency rather than distributional issues. The contingent valuation method is consistent with the consumer sovereignty assumption and is unique among benefit measurement techniques in its ability to obtain detailed distributional information. In CV studies, individuals are presented with a realistic but hypothetical situation and then asked questions about the maximum amount of money they would be willing to pay (WTP) for amelioration from the *status quo* or the minimum amount of compensation they would be willing to accept (WTA) for deterioration from the *status quo*. By determining their WTP or WTA for a good, CV seeks to place a figure on the benefits people derive from consuming such a good. The assessment of WTP

through CV has a sound theoretical basis in welfare economics (Mitchell and Carson, 1989).

Contingent valuation was developed in the environmental field to assess the value of “intangible” items. The initial applications of the CV method in developing countries were in the following areas; water supply and sanitation, recreation, tourism and national parks. It has subsequently been used in a variety of situations to provide a guideline for setting a price for an intangible good or service. The areas of applications are growing rapidly and now include surface water quality, health care services and biodiversity conservation (Klose, 1999; Echessah *et. al.*, 1997).

If a demand for a good or service exists, this is reflected in willingness and ability to pay for it, whether or not the demand is normally expressed in a monetary transaction. CV has the advantage over the revealed preference methods of being able to estimate total economic value (Whittington, 1998). In addition, CV results in data that can be directly analysed using conceptual models. Since the non-market benefits of cattle are non – market goods, the contingent valuation technique is appropriate in this context.

CV methods also have some disadvantages due to the fact that it uses hypothetical rather than actual markets. It provides opportunities for respondents to behave in a strategic way. Strategic bias is minimised in this study through use of closed-ended approach in elicitation of WTP rather than open-ended.

## CHAPTER FOUR

### 4. METHODOLOGY

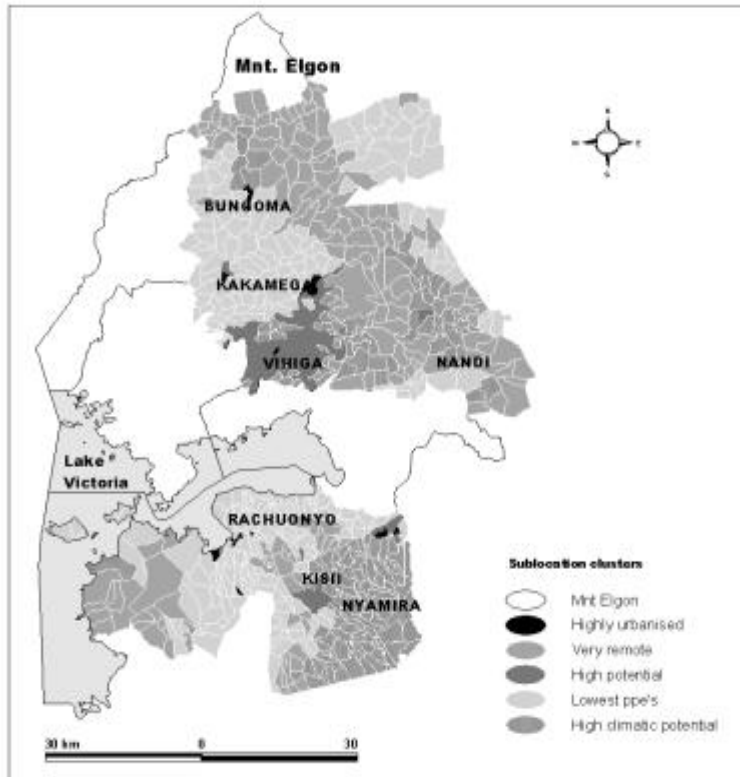
This chapter presents a description of the methods employed in this study. The study was a follow up of a DFID funded project work; the Smallholder Dairy (R&D) Project, a collaborative project between three institutions namely; ILRI, KARI and MoARD. The chapter begins with a brief description of the Smallholder Dairy Project work in Western Kenya since it contributes to the study's sampling framework. It further presents the methods employed in selection of the respondents, data collection instruments and the analytical methods used.

