EXTENSION AND ITS EFFECT ON DAIRY CATTLE NUTRITION AND PRODUCTIVITY IN SMALLHOLDER DAIRY ENTERPRISES IN KIAMBU DISTRICT.

BY

WAMBUGU, M. N.

BSc. Anim. Prod. (Egerton Univ.)

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ANIMAL SCIENCE, UNIVERSITY OF NAIROBI

DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

MARGARET NYAWIRA WAMBUGU

This thesis has been submitted with our approval as supervisors:

DR. RAPHAEL G. WAHOME (University of Nairobi)

DR. CHARLES K. GACHUIRI (University of Nairobi)

DR. JONATHAN C. TANNER (International Research Livestock Institute)

DEDICATION

To Charlotte, My Mum

And

Ben, my Husband, Friend and Colleague

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS

ARC	AGRICULTURAL RESEARCH COUNCIL
DEAF	DAIRY EVALUATION AND ADVICE FORM
DFST	DISTRICT FARMING SYSTEMS TEAM
DLPO	DISTRICT LIVESTOCK PRODUCTION OFFICE
FAO	FOOD AND AGRICULTURE ORGANIZATION
FEW	FRONTLINE EXTENSION WORKERS
ILCA	INTERNATIONAL LIVESTOCK CENTER FOR AFRICA
ILRI	INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
IRRI	INTERNATIONAL RICE RESEARCH INSTITUTE
ISNAR	INTERNATIONAL SERVICE FOR NATIONAL AGRICULTURAL RESEARCH
KARI	KENYA AGRICULTURAL RESEARCH INSTITUTE
KCC	KENYA COOPERATIVE CREAMERIES
MALDM	MINISTRY OF AGRICULTURE, LIVESTOCK DEVELOPMENT AND MARKETING
NARS	NATIONAL AGRICULTURAL RESEARCH SYSTEM
NDDP	NATIONAL DAIRY DEVELOPMENT PROJECT
NEP	NATIONAL EXTENSION PROGRAMME
OVP	OFFICE OF THE VICE-PRESIDENT AND MINISTRY OF PLANNING AND NATIONAL DEVELOPMENT
SAS	STATISTICAL ANALYSIS SYSTEM
SDP	SMALLHOLDER DAIRY PROJECT

SMS	SUBJECT MATTER SPECIALIST
TSFS	THREE STRATA FORAGE SYSTEM
USAID	UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
UON	UNIVERSITY OF NAIROBI

ACKNOWLEDGEMENT

I wish to thank the Ministry of Agriculture for granting me the study leave that enabled me to undertake these studies. I am greatly indebted to Mr. Ngugi the District Livestock Production Officer Kiambu and all the livestock production staff and particularly Miss E. Munene and Mr. M. Mugaru (Agric. Dept.) for their participation and commitment during the cross-sectional survey. The supervisors and enumerators working in the Smallholder Dairy Project (SDP) provided assisted me in the work of milk sampling and feed monitoring. I am very grateful to them all. Milk analysis was done in the Biochemistry laborattory at the department of clinical studies, UON. I wish to thank the staff of that lab and especially Elsie Wambui for her commitment and support.

Funding for the first year of my studies was provided by the Second Agricultural Sector Management Project (ASMPII) through the Ministry of Agriculture. I am very grateful to the ASMPII staff particularly Mr. G. Ogola, Mr G. Kimani and Martin who worked tirelessly to make sure everything was sorted out.

Funding for this work and the whole of my second year was provided by the KARI/ILRI/MOA Smallholder Dairy Project. I particularly wish to thank Dr. Thorpe the field manager who not only worked hard to ensure that the funding went through but also gave me a lot of guidance; I also thank the project managers Mr. H. Muriuki and Dr. M. Owango for allowing the commitment of these funds.

My supervisors Dr. R. G. Wahome and Dr. C. K. Gachuiri of the University of Nairobi and Dr. J. Tanner of the International Livestock Research Institute gave me invaluable help, both academic and moral, during my studies which I really appreciate. I am also very grateful to Dr. R. Kaitho who gave me a lot of guidance and helped me to sort out the feed data. Dr. R. Eley of the training department ILRI made sure my studentship was a success. I thank him most sincerely; I also thank Sonal and Kuria for their statistical advice. All my colleagues at ILRI house particularly Mercy, Liston, Matthew, Amos, Elphas, Pauline, and my colleagues Biwott and Muli and all the rest gave me all the support I required. I am indebted to them all.

I wish to most sincerely thank my husband and colleague Ben and our children Angela, June and Brian for being there for me.

