c. Level of access to output markets and input services.

As seen from the description of the survey results, there is considerable variation in the level of intensification of dairy activity between farm/households, where intensification is related to the level of purchased inputs per animal and the output of milk per acre of land used. Farm/household resources such as labour and capital may be critical to intensive dairy farming, where dairy requires labour for cut-and-carry feeding and capital for purchases of animals, cattle housing, feed or other inputs.

Market access is also important in this market-oriented system, which the survey showed to produce a large proportion of the milk marketed in Kenya, and where nearly 80% of extracted milk is marketed.

For each theme a set of variables, considered to reflect the primary measures of variability within that theme, was chosen. Table 23 below shows the variables used to indicate the level of intensification of dairy production system, including relative use of maize, napier grass, concentrates, the stocking rate, grazing system and density of milk production.

Table 23: Variables used to Indicate Level of Dairy Intensification

Name	Description	Mean (n=354)	Std dev
MAIZ_CAT	Acreage of maize planted per TLU of dairy cattle	0.59	0.82
NAP_CAT	Acreage of napier planted per TLU of dairy cattle.	0.19	0.42
CONC_CAT	Concentrate feed purchased, in Ksh, per TLU of dairy cattle	1,487	3,257
FODD_CAT	Fodder purchased, in Ksh, per TLU of dairy cattle	491	1,159
LAND_LIV	Total household land in acres per TLU of livestock	2.80	2.90
MILK-ACR	Milk produced per acre	2.16	2.72
COWFEED	Grazing system	2.55	1.15

Similarly, a set of variables was chosen to address the theme of household resources available to the dairy activity and to the farm/household in general. The variables selected as important measures of household resources were female-headedness, off-farm employment by household members, the overall household income level, the total land held by the household and the ratio of dependants (children under 15 and adults over 65 years) to adults in the household. These variables are described in Table 24.

Table 24: Variables used to Indicate Level of Household Resources

Name	Description	Mean (n=354)	Std dev
FEMHEAD	Whether household is female-headed, 1=yes, 0=no	0.22	0.42
OFF_ADT	Proportion of adult (>16yr) hh members who work primarily off-farm.	0.10	0.17
INCOME	Level of total household cash income from all sources, where 1 <2,500 Ksh, 2 is 2,500-5,000, 3 is 5,001-10,000, 4 is 10,001-20,000, 5 is 20,001-30,000, 6 >30,000.	2.77	1.26
TOTLAND	Total acres of land held by household	8.50	13.10
DEPEN_RT	Ratio of dependants to adults	0.41	0.26

Female-headed households were postulated to have poorer access to resources such as formal credit facilities, co-operative services, etc. Off-farm employment of household members affects labour availability for dairying, but may also affect household wealth. Monthly cash income level and total land held were considered indicators of wealth. Dependant ratio may affect household milk consumption, capital liquidity, and availability of household labour.

Finally, a group of variables were selected to measure access of farms to markets. These included distance of the farm to Nairobi, the availability of veterinary services locally (offered mainly by the government and private sector), availability of GoK extension services locally, the farm-gate price of milk received by the farmers, co-operative membership, and milk sales to informal market outlets. The variables are described in Table 25 below. The study shows that government veterinary and extension services were still significant to over half the farmers. Unlike in Kiambu, lack of use of non-governmental outlets is an indicator of lack of market development as a result of low market access, while co-operative membership is not an indicator of access to both input and output markets as most of the cooperatives do not offer any veterinary or extension services. Complete data for the three sets of variables was available from 354 dairy farm/households.

Table 25: Variables Selected as Indicators of Market Access in the Principal Component Analysis and Their Means and Standard Deviations

Name	Description	Mean (n=354)	Std dev
DISTNBI	Distance to Nairobi, in Km	144.89	54.64
VETAVAIL	Availability of veterinary services (1=yes, 0=no)	0.08	0.09
EXTAVAIL	Availability of extension services (1=yes, 0=no)	0.003	0.05
DDFRPRC1	Average price received per litre of milk in most recent dry season Ksh.	13.51	3.31
COOPMEMB	Co-operative membership: 1=yes, 0=no.	0.47	0.50
INFRMKT	Reported milk sales to non-co-operative outlet in last 12 months, 1=yes, 0=no	0.91	0.28

4.3 Cluster Analysis

Cluster analysis was then carried out using the new variables derived through principal component analysis from the variables shown above (see Staal et al, 1998 for a description of the method). The number of clusters was set to different values and the results compared and interpreted for ability to differentiate the observations along the desired axes. Clustering into eight clusters was selected. From these, 4 clusters contain most of the farm/household observations with cluster 1 containing the largest group. Table 26 shows the frequency of households falling under each cluster, and the mean cluster values of a number of descriptive variables from the original survey variable set.