#### 4.1 Survey Design

The Smallholder Dairy (R&D) Project selected research sites in seven districts (Bungoma, Kakamega, Vihiga, Nandi, Rachuonyo, Kisii and Nyamira) using cluster analysis approach with an objective of characterising dairy production systems in the region. To give a rough description of the region, spatial analysis of geo - referenced secondary data was done by overlaying various data layers. This resulted in describing areas with potential dairy development and clustering districts and sub-locations into groups with similar dairy-related factors that provided a basis for survey area selection (Figure 6).

A simple random sample of 1,563 households for the whole area was obtained. The characterisation survey data was used as a guide to identify the different cattle keeping systems across the sites and hence selection of farms for this study. The study utilized three crop - livestock systems; smallholder intensive, semi – intensive and extensive cattle keeping systems. The smallholder dairy intensive system is characterised by declining farm sizes, upgrading into dairy breeds and an increasing reliance on purchased feeds, both concentrates

and forage. This system was mainly found in Kisii and Vihiga districts. In land – extensive systems, smallholder dairy production relies on grazing to a greater extent and the breeds are mainly local zebus (McDermott, *et. al.*, 1999). These systems were found in Bungoma and Rachuonyo districts.



**Figure 6: Clusters of similar sub – locations in Western and Nyanza provinces**

Source: Waithaka *et. al.*, 2000 pg 10

#### **4.1.1 Sample Selection**

The sampling frame for this study was cattle keeping households in Kisii and Rachuonyo districts from the characterisation survey. Simple random sampling was done to select two hundred and fifty five cattle – keeping households in nine sub – locations of Masaba and Suneka divisions in Kisii district and eight sub-locations of Kasipul and West Karachuonyo divisions in Rachuonyo district. One hundred and twenty nine cattle keeping households

were interviewed from Kisii and one hundred and twenty six from Rachuonyo districts. Three cattle feeding and keeping systems were identified (Table 2); extensive (open – grazing), semi- intensive (semi – zero grazing) and intensive (zero – grazing).

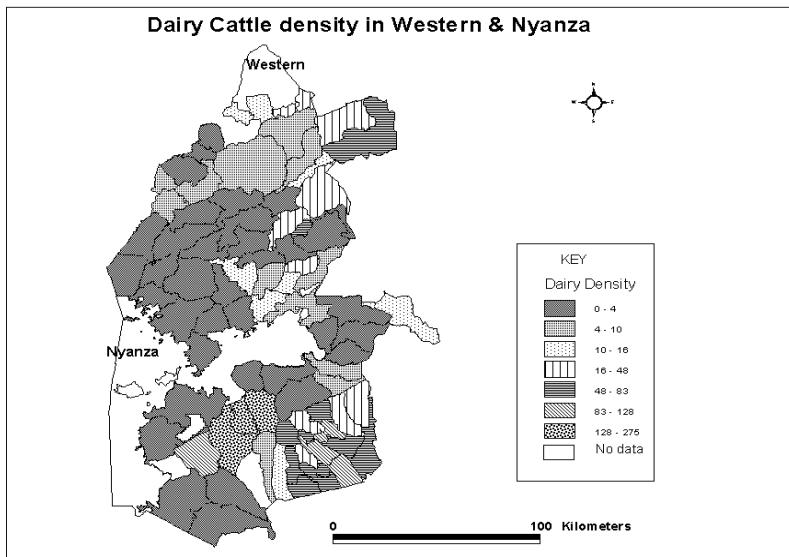
**Table 2: Cattle grazing systems in the survey area**

System type	Number of households	Percent of households
Mainly grazing	132	52
Semi – zero grazing	111	43
Zero - grazing	12	5
Total	255	100