Lastly and above all I thank our Lord God, without whom nothing would ever have been possible.

ABSTRACT

A cross-sectional survey covering 63 households (HH) in three administrative locations of Limuru Division in Kiambu District was carried out by means of a structured questionnaire. The three locations with high contact (HCL), medium contact (MCL) and low contact (LCL) of extension respectively, were selected on the basis of their exposure to government extension service. Twenty-one HH stratified by wealth status, (rich [R], medium [M] and poor [P]) were randomly selected from each location. The information gathered included farm/farmer characteristics, dairy herd structure, farmers' exposure to extension agencies and participation in extension activities, and performance and level of farmers' knowledge and practice of dairy technologies. The data was subjected to descriptive analysis and analysis of variance to establish the extent to which extension service affected farming practice.

Only 32% of the farmers were in contact with the government extension service. Dairy co-operatives and neighbours were the most important sources of information to all the farmers regardless of location and wealth status. HCL and MCL farmers ranked field days first in extension delivery, while LCL farmers did not express a preference. Knowledge of all dairy technologies was low across locations and wealth groups. However, farmers who were exposed to government extension service both knew and practised more technologies than the LCL farmers ($p < 0.05$), particularly in technologies related to feeding of napier grass and concentrates. Extension contact had a positive effect on uptake of technologies across extension contact groups, regardless of wealth group, implying that there was need for sustained extension farmer contact. The results showed that field days were the best method of information delivery and therefore needed to be enhanced.

To assess suitability of milk urea nitrogen (MUN) concentration as an indicator of nutritional status, data on feed offered, body condition, live weight and milk yield was collected from 21 farms for a period of 12 weeks. Milk samples were also taken and analysed for MUN concentrations. Napier grass comprised at least 60% while concentrates formed less than 5% of the total feed offered. The average total dry matter on offer was 2.54 kg/ 100 kg live-weight and average milk yield was 5.5± 3.55 kg. Body condition scores (BCS) taken on a scale of 1 to 5 showed an average score of 2±0.62 Average live weight was 323.6± 47.1kg and MUN 17.4±5.14 mg/100ml. MUN showed a non-significant negative correlation with dry matter (DM) offered, milk yield and BCS. There was a significant ($P< 0.01$) positive correlation between milk yield and both DM offered and body condition score. Metabolisable energy-protein (ME:CP) ratio and DM crude protein content in g/kg were also significantly ($P<0.01$) and positively correlated.

Though MUN concentrations have been used as an indicator of nutritional status (protein-energy balance) in intensive temperate systems this method did not appear to be useful in the smallholder farms studied. This study concluded that the method was not effective where feed supply is highly varied, scarce and animals are often fed below their nutrient requirements.

CHAPTER 1: INTRODUCTION

Seasonal inadequacy of the quantity and quality of available feeds are the major problems facing dairy cattle production in the developing countries (Preston and Leng, 1987). Additionally the efficiency with which the available feed is utilised is constrained by failure to use recommended management practices that could improve livestock output. A variety of feed resources for ruminant livestock are unused, undeveloped and poorly utilised due to, among other reasons, lack of technical know-how, resulting in decreased livestock output (Preston and Leng, 1987). For instance, feeds such as stovers, straws and haulms (i.e. plant material left after harvesting dry grain legumes) if better utilised could make a substantial contribution to the basal feeds available to the dairy animals.

Despite the high genetic potential, dairy cattle in smallholder farms continue to be of low productivity and poor feeding was reported to be responsible for this poor performance (Omore, 1997). In Kiambu for instance, studies conducted by Staal *et al*. (1997) showed that milk production in smallholder farms averaged, 7kg/cow/day, which was far below the animals' expected potential (15-20kg/cow/day). This situation could be improved by more efficient utilisation of the already available feed resources.

Due to growth in human population, the demand for livestock products has risen and it is estimated that twice as much milk and meat will have to be produced in the next 30-35 years to satisfy this demand (Plucknett, 1995). Thus, livestock production will have to be even more intensive. It will also depend heavily on efficient and effective use of inputs, which will require increased knowledge of better farm or enterprise management. In addition, information will be required to support new enterprise development in response to changing farming systems, increased demand for livestock products and opportunities for investment in livestock as financial incentives increase (Morton and Matthewman, 1995). The need for new appropriate technologies is growing especially in dairy production because of the need for greater efficiency of resource use due to the decreasing farm sizes. In response to this, dairying in the future will be even more management and knowledge intensive, creating greater need for understanding of the factors that affect the dairy enterprise (Islam, 1995).