Table 26: Means of Farm/Production, Household and Market/Institutional Participation Characteristics for the Identified Major Dairy Farmer Groups

Cluster	Informal Resource Poor (1)	Intensive Part-time (2)	Extensive Landed (3)	Specialist (4)
Number of households	179	68	67	26
Percent of households*	51	19	19	7
Farm/Production Characteristics				
Farm size (acres)	4.0	4.7	23.3	6.1
Napier acreage	0.2	0.4	0.4	0.6
Maize acreage	0.8	1.0	1.9	1.0
Dairy cattle TLU	1.8	2.3	5.0	2.0
Farm acres per TLU	2.0	1.6	5.0	3.0
Napier acres per TLU	0.1	0.2	0.1	0.4
Concentrate purchased Ksh/TLU/yr	1,300	2,600	1,800	18,700
Fodder purchased Ksh/TLU/yr	390	590	930	6,740
Milk prod./day of calving interval (lts/day)	3.9	3.9	7.0	4.2
Household Characteristics				
Age of household head	50.3	51.3	52.2	48.4
Years dairy experience	17.0	21.2	21.3	21.3
Female hh heads (%)	23	24	20	15
Total household size	6.2	4.5	7.4	5.7
HH adults working off-farm (% of adults)	4	29	5	10
Hh income category	2.1	3.2	3.6	3.4
Market /Institutional Participation Characteristics				
Distance to Nairobi (km)	164	111	134	142
Distance to market (km)	4.6	4.2	6.1	2.5
Co-op membership (%)	34	67	66	69
Availability of vet services (%)	90	100	85	92
Availability of extension (%)	70	80	77	68
Informal milk market participation (%)	99	92	75	78
Multiple market outlets (%)	84	86	63	91
Avg price for milk (Ksh/lt)	12.5	13.8	14.9	14.6
Avg qty of milk sold (lt/day)	2.6	4.3	7.0	5.2

* Some 4% of farms did not fall into these clusters.

Farmers in the largest cluster (1) have the smallest land holdings (4 acres on average), buy very little fodder (less than Ksh 400 per year), have the lowest levels

of total income, and operate mostly through the informal market. They plant only a small amount of land in Napier. Only 34% of them are members of dairy cooperatives, compared with much higher proportions among other farmers. They receive the lowest price for their milk of the 4 groups, which may be related to the fact that they tend to the furthest from Nairobi. Nearly a quarter are female-headed households. Given these characteristics, we will consider these to be the **Informal Resource Poor** (IRP) group of dairy farmers. These farmers comprise some 51% of the dairy farms surveyed, and are thus by far the largest group.

The second largest cluster (2) is composed of farmers with only slightly larger land holdings (4.7 acres), but who grow more Napier and who purchase significantly more concentrate feed and fodder. Milk yields however are as low as those in the IPR group. They tend to be found relatively close to Nairobi, and 66% of them are members of dairy cooperatives. A significant proportion of adults in these households (29%) work off-farm, and 24% of the households are female-headed. These are thus **Intensive Part-time (or Peri-urban) Dairy** farmers (IPD), and make up 19% of the dairy farms surveyed.

Farmers in another cluster of about the same size (3) have large land resources (23 acres) and plant more Napier (0.4 acres), although they also purchase fodder and concentrates. Possibly as a result of these land resources, they exhibit the highest milk yields, at 7 l/day of lactation. They have higher income levels than the other farmers, and tend to rely on dairy cooperatives to market their milk. They can be called the **Extensive Landed Dairy** farmers (ELD).

The last significant group is distinguished primarily by the very large amounts of concentrate feed and fodder they purchase, as well as larger areas of Napier planted (0.4 acres per TLU). More than 90 % of them also rely on multiple market outlets to sell their milk. These are characteristics of specialization in dairy production, and so this group can therefore be called **Specialised Dairy** (SD) producers. The milk yields they obtain remain relatively low, however, at 4.2 liters per day. They comprise a small group within the dairy farmers at less than 10% of the total.