**Source:** *Survey results, 2002*

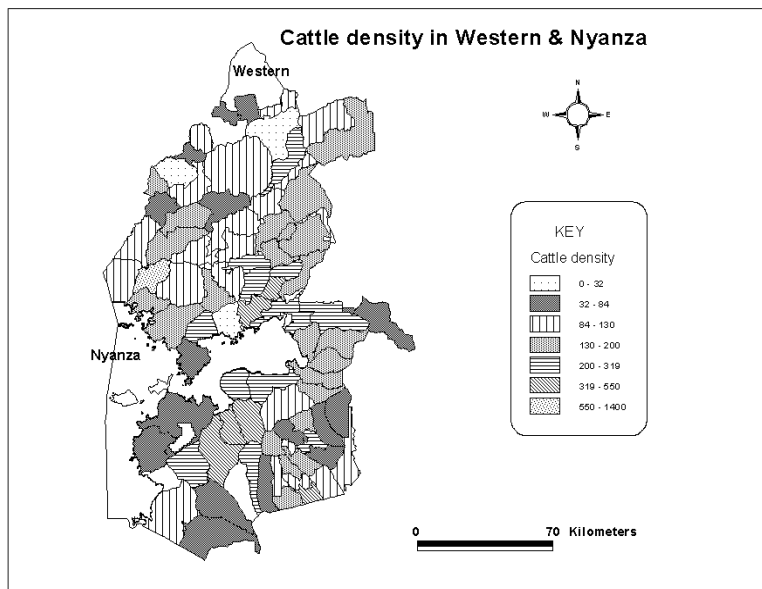
Much of the open grazing and semi – zero grazing is practised in Rachuonyo and Kisii districts respectively. Compared to Rachuonyo, Kisii has a favourable agroecology for crop and livestock production. However, the human population growth has resulted in diminishing land sizes, through subdivision and fragmentation. There is therefore general lack of grazing areas in Kisii as opposed to Rachuonyo district. This has had an important influence on the cattle feeding and management systems as well as the cattle breeds kept. The data was collected between February and April 2002.

Generally, in western Kenya, the prevalence of dairy cattle is at low levels as opposed to the zebus as seen in Figures 7 and 8. This is due to low feed supply during the dry season and poor husbandry methods. In some cases, the high prevalence of zebus is associated with the cultural practices of dowry payment and prestige since the number of cattle per household is more valuable than the quantity and quality of their produce (Waithaka *et al.*, 2000)



**Figure 7: Dairy cattle density (per Sq. Km) in Western and Nyanza provinces**

Source: *ILRI Geographic Information Systems Database*



**Figure 8: Cattle density (both zebu and dairy) in Western and Nyanza provinces**

Source: *ILRI Geographic Information Systems Database*

## **4.2 Data Collection**

Collection of data was performed using questionnaires that were administered to cattle keeping households. The survey covered issues related to valuation of non – market benefits of cattle keeping by using the Analytical Hierarchy Procedure and Contingent Valuation method. The questionnaire was focused on ranking of the benefits derived from cattle keeping as well as the willingness to pay for the socio – economic functions of cattle keeping after the imposition of a hypothetical scenario. Household related characteristic variables were also collected in addition to animal and system related characteristic variables.

### ***4.2.1 Elicitation of Willingness to Pay***

To introduce the willingness to pay section of the questionnaire, respondents were asked to outline the objectives or reasons for keeping different categories of cattle. Next, they were asked to give their perceived value of the animal, this is not necessarily its market price. Subsequently, a hypothetical scenario was posed whereby they were to suppose that a new government policy was in place, restricting movement and sale of the animals. As a result, the farmer loses control of disposal of the animal through sales and dowry payment. Consequently, he loses the dowry payment, insurance and finance benefits, as he is unable to sell the animal to meet planned and unplanned needs. Next, using the original perceived value as the base the farmer was asked his “new” perceived value after this loss, using predetermined values. The difference between the “new” perceived value and the original perceived value gives the value of these socio – economic benefits.

Elicitation of WTP values can either be closed or open ended. When a continuous variable is used to measure WTP, as with open ended responses, a simple arithmetic mean can be calculated and ordinary least squares models used to explain the variation in the dependent

variable. Closed – ended responses can be obtained using discrete choice responses. Different models are required based on the probability that a respondent will answer, “yes” to the valuation question. Since the printed shillings amount varies across the sample, the discrete choice format allows analysts to statistically trace out the demand – like relationship between the probability of a “yes” response and the shillings amount.