Many developing countries have taken up initiatives to help resource-poor farmer households improve the productive capacity of their livestock (Merrill-sands and Kaimowitz, 1994). The most important initiative in Kenya is the government extension service, which is involved in dissemination of information on new technologies to farmers (Morton and Matthewman, 1996). Other sources of information include neighbours, co-operative union, mass media, churches and non-governmental organisations (NGO). Recent changes in the livestock sub-sector which include liberalisation of milk marketing, privatisation of veterinary clinical and artificial insemination services demand that farmers produce milk in a more efficient way, hence the need to use advanced technology.

In Kenya, dissemination of information necessary in improving the feeding of dairy cattle has been the responsibility of the Ministry of Agriculture and Livestock Development (MOALD). However, it is acknowledged that the livestock production arm of MOALD extension has been less effective than that of crops (Barton and Reynolds, 1996).

The sources of technical information to small-scale dairy farmers in Kenya's central highlands are not well documented and their effectiveness has not been assessed. No specific studies have been done on the effect of availability of technical information on the nutrition and productivity of dairy cattle, especially in the small-scale dairy farms. Therefore, this study determined and categorised the sources of information on dairy cattle feeding available to smallholder farmers in Kiambu District, assessed the effectiveness of each information source and the impact these had on dairy cattle nutrition and productivity. The study also evaluated use of milk urea nitrogen concentration as a tool for assessing nutritional status of dairy cattle.

CHAPTER 2: LITERATURE REVIEW

2.1. DEVELOPMENT OF LIVESTOCK EXTENSION SERVICE IN KENYA

Before colonisation, Kenyan farmers were engaged in subsistence farming, growing indigenous crops and keeping indigenous cattle and managing the enterprises using their own traditional knowledge. With the coming of Europeans, exotic crops such as tea and coffee and livestock such as pigs and exotic dairy cattle were introduced and hence, there was need to educate farmers on modern husbandry. By 1955, Kenya had 3 farmer training institutions offering one-week courses mainly in crop husbandry with a total capacity of 80 beds. By 1965 this had risen to 27 with a capacity of 1442 beds and the target was to have a farmers' training centre in every district by 1970 (FAO, 1966). Extension messages were based on soil conservation and the newly introduced cash crops. Farmers were forced to construct soil conservation structures, which later on served as sites for growing Napier grass.

From 1959, a few Kenyan farmers who met certain conditions were allowed to keep exotic dairy cattle. To qualify, the farmers had to set aside pastureland and divide it into paddocks as well as have water tanks to ensure that the cattle had sufficient water. Extension workers visited the farms to ascertain that the requirements were met and thereafter to ensure that the animals were managed properly. Some of the farmers were taken to Farmers' training centres to learn more on dairy cattle husbandry. While frontline extension workers delivered messages on both crop and livestock production through routine farm visits, there were specialised extension workers dealing with tea who were affiliated to the Tea Development Authority.

2. 1. 1. The National Extension Programme

The World Bank-supported reorganisation of National Agricultural Extension systems in Africa started in Kenya in 1981 with a pilot project based on the Training and Visit System of extension (Venkatesan and Schwartz, 1991). Phase I of the National Extension Programme (1983-1991) was run by the Agriculture Department. Livestock extension was delivered separately from crop extension and animal health services, but generally with low impact. Phase II (designated as NEP II) was launched on 1st July 1991. Under NEP II the extension of crop and livestock messages was integrated into a unified extension system (Morton and Matthewman, 1996). In 1995, livestock health advice was integrated into the general extension service. Through NEP II, the government also sought to ensure an effective transfer of new agricultural technologies from research to extension staff and farmers by strengthening linkages between research functions and extension services (Kandie, 1991). Therefore, research extension liaison units (District Farming Systems Teams - DFST) were set up with emphasis on on-farm research. A key component of NEP II was regular fortnightly visits of Frontline Extension Workers (FEW) to contact farms/groups to disseminate technologies. Regular fortnightly and monthly training for FEW and Subject Matter Specialists (SMS) respectively were also held and joint demonstrations and field days were emphasized. A wide range of technologies was delivered under NEP II and this constrained the effectiveness of messages delivery.

2. 1. 2. The National Dairy Development Project

The National Dairy Development Project supported by the Dutch government was launched in 1990 with an overall objective of increasing the efficiency and productivity of dairy enterprises in Kenya, focusing on small-scale farms (Metz, *et al* 1995, Barton and Reynolds, 1996). The project was implemented in five phases with the final phase ending in 1995 and was instrumental in improving fodder production and dairy management under smallholder system (Metz, *et al* 1995). By the end of the project, it was covering 28 districts mainly in medium and high potential areas and had 234 field staff from the Department of Livestock Production engaged full-time in project activities (MALDM, 1994).