Table 27: Number of Observations and Percentages per Cluster by Agro-climatic Potential and Market Access

Agro-climate potential	High		Medium		
Market access	Medium	Low	High	Medium	Low
Cluster (% of total in row)					
Inf Resource poor	37 (19%)	34 (20%)	- (0%)	107 (60%)	1 (1%)
Intensive part-time	44 (65%)	5 (7%)	6 (7%)	13 (19%)	- (0%)
Extensive landed	5 (7%)	30 (45%)	8 (12%)	18 (27%)	6 (9%)
Specialist	12 (46%)	5 (19%)	3 (12%)	6 (23%)	- (0%)

Table 27 shows where the clusters of households fall according to the 2 criteria used to initially stratify the survey: agro-climatic potential and market access. These criteria were assigned to the survey districts based on expert informant opinion. The Informal Resource Poor are clearly found mainly (60%) in areas with relatively-low (medium) agro-climatic potential, and medium market access (note that in this survey area, medium represents the lowest level of agro-climatic potential). It is thus apparent that relatively low levels of these factors are related to the combination of traits found in this group of farmers: low incomes, low access to services, and small land-holdings. A significant proportion of IPR farms are also found in high agro-climatic potential zones, equally divided between market access levels there. Intensive Part-Time dairy farmers are found mainly (65%) in areas of both high productive potential and good market access, in line with the peri-urban nature of their activity in zones close to Nairobi with high rainfall. The Specialists are in the same zones, and may simply represent a more intensive form of peri-urban dairy production. Extensive Landed dairy farmers are mainly in areas of lower market access, with 45% of them in areas where productive potential is also high. The results in Table 27 show clear patterns of farm type and intensification strategy in different combinations of two of the main determining factors.

4.4 Selection of Target Farmers

Based on the above analysis, and given the project goal of poverty alleviation, the Informal Resource Poor group of dairy farmers may be the appropriate target group for further research and development efforts. The constraints they face go beyond landholding and resource poverty to include access to services, markets and information. They also represent a majority of dairy farms in the survey area, and thus positive interventions among this group offer the potential for substantial impact.

5. Conclusions

The survey showed that in the districts where land sizes are small and land is thus a constraint, farmers have incentive to intensify and the main system of keeping cattle is "stall feeding". Thus even though extensive grazing is still practised in districts where the land holdings are large, the continued subdivision of the land in successive generations mean that in future, intensive grazing may be the predominant system for keeping cattle. This trend is reflected in the higher level reported by the surveyed farmers of zero grazing now compared to 10 years ago, a relatively short period. Future planning of dairy development efforts, and technology delivery efforts, should keep these strong trends in sight. It is unclear, however, what the long-term competitiveness of these different production systems will be, but with current low opportunity costs for labour, the advantage is apparently with more intensification. Analysis of labour allocation to dairy indicate that males contribute 36% and females 24% of the dairy labour, and the rest is provided by children and hired labourers. This result is significant because it appears to contradict an important hypothesis that labour associated with intensification of smallholder dairying is mostly shouldered by the women of the household (Rey et al, 1993). However, preliminary results from the longitudinal surveys in Kiambu, Nakuru and Nyandarua corroborate the conclusion from this characterisation survey. Given these heavy labour demands of intensive dairy production, any increase in labour costs due, for example, to general economic development, could swing the advantage towards more extensive production. Some analysis of these trade-offs has been conducted by Baltenweck et al (1999) using this same survey data.