Following Griffiths, *et. al.* (1993), one parametric approach to modeling discrete choice CV responses is based on the random utility model. The starting point is a respondent’s utility function. This is the way in which the good or service in question, together with other factors contribute to the well - being or utility of the respondent. Since the exact form of a respondent’s utility function is not known, some assumptions must be made about its form. Such models must include a random element to reflect the unobservable part of an individual’s utility function represented as:

$$U_{ij} = \bar{U}_{ij} + \varepsilon_{ij} \quad i = 1, \dots, T; j = 1, 0 \quad (6)$$

Where  $U_{ij}$  is the utility received by the  $i$ th individual from the  $j$ th alternative,  $\bar{U}_{ij}$  is the systematic part of the utility function, and,  $\varepsilon_{ij}$  the random part.

The individual’s utility is also a function of the attributes of the alternative to the individual and characteristics of the individual such as income, educational attainment etc. Hence, the indirect random utility model for  $U_{ij}$ , the unobservable economic variable utility becomes;

$$U_{ij} = z'_{ij}\alpha + c'_i\beta_j + \varepsilon_{ij} \quad (7)$$

Where  $z'_{ij}$  is the vector of attributes of alternative  $j$  to individual  $i$ ,  $c'_i$  is the vector of characteristics of individual  $i$ , and  $\alpha, \beta_j$  ( $j = 1, 0$ ) are vectors of unknown parameters.

In discrete choice CV questions, the respondent is offered two choices, the “*status quo*” and

the “change in the *status quo*”. From the above utility function, the probability that the respondent will answer “yes” is the probability that their utility with the proposed change (alternative 1) is greater than their utility without the proposed change (Alternative 0). Thus;

$$\begin{aligned}
 P_{1i} &= \Pr[\bar{U}_{i1} + \varepsilon_{i1} \geq \bar{U}_{i0} + \varepsilon_{i0}] \\
 &= \Pr[\varepsilon_{i0} - \varepsilon_{i1} \leq \bar{U}_{i1} - \bar{U}_{i0}]
 \end{aligned}
 \tag{8}$$

Where  $P_{1i}$  is the probability that the  $i$ th respondent will answer, “yes” to an offered price,  $u_{i0}$  is the respondent’s total utility in the *status quo*;  $u_{i1}$  is the utility with the change. In this study, a hypothetical scenario is paused and a willingness to pay function estimated to assess the socio – economic values of cattle.

### **4.3 Analytical Methods**

The gathered mini survey data was entered into the MS Access computer program and both descriptive and econometric analytical procedures adopted for data analysis using STATA software. To assess the value of non – market benefits of cattle keeping using contingent valuation method, a Tobit model was fitted to obtain estimates of factors that jointly influence the probability of a “yes” response to a WTP amount and the level. Secondly, a complete budget analysis was undertaken for the three systems to assess the competitiveness of the systems when the non-market benefits are taken into consideration and finally, a multiple regression model was fitted to obtain estimates of factors that influence the probability of keeping cows longer than their optimal period.

#### ***4.3.1 The Tobit Model and Willingness to Pay Function***

The WTP function can be likened to the demand function for the socio – economic product of cattle. This function has a censored distribution since the WTP is zero for those

not demanding the socio – economic product of cattle. In cases like this (where the dependent variable is only observed in some range), the application of Tobit analysis is preferred because it uses both, data at the limit as well as those above the limit to estimate regressions (McDonald and Moffit, 1980). According to Maddala (1992), the standard Tobit model can be defined as:

$$Y_i = Y_i^* = \lambda X_i + \mu_i \text{ if } Y_i^* > 0$$

$$\text{Otherwise, } Y_i = 0 \text{ if } Y_i^* \leq 0 \tag{9}$$

The model assumes that the random error term  $\mu_i$ , is normally and independently distributed with mean = 0 and constant variance  $\sigma^2$ . If the non-observed latent variable  $Y_i^*$  is greater than 0, the observed qualitative variable  $Y_i$ , which is indicative of the socio-economic WTP value, becomes a continuous function of the explanatory variables,  $X_i$  which represents a vector of independent socio – economic and institutional variables. On the other hand, if  $Y_i^*$  is less than or equal to 0,  $Y_i$  becomes zero implying that there is no demand for socio-economic product of cattle.