To qualify to join the project, a farmer had to establish a plot of Napier grass, construct a zero-grazing unit for the animals and obtain crossbred or grade dairy animals. At the end of 1994 the project had a record of 9692 registered farmers countrywide (MALDM, 1994). The project, through the field staff provided information to the farmers on all aspects of dairy production, but laid emphasis on zero grazing. Several extension methods were employed to ensure effective dissemination of technical information. These included farmers' workshops, field days, tours, barazas and farm demonstrations. Research-extension-farmer linkage was strengthened through the formation of clusters comprising research and extension personnel. By the end of the project there were eight such clusters (MALDM, 1994). Evaluation and monitoring was done through analysis of breeding calendars and Dairy Evaluation and Advice Form (DEAF) surveys (originally done twice a year for wet and dry seasons, and later done once a year) and milk record books.

Apart from the aforementioned extension activities, the project also produced videotapes, pamphlets and manuals covering all aspects of dairy farming and these were distributed to farmers, staff and other organisations. After the completion of the project, the field staff were reintegrated into the general extension system of Ministry of Agriculture, Livestock Development and Marketing (MALDM, 1994, Barton and Reynolds, 1996).

2. 1. 3. Problems in livestock extension

Livestock production extension has in the past faced institutional problems, being marginal to both agricultural extension and animal health services. Until 1986, Livestock Production did not exist as a department in the Ministry and neither fitted in the department of agriculture, nor in that of Veterinary Services (Morton and Matthewman, 1996). The institutionalisation of livestock extension was also affected by repeated changes of policy over the existence of a separate livestock ministry, which resulted in frequent separation and merging of the Ministries of Livestock Development and that of Agriculture. For instance, these ministries were merged in 1984, separated in 1987 and merged again in 1992. Dairy farmers therefore benefited more from special projects than the general government extension service (ODA/World Bank Project, NRI, 1996 cited by Barton and Reynolds, 1996).

The public sector extension system may not be capable of providing all the information that farmers might need due to the broad nature of its clientele and limited resources. Some of the other stakeholders in provision of such information are NGOs, farmers' organisations, the private sector, and even individual farmers (Venkatesan and Schwartz, 1991). There are many instances of successful collaboration in the field between the public sector extension services on one hand, and NGOs, farmers organisations and the private sector on the other (Venkatesan and Schwartz, 1991). There is collaboration, for instance, between the MALDM and NGOs such as Plan International, Heifer Project International, World Vision, private companies such as Cooper (K) Ltd., Unga Feeds Ltd and Dairy Co-operatives.

2.2. NEED FOR INFORMATION

The two most important factors that could contribute to future increase in food supply in developing countries are expansion of cultivated land and increase in yield (Islam, 1995).

Because of constraints in the expansion of land and water resources, future growth in food supply depends predominantly on growth in yields. Improvement of output from existing ruminant production systems could be achieved through better use of the available basic feed resources, increased use of external inputs (e.g. commercial concentrates) and more intensive and high level management (Devendra, 1994). Improved maize stover utilisation for instance through technologies that would address the low digestibility and low voluntary intake by animals could improve feed availability in smallholder dairy farms (Methu *et al*., 1996).

New trends in production have created demand for a variety of technical information on livestock production especially on breeding, feeding, handling and marketing of livestock products (Morton and Matthewman, 1996). In many high potential areas of Kenya, land pressure has driven farmers to adopt the zero-grazing system of dairy production. There is need therefore to maximise on output per unit land. Studies conducted in Kiambu District revealed that many cows were producing 4-12 kg milk/cow/day, which was far below the animals' estimated potential of 15-20 Kg./cow/day (Staal, et. al., 1997; Van der Valk, 1992). One of the suggested reasons for this was that the animals' roughage requirement was not met, and coupled with lack of strategic supplementation, the response to feeding in terms of milk production was poor. The animals also had long calving intervals of between 273 and 1308 days (average 410 days) and this was attributed to poor nutrition and poor heat detection (MALDM, 1993; Staal, et. al., 1997). Lack of technical information particularly on fodder production, dairy cattle feeding and breeding was cited as one of the major constraints these farmers were facing (Mwangi, 1995).