The two predominant breeds of cattle are Friesian and Ayrshire, reported in 42% and 18% of the farms respectively. There is a definite preponderance for these bigger breeds and a disregard for smaller breeds such as Guernsey and Jersey. There is evidence from the survey of under-nutrition in livestock. Estimates from the survey results show that zero-grazed dairy cattle each get about 47 kg of fodder per day, which is lower than the recommended 60 to 70 (approximately 10 to 15 DM) Kg per day. The problem of under-nutrition may largely be explained by shortage of fodder due mainly to small land holdings relative to the number of animals, although concentrates are also fed at relatively low levels, about 1 kg per zero-grazed milking cow per day, and much less for the grazed cattle. Partly as a consequence, productivity indicators are also low. The mean age at first calving for the high-grade animals is 32 months, the mean calving interval is 519 days and the mean milk yield is 5.9 litres per day. However, the low levels of feeding may yield optimal overall returns to farmers, given their aversion to risk-taking. Previous research in Kiambu (Wachira et al, 1997) has shown that the increased risks from higher investment in fodder production and purchase of concentrates may outweigh the increased returns for many farmers. Interventions to improve the levels of nutrition should therefore consider farmer resources, and not require significant increases in exposure to market and climatic risk through greater cash expenditure or reallocation of crop land. Herbaceous or tree fodder legumes that compete less with crops may be options. Shifting of concentrate feeding to the first half of the lactation to raise milk yields per lactation, without significantly increasing overall purchases, has also been proposed.

Production systems in dairy farming in Kenya display a wide variability of strategies, each of it responding to the particular marketing and environmental conditions present in the area. The longer-term competitiveness of these systems changes over time, depending in land values, market and institutional infrastructure. The results show that organised marketing channels are still mainly predominant in areas closer to the Nairobi milk shed, while in more distant areas, direct sales to consumers and traders prevail. If road and market infrastructure were to improve then organised marketing is likely to better reach distant areas, enabling high milk prices to those producers. Under those circumstances, the competitiveness of production is likely to shift significantly.

Important implications from the findings can be drawn in four key areas: a) intensification of smallholder systems; b) constraints to dairy productivity; c) access to services; and, d) identification of target groups.

The results point clearly to the rapid intensification of smallholder dairy production, which is occurring in the central part of Kenya apparently as a result mainly of shrinking land holdings. Over the last ten years farms have shifted increasingly to the use of stall-feeding and to planting of fodder, and now rely less on natural fodder. Also clear, however, are the wide differences in levels of intensification across the area depending on agro-climate and market access. The main implication is that while improved technologies for sustained intensification are needed, they cannot be applied uniformly. Blanket recommendations for intensive production strategies should be avoided. A difficult challenge may be to assist the appropriate intensification of farms in those outlying areas where many of the resource poor farmers are found, which do not have high agro-ecological potential, yet which need to improve productivity due to shrinking land holdings.

Constraints to dairy productivity continue to centre around inadequate and seasonal feed resources. Solutions to these problems will have to keep in mind the limitations to opportunities for intensification outlined above. For example the use of planted grass fodders for stall-feeding may be limited in extensive areas where labour rather than land is the limiting constraint.

Threats to productivity over the long term may be posed by the constraints to selective breeding. AI services continue to be used by only a relatively small proportion of farmers and the long-term trends in herd genotype are unclear. Private veterinary services of indeterminate quality are now available to most farms across the area. Few cooperatives offer breeding or vet services. Perhaps surprisingly, most farms report continued contact with government extension services. The status of access to services is thus mixed with apparently successful private sector entry into vet services, but less success in the private provision of AI services. However, these services are used mostly by the more privileged or advanced dairy farmers.

The cluster analysis shows that about half the dairy farms in central Kenya remain resource-poor with small land holdings and located far from formal market services and urban areas. Improving the sustained productivity and profitability of this large majority group of farms and households will be key to success in rural development, poverty reduction and environmental protection in the region.

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References

Baltenweck, I., S. J. Staal, M. Owango, H. Muriuki, B. Lukuyu, G. Gichungu, M. Kenyanjui, D. Njubi, J. Tanner and W. Thorpe. 1998. Dairy Systems Characterisation of the Greater Nairobi Milk-Shed: Application of Spatial and Household Analysis. *Presented at the Workshop on Urban Markets and Dairy Development in sub-Saharan Africa, Montpellier, France, 9-10 Sept. 1998*

Carter, S. E. 1997 Spatial Stratification of Western Kenya as a Basis for Research on Soil Fertility Management. Agricultural Systems, 55(1), 45-70.

C.B.S (Central Bureau of Statistics). 1994. Kenya Population Camus 1989. Vol. 1. Office of the Vice - President and Ministry of Planning and National Development, Nairobi.

DANIDA/Ministry of Livestock Development. 1991. Kenya Dairy Master Plan.