The interpretation of Tobit coefficients is rather more complicated than the interpretation of ordinary least squares coefficients. This is because the ordinary output from Tobit analysis provides only one coefficient for each independent variable, despite the presence of two types of cases in the analysis. These two types of effects are predicted for each independent variable. For nonzero (or nonlimit) values of  $Y$ , the Tobit model yields the effect of the independent variable on values of the dependent variable. For zero (or limit) values of  $Y$ , the model yields the probability of observing a nonzero (or nonlimit) value of the dependent variable. Therefore, by itself a Tobit coefficient cannot directly describe these two different effects and, as McDonald and Moffitt (1980) noted, researchers often misinterpreted these

coefficients.

These errors can be avoided by focusing on the statistical significance of the coefficients and their magnitudes, then decomposing the coefficients into the two effects. Roncek (1992) reinterprets Tobit coefficients obtained by Walton and Ragin (1990) according to McDonald and Moffitt's decomposition technique, and obtains a great deal of information from their coefficients which they failed to discuss. Walton and Ragin's study explored the effects of debt crisis on the severity of protests in developing countries. They had an N of 56 countries, of which only 26 had recorded protests, while 30 did not. A recorded protest was one, which was severe enough to merit international media attention. It follows that some of the countries may have had protests, but they were not severe enough to have captured the attention of the media. Therefore, the protest severity score for countries without recorded protests was unobservable, and presumably would have been less than zero on their scale, had such a score been empirically possible. Roncek simply demonstrates how breaking down the coefficients would yield the effects demonstrated by McDonald and Moffitt.

Following McDonald and Moffitt (1980), the coefficients obtained from the Tobit analysis are decomposed to show the effect of changes of the independent variables in the probability and level of WTP. The basic relationship utilized in conducting the decomposition follows from results obtained by Tobin (1958) given as:

$$E(y) = F(Z) * E(y^*) \quad (10)$$

In the context of WTP, the terms in the equation can be interpreted as:

$E(y)$  = Expected value of the dependent variable across all the observations

$E(y^*)$  = Expected value of the dependent variable given that the farmer is willing to pay and

the only concern is the level he is willing to pay.

$F(Z)$  = Probability of WTP for those willing to pay (probability of being above the limit).

To get the effect on WTP behavior due to a change in any one of the dependent variables, equation 9 is differentiated with respect to  $X_i$

$$\partial E(y) / \partial X_i = F(Z) [\partial E(y^*) / \partial X_i] + E(y^*) [\partial F(Z) / \partial X_i] \quad (11)$$

Multiplying through by  $X_i / E(y)$ , we get

$$[\partial E(y) / \partial X_i] X_i / E(y) = F(Z) [\partial E(y^*) / \partial X_i] X_i / E(y) + E(y^*) [\partial F(Z) / \partial X_i] X_i / E(y) \quad (12)$$

Rearranging equation 12 using equation 10 whereby

$F(Z) = E(y) / E(y^*)$  and  $E(y^*) = E(y) / F(Z)$ , we get

$$[\partial E(y) / \partial X_i] X_i / E(y) = [\partial E(y^*) / \partial X_i] X_i / E(y^*) + [\partial F(Z) / \partial X_i] X_i / F(Z) \quad (13)$$

This implies that total elasticity = WTP level elasticity + WTP probability elasticity

Tobin (1958) show that consistent estimates of  $\beta$  and  $\sigma$  are obtained by using maximum likelihood techniques, where  $\text{plim}(b) = \beta$  and  $\text{plim}(s) = \sigma$ .