Gockowski, J. J. and Baker, D. 1996. Targeting Resource and Crop Management Research Through an Eco-regional Methodology for the Humid Forest of Central and West Africa. Paper presented at 1996 Biennial Meeting of Rockefeller Social Science Research Fellows, Aug. 15, 1996, Nairobi, Kenya

Ikombo, B.M., Esilaba, A.O. and Kilewe, A.M. 1994. A diagnostic survey of the farming systems in Kiambu District: report on diagnostic survey results from Kikuyu, Kiambaa, Gatundu and Thika Divisions. National Agricultural Research Centre - Muguga. Kenya Agricultural Research Institute.

Kaguongo, W.N.W., S. Staal, and C. Ackello-Ogutu. 1997 "Risk with Intensification of Kenyan Smallholder Dairying." *Poster paper presented at XXIII International Conference of Agricultural Economists, August 10-16, Sacramento, California*

Jaetzold, R. and Schmidt, H.. 1983. Natural conditions and farm management information. In :Farm Management Handbook of Kenya, Volume II. Part B, Central Kenya, Ministry of Agriculture, Kenya, pp. 510-620.

Kaguongo, W.N.W. M Sc. Thesis. 1996. Smallholder adoption of dairy technologies: effect of risk management strategies in a liberalising economy.

Karlen, L (1995). 'Draft report on the findings from a survey of active marketing co-operatives in Kenya, 1995'. Kenya Nordic Co-operative Development Programme, Nairobi (unpublished).

Ouma, E. A. 1997. The Role of Women in Farm and Household Decision Making and Effects on the Productivity of Smallholder Dairying Enterprise. Unpublished paper. Dept of Agricultural Economics,

Egerton Univ. and Market-Oriented Small-holder Dairy research team, ILRI.

Odima, P.A., McDermott, J.J. and Mutiga, E.R. 1994. Reproductive performance of dairy cows on smallholder dairy farms in Kiambu District, Kenya: Design, Methodology and Development constraints. In: *Proceedings of the 7th ISVEE Symposium*. 15th - 19th August, 1994. Nairobi, Kenya. *The Kenya Veterinarian* 18(2): 366.

Omore, A., H. Muriuki, M. Kenyanjui, M. Owango and S. Staal. 1999. The Kenya Dairy Sub-Sector: A Rapid Appraisal. *MoA/KARI/ILRI Smallholder Dairy (Research & Development) Project Report, Ministry of Agriculture (Kenya), Kenya Agricultural Research Institure and the International Livestock Research Institute (Kenya). Nairobi, Kenya. 51 pp*

Ombui, J.N., McDermott, J.J. Arimi, S.M., Mbugua, S.K, Kakuko, S., and Kilungo, J.K. 1995. Current and potential roles of dairy co-operative societies in Kiambu District, Kenya. *East African Agricultural and Forestry Journal.* 61(2):129-140.

Omore, A.O., 1997. Epidemiology and economics of mastitis in the smallholder dairy sector of Kiambu District, Kenya. PhD Thesis, University of Nairobi. 224pp

Omore, A.O., McDermott, J.J., Arimi, S.M., Kyule, M.N. and Ouma, D. 1996a. A longitudinal study of milk somatic cell counts and bacterial culture from cows on smallholder dairy farms in Kiambu District, Kenya. *Prev. Vet. Med.* 29:77-89.

Omore, A.O., McDermott, J.J., Gitau, G.K., 1996b. Factors influencing production on smallholder dairy farms in central Kenya. In: *Proceedings of the 5th Scientific Conference of the Kenya Agricultural Research Institute (KARI).* 14th - 16th October, 1996. KARI Headquarters, Nairobi, Kenya. pp 370-379

Owango, M.O, Staal, S., Kenyanjui, M., Lukuyu, B., Njubi, D. and Thorpe, W. 1998. Dairy Co-operatives and Policy Reform in Kenya: Effects of Livestock Service and Milk Market Liberalisation. *Food Policy*, forthcoming.

Poate, C.D. and P.F. Daplyn. 1993. *Data for Agrarian Development*. Wye Studies in Agric. and Rural Development. Cambridge: Cambridge Univ. Press.

Rey, B., Thorpe, W., Smith, J., Osuji, P., Mullins, G., Agyemang, K. 1993. Improvement of dairy production to satisfy the growing consumer demand in sub-Saharan Africa. A conceptual framework for research. Market-oriented Smallholder Dairying Research Working Document No. 1. ILCA 13pp.