The formation of the Tobit model in this study was influenced by a number of working hypotheses. It was hypothesized that the producer's demand for the socio – economic functions of cattle is influenced by the combined effect of household related characteristics as well as animal related characteristics. The Tobit estimation model is specified as follows;

$$Y_i = \lambda_0 + \lambda_1 OFFINC + \lambda_2 DEPRAT + \lambda_3 CATTLETYPE + \lambda_4 HRDSZE + \lambda_5 CREDIT + \lambda_6 ANAGE \\ + \lambda_7 LSIZE + \lambda_8 ANSEX + \lambda_9 MLKPRC + \lambda_{10} GENDER + \lambda_{11} HHS + \lambda_{12} SYST + \lambda_{13} PPE \\ + \lambda_{14} INFKM2 + \lambda_{15} EDUCYRS + e_i$$

$$\text{Otherwise } Y_i = 0 \quad (14)$$

Where  $\lambda_l$  are the coefficients to be estimated and  $e_i$  are the error terms.

The dependent variable,  $Y_i$  is the proportion of the value of non – market benefits (WTP amount) to total value of the animal. The exogenous variables are described in Table 3. The dependent variable is based on animal level observations, while the independent variables are a mixture of animal and household level variables. This implies chances of multiple observations per household, yielding observations that are not necessarily independent within the household but independent across households. This requires a robust estimator of variance, which has the ability to relax the assumption of independence of the observations to being independence across households. A Tobit model that produces robust standard errors is therefore estimated.

**Table 3: Description of variables specified**

Variable acronym	Variable meaning	Variable description	Variable Measurement	Mean	S.D.	Minimum	Maximum
HEIFERS	Animal type	1= Heifers, 0 otherwise	Dummy	0.22	–	0	1
BULLS_OX	Animal type	1= bulls/oxen, 0 otherwise	Dummy	0.16	–	0	1
CALVES	Animal type	1= calves, 0 otherwise	Dummy	0.18	–	0	1
UPGSTSEM	Breed type*feeding system	Interaction between upgraded breeds and stall feed and semi – zero system	Dummy	0.35	–	0	1
INDGRAZE	Breed type*feeding	Interaction between indigenous breeds and grazing system	Dummy	0.55	–	0	1
INDSEMI	Breed type*feeding	Interaction between indigenous breeds and semi -zero system	Dummy	0.10	–	0	1
ANAGE	Age of the animal	Age of the animal	Years	4.6	3.5	0.1	18
ANAGE2	Age of the animal	Age of the animal, squared	Years <sup>2</sup>	33.0	46.1	0.01	324
HRDSIZE	Herd size	Tropical Livestock units	TLU	3.6	3.1	0	28.5
LSIZE	Land size	Total land owned by household	Acres	5.0	5.9	0	49
DEPRAT	Dependency ratio	Ratio of number of dependants (<5 years and > 65 yrs in the household) to household size	Ratio	0.8	0.4	0	1.5

Variable acronym	Variable meaning	Variable description	Variable Measurement	Mean	S.D.	Minimum	Maximum
HHS	Household size	Factors used are 1 if >15 years of age, 0.5 if between 6 and 14 years, 0.25 if <5 years	Adult equivalent	5.3	2.1	1.5	12
GENDER	Sex of decision maker	1 = Male 0 = Female	Dummy	0.8	_	0	1
HEAD_AGE	Age	Age of household head	Years	53.1	13.2	21	90
EDUCYRS	Number of education years	Number of education years of household head	Years	7.9	4.6	0	16
CREDIT	Access to credit	1= Yes, 0 otherwise	Dummy	0.4	_	0	1
OFFINC	Annual off – farm income	Value in KSh	KSh	68942.0	21,4069.3	0	2,256,000
TOTINC	Total income	Value in KSh	KSh	97743.0	22,5302.2	0	2,294,400
INFKM2	Market access indicator	Market access indicator: Distance to nearest informal milk collection point on murram road	Km	5.8	7.9	0	34.1
SMALLKM2	Market access indicator	Market access indicator: Distance to nearest small urban centre on tarmac road	Km	9.3	7.6	0	27.0
URBKM2	Market access indicator	Market access indicator: Distance to nearest large urban centre on murram road	Km	23.0	10.9	0	49.0

Variable acronym	Variable meaning	Variable description	Variable Measurement	Mean	S.D.	Minimum	Maximum
ACCESS	Market access indicator	Market access indicator - Travel time		167193.0	49030.1	48,237.1	265,797.2
MLKPRC	Milk price	Per litre price of milk	KSh	27.8	3.7	21.25	33.3
ANSEX	Sex of animal	1 = Male 0 = Female	Dummy	0.3	_	0	1
CALV_YEAR	Calvings/year	Calvings per year of age		0.37	0.1	0.1	0.75
MILK_LT	Milk production	Average daily milk production	Lt.	2.7	2.7	0.3	20.25
DIST	District	1= Kisii 0=Rachuonyo	Dummy	0.28	_	0	1
SYST	Grazing system	1 = Grazing, 0 otherwise	Dummy	0.73	_	0	1
PPE	Precipitation over potential evapo - transpiration	Ratio of amount of rainfall over potential evapo - transpiration	Ratio	0.94	0.3	0.73	1.34
NONMKT	Non market benefits	Value in KSh	KSh	5364.2	531.4	4386.6	7110.8
POPDENS5KM	Population density	Population density in a 5 km buffer around each household	Number of persons per square km	405.5	159.8	183.1	795.7

The different cattle types are included as explanatory variables in the model because different socio – economic values may be placed by the producers on different cattle types. For instance, farmers may prefer to sell male animals to meet financial obligations as opposed to female animals since sales of the latter may adversely affect production.

The cattle feeding systems to a large extent, is influenced by the type of cattle breeds kept. In the intensive systems, investment costs are high and the objective is mainly market-oriented production as opposed to the less intensive systems. Therefore it is expected that socio – economic values of cattle would tend to be higher in the less intensive systems.

The age of the animal is also introduced as an explanatory variable since it is expected that, older animals may have a higher socio – economic value than the young stock. This is expected to rise up to a point then start declining when costs outweigh benefits. This is the rationale behind introducing the variable age and age – squared as explanatory variables.

Herd size is expected to have a positive influence on the socio –economic value of cattle. As the herd size rises, then the higher the chance cattle are kept as a store of wealth. Herd size is measured in terms of Tropical Livestock Units. A Tropical Livestock Unit is an animal of approximately 250 Kg live - weight.

Land size is introduced as an explanatory variable since it influences credit access in the form of collateral. It is therefore expected to have a negative influence on the socio – economic value of cattle, especially in areas where credit is available but households have no access due to lack of collateral.

Dependency ratio and household size are expected to have a positive influence on the value of the socio – economic benefits. This is because of the high financial obligations

associated with a high number of dependants and household size.

Households that are female headed are expected to place higher socio – economic values on their animals than their male headed counterparts since they have low access to financial and insurance alternatives. The number of years spent acquiring education is also introduced as an explanatory variable. It is expected to have a negative influence on the socio – economic benefits of cattle, since a higher number of education years by the household head may increase opportunities for off – farm employment (white collar jobs) if there are no distortions in the labour market. Off – farm employment may also increase chances of access to credit and insurance. Households that have access to credit may not place high values on the socio – economic roles of cattle, since credit is a financial alternative.

Market access variables are included as explanatory variables in the model. Market access influences producers' access to input and output markets. It is a very important factor in smallholder dairy production. Market access encompasses several elements, one of which is the distance between the point of observation and some market destination or combination of destinations. The market access variables used in this model are GIS variables derived by Staal *et al* (2002). The market access measures are calculated using road networks connecting points with specific destinations. GIS (Geographic Information Systems) data make distance and other spatial measures more accurate as opposed to previous methods of representing these variables in the form of dummy variables, used as a proxy to measure a variety of spatial factors. This makes interpretation of observed outcomes difficult to associate with a specific factor. Since most of milk production in Kenya is marketed informally, distance to the nearest informal market variable is used as an explanatory variable. It is expected to have a positive sign since producers further from informal markets may be less market oriented and place higher values on the non – market value of cattle.

PPE, a GIS derived spatial variable of rainfall and temperature is also incorporated as an explanatory variable. It is expected to have a negative influence on the value of socio – economic functions of cattle since a higher value of PPE implies favourable agro – climate for fodder and dairy production, which tends to be more market oriented than the traditional extensive systems.