Rey, B., Mullins, G., Agyemang, K., Shapiro, B., Nokoe, S., and Thorpe, W. 1999. A research methodology for characterizing dairy production systems. Market-oriented Smallholder Dairy Research Working Document No.4. ILRI (International Livestock Research Institute), Nairobi. 82pp

Staal, S.J., R. Kruska, I Baltenweck, M Kenyanjui, A Wokabi, D Njubi, P Thornton and W Thorpe. 1999. Combined household and GIS analysis of smallholder production systems: an application to intensifying smallholder dairy systems in Central Kenya. *Paper presented at the Third International Symposium on Systems Approaches for Agricultural Development, (SAAD-III), Nov. 8-10, 1999, National Agrarian University La Molina, Lima, Peru.*

S. Staal, L. Chege, M. Kenyanjui, A. Kimari, B. Lukuyu, D. Njubi, M. Owango, J. Tanner, W. Thorpe, and M. Wambugu. 1997. Characterisation of Dairy Systems Supplying the Nairobi Milk Market: A Pilot Survey in Kiambu District for the Identification of Target Groups of Producers. *KARI/MoA/ILRI Collaborative Research Project Report. ILRI, Nairobi, Kenya.*

Background Reading

CAPD (Chief Animal Production Division). 1993. Annual Report 1992. Animal Production Division. Ministry of Agriculture, Livestock Development and Marketing, PO Box 34188, Nairobi, Kenya. 93pp.

DLPO (District Livestock Production Officers): Kirinyaga, Machakos, Maragua, Murang'a, Nairobi, Nakuru, Narok and Nyandarua. 1998. Annual Reports 1997. Livestock Production Department, Ministry of Agriculture.

FAO/World Bank Co-operative Programme. 1993. Kenya Dairy Development Project Preparation Report. No: 34/93 CP-KEN 33

Gitau, G.K., O'Callaghan, C.J., McDermott, J.J., Omore, A.O., Odima, P.A., Mulei, .M., and Kilungu J.K., 1994. Health and productivity of cattle in smallholder dairy farms in Kiambu District, Kenya: Study design and farm description. Prev. Vet. Med., 21: 155-166.

Gitau, G.K., McDermott, J.J., Waltner-Toews, D., Lissemore, K.D., Osumo, J.O. and Muriuki. D. 1994. Factors influencing morbidity and mortality on smallholder dairy farms in Kiambu District of Kenya. Prev. Vet. Med., 21: 167-178.

Gitau, G.K., McDermott, J.J., Adams, J.E, Lissemore, K.D., and Waltner-Toews, D. 1994. Factors influencing calf growth and daily weight gain on smallholder dairy farms in Kiambu District of Kenya. Prev. Vet. Med., 21: 179-190.

Kaguongo, W.N.W. and Staal, S. 1996. Smallholder adoption of dairy technologies: effect of risk management strategies in a liberalising economy. Paper presented at the 5th KARI Scientific Conference, 14th - 16th Oct. 1996, KARI Headquarters, Loresho.

Methu, J.N., Owen, E., Abate, A., Mwangi, D.M. and Tanner, J.C. 1996. Feeding practices by smallholder dairy farmers in Central Kenya highlands; Maize stover utilisation. Paper presented at the 5th KARI Scientific Conference, 14th - 16th Oct. 1996, KARI Headquarters, Loresho.

Mwangi. D. M. 1994. Diagnostic survey in livestock feeds, feeding and management practises in Central Kenya. Proceedings 4th KARI Scientific Conf.

Mwangi. J.N., Thomas, D.B., Esilaba, A.O., Wamuongo, J.W. and Miriti, J.M. 1995a. Reconnaissance survey of 18 catchments In Kiambu District to identify priorities for on-farm research in soil and water conservation. PRA reports - KARI Muguga Crops, Soil and Water Department.

Mwangi. J.N., Mwarasomba, L.I., Esilaba, A.O., Mwangi, D.M., Miriti, J.M. and Mwangi, P.W. 1995b. Identification of priorities for on-farm research through participatory rural appraisal in Kijabe Escarpment catchment, Kiambu District.. PRA reports - KARI Muguga Crops, Soil and Water Department.

Mwarasomba, L.I., Chui, J.N., Esilaba, A.O., Mwangi, J.N., Kimani, S.K., Miriti, J.M. and Odongo, N. 1995a. Identification of priorities for on-farm research through participatory rural appraisal in Kinale I catchment, Kiambu District.. PRA reports - KARI Muguga Crops, Soil and Water Department.

Mwarasomba, L.I., Chui, J.N., Esilaba, A.O., Mwangi, J.N., Mwangi, D.M., Kimani, S.K., Miriti, J.M., Wamuongo, J.W. and Odongo, N. 1995b. Farmers participation in identification of on-farm research priorities in Kiamathare catchment, Kiambu District.. PRA reports - KARI Muguga Crops, Soil and Water Department.

NDDP (National Dairy Development Project). 1994. Results of the Farm Survey (June/July 1993) in Kiambu District. NDDP Monitoring and Evaluation Unit, Ministry of Agriculture, Livestock Development and Marketing, Hill Plaza, Nairobi. NDDP/ME/94/045. 23pp.

Omore, A.O., 1996. Epidemiology and economics of mastitis in the smallholder dairy sector of Kiambu District, Kenya. PhD Thesis, University of Nairobi.

Omore, A.O., McDermott, J.J., Gitau, G.K., 1996. Factors influencing production on smallholder dairy farms in central Kenya. Paper presented at the 5th KARI Scientific Conference, 14th - 16th Oct. 1996, KARI Headquarters, Loresho

S. Staal, L. Chege. M. Kenyanjui, A. Kimari, B. Lukuyu, D. Njubi, M. Owango, J. Tanner, W. Thorpe and M. Wambugu. 1997. Characterisation of Dairy Systems Supplying the Nairobi Milk Market: A Pilot Survey in Kiambu District for the Identification of Target Groups of Producers." *KARI/MoA/ILRI Collaborative Research Project Report. Nairobi, Kenya.*

Wamuongo, J.W., Mwarasomba, L.I., Esilaba, A.O., Mwangi, J.N., Kimani, S.K.and Miriti, J.M.. 1995. Farmers participation in identification of on-farm research priorities in Kinyogori catchment, Kiambu District.. PRA reports - KARI Muguga Crops, Soil and Water Department.

Appendix 1 Number of Households to Sample in Each District by Land-Use System

a. Sheep/Dairy Land-use System

District	Division	Sub-location	LUZ	Households	
				census	sample
Murang'a	Kangema	Ichichi	sheep/dairy	3,346	22
Nakuru	Molo	Keringeti	sheep/dairy	14,397	13
Nakuru	Njoro	Likia/Teret	sheep/dairy	18,059	20
Nakuru	Molo	Kiambiriria	sheep/dairy	13,187	14
Nakuru	Bahati	Kabatini	sheep/dairy	9,079	50
Narok	Mau	Ntulele	sheep/dairy	7,546	10
Nyandarua	Ol-Kalou	Ruiru	sheep/dairy	3,462	10
Nyandarua	Kinangop	Gathara	sheep/dairy	6,094	10
Nyandarua	Kinangop	Kahuru/Muruaki	sheep/dairy	10,540	10
Nyandarua	Kinangop	Bamboo	sheep/dairy	5,706	10
Nyandarua	Ol-Kalou	Melangine	sheep/dairy	6,951	10
Nyandarua	Kinangop	Gitwe	sheep/dairy	3,546	19
				101,913	203

b. Tea/Dairy Land-use System

District	Division	Sub-location	LUZ	Households	
				census	sample
Kirinyaga	Gichugu	Ngiriambu	tea/dairy	4,914	10
Kirinyaga	Gichugu	Thirikwa	tea/dairy	3,519	10
Kirinyaga	Gichugu	Nyangeni	tea/dairy	4,438	10
Kirinyaga	Gichugu	Kariru	tea/dairy	3,673	10
Kirinyaga	Ndia	Nguguine	tea/dairy	5,685	12
Murang'a	Kangema	Gacharageini	tea/dairy	6,288	14
Murang'a	Kangema	Kairo	tea/dairy	2,850	10
Murang'a	Kangema	Gikui	tea/dairy	9,008	19
Murang'a	Kiharu	Kahuro	tea/dairy	8,733	35
Murang'a	Kiharu	Kahuti	tea/dairy	5,629	22
Murang'a	Kandara	Mungaria	tea/dairy	9,043	30
				63,780	180