#### ***4.3.2 Budget Analysis***

A complete budget analysis is undertaken for the cattle enterprise for the different livestock production systems. This enables the assessment of the contribution of non – marketed benefits to the competitiveness of the livestock production systems. The benefits include both marketed as well as non – marketed benefits since the household’s objective is to maximise its utility. These benefits are observable by the cattle keepers who are both producers as well as consumers, with total benefits resulting from utilisation of the household’s production factors. These factors can be used in alternative on – farm and off – farm enterprises hence; the total benefits are compared with the returns to these factors in alternative enterprises (Moll *et. al*, 2001; Staal, 2001).

Profitability of an enterprise is one indicator for assessing competitiveness of the enterprise. For an enterprise to be competitive, it should at least earn normal profits. Normal profits are realized when the enterprise generates enough shillings to exactly pay the best alternative return to the investment (operator's labor, management, and equity capital). An enterprise earning above normal profits can be considered worthwhile and competitive relative to other enterprises since the returns to the factors of production (labor, management, and equity capital) are greater than their opportunity costs. These profits above the normal profit are regarded as economic profits.

Following Moll *et. al* (2001), the budget is composed of the recurrent cash and in kind production, recurrent purchased inputs, annual cost of capital items and the socio-economic value of cattle. The livestock production systems includes, the open grazing system characterised mainly by low input use, predominant occurrences of local breeds, low agricultural potential and extensive grazing as the main feeding system. There is relatively good market access, but due to unfavourable agro-climatic conditions for improved breeds, there is low intensity of milk production and focus is mainly on subsistence milk production and traction; the semi – zero grazing system is characterised by low input use, occurrences of local breeds and few upgraded breeds, medium market access and agricultural potential, and use of both open grazing, tethering and cut and carry fodder feeding systems; the zero – grazing system is characterised by high input use, presence of upgraded breeds, small land holdings, high agricultural potential, good milk market access and stall feeding as the main feeding system. The components of the budget are discussed below:

#### ***4.3.2.1 Recurrent cash and in-kind production***

Recurrent cash production generates revenue through sale of products and includes milk, and sale of stock. These are valued through markets where supply and demand conditions result in prices. However, recurrent production in kind is not marketed but consumed internally by the household. It includes products such as manure, milk consumed by the household, draught power and herd increase through births. In smallholder livestock systems, population pressure, consequent diminishing land sizes and poor soil fertility resulting from continuous cropping across seasons are challenges that have to be dealt with.

In mixed crop – livestock systems, manure is used in fertilisation of agricultural plots. An estimation of quantity of manure produced is done following Lekasi (2000), whose study in the Kenya Highlands indicate that a ruminant produces 0.8 % faecal DM of its bodyweight

per day. The average price of manure is obtained from farmers selling or buying manure in the survey area. Draught power is valued based on the average use of bulls/oxen and the price paid for ploughing. The farm gate prices for a unit price of milk is used for the computation of the home consumed milk and milk given away.

#### **4.3.2.2 Recurrent purchased inputs**

Recurrent purchased inputs includes annual cost of treatment of the animals, purchased concentrates and purchased fodder. Use of purchased inputs is common in intensive and semi – intensive systems. In the extensive systems, the main form of feeding is through grazing and occasional feeding of fodder trees such as *Greivia simplex* (poo), which is used as a drought management strategy. Natural salt lick is used to enhance palatability of the pasture. Other costs incurred from the enterprise include milk given away to relatives, friends, labourers and calves, and the cost of hired labour.

#### **4.3.2.3 Annual cost of capital items**

The annual cost of the capital items is obtained by calculating the annual equivalent values of these items used in the dairy enterprise using the capital recovery factor (crf) method, which recognizes the time value of money and converts the capital cost to an annualised cost using the formula below:

$$Annual\ value = initial\ cost * \left[ \frac{i(1+i)^n}{(1+i)^{n-1}} \right] \quad (15)$$

Where;

i = interest rate (15%), the opportunity cost of capital

n = Years of useful life