2.3. GENERATION OF INFORMATION FOR EXTENSION PROGRAMMES

The four principal agents for technology development encompassing the generation, development assessment, and diffusion of technology are the National Agricultural Research Institutes, Universities/faculties of Agriculture, Public Extension systems, and farmers/farm households (ISNAR, 1992). In Kenya, the public research sector has been the major source of new agricultural technologies, while the government and the farming community have remained the major end-users of the results of research emanating from this huge public research machine (Hobbs and Taylor, 1987).

There are however, private organisations carrying out research in animal health and nutrition in Kenya e.g. Cooper (K) Ltd and Unga Feeds Ltd (Kamau, 1997). These organisations are focused on the needs of the farmer more easily and deliver what the farmer needs at a cost, which is recovered through product pricing. However, collaboration between the public and private research would ensure that all important research problems are covered (Hobbs and Taylor, 1987).

If research is to generate technologies that farmers can adopt, then it should be designed and implemented based on a farming system perspective (Farrington and Nelson, 1997). Generation, dissemination and utilisation of appropriate technology could be enhanced by use of interdisciplinary team approach involving researchers, extension workers and farmers (Orodho, 1990). Researchers and farmers combine complementary types of knowledge in developing technologies to improve the productivity and sustainability of farming systems. In Botswana, for instance, the National Research programme had three major components: (i) researcher managed trials (ii) research oriented farmer groups and (iii) extension oriented farmer groups (Heinrich, 1993). The interdisciplinary team is especially important during identification of priority areas for research. Priority setting increases the efficiency and relevance of the research agendas of National Agricultural Research Institutes (Kamau., 1997).

Different farming systems require different technical information. Isahak (1991) showed that Estate Sectors, government sponsored land schemes and the small-scale farmers in Malaysia had different information needs. A similar scenario exists in Kenya where farmer characteristics and also farming conditions vary.

There are technologies that have been generated in Kenya in an attempt to solve the problem of feed shortage in dairy production. These include production of high yielding fodder crops whose adaptability and suitability to different ecological zones has been ascertained, use of farm by-products and crop residues (Orodho, 1990).

In the past, National Agricultural Research Stations were not able to produce appropriate technologies in a sustained manner. The transfer of technology was poor and the generation of information was top-down, lacking farmer/client participation (Venkatesan and Schwartz, 1991). Development of improved agricultural technology is a continuum that should involve a spectrum of participants in an interactive process. Without continuous generation and diffusion of improved technology, few programmes would move far, or have a lasting effect on productivity (ISNAR, 1992).

2.4. DELIVERY OF TECHNICAL INFORMATION

To contribute to development, agricultural research must be innovative and relevant, and its results must be broadly disseminated (Merrill-Sands and Kaimowitz, 1994). The fact that some technology remained "on the shelf" (not transferred) was ascribed either to the failure of farmers to appreciate its benefits or to “bottlenecks” in the transfer process. An example of improved technology that was not adopted due to the fact that extension agents did not propose it was urea treatment to improve the palatability and digestibility of straw/stover in an effort to increase feed supply in smallholder dairy farms (Methu, 1998).

2. 4.1. Research-Extension-Farmer Linkage

One major cause of inefficient technology generation and transfer systems in Africa is the poor linkages between research and its clients, namely extension services and farmers (Eponou 1994). This denies farmers, especially the more impoverished, access to technologies that are either improved or at least adapted to their needs. Research institutions need to develop greater capacity to facilitate effective interaction between researchers, technology transfer workers and resource-poor farmers (Merrill-Sands and Kaimowitz, 1994). The research system alone cannot solve the problems of technology transfer; neither can it substitute the extension system developed over so many years by the relevant ministries. Similarly, the extension service cannot function singly without an effective research service. The two are therefore complementary in role (Kandie, 1991). Few livestock messages have been taken up by farmers over the past decade and this is because they were either not appropriate, or they were not disseminated (Morton and Matthewman, 1995). Research managers therefore, must forge and sustain direct links with farmers, on farm and on-station researchers and technology transfer agents.

Strong links with farmers and technology transfer workers are not merely a matter of efficiency; they are vital for successful technology development and delivery (Merrill-Sands, and Kaimowitz, 1994). In Colombia for instance, implementation of the Integrated Development Programme (DRI) in mid 1970s, in which activities of the core technology development and transfer institutions were co-ordinated, resulted in an increase in milk, wheat and guinea fowl production. This contrasted sharply with yields of maize and beans, the two crops for which there had been far less integration between research and extension (Islam, 1995).

Strong links ensure that researchers tackle users' (farmers) priority needs while involving technology transfer workers in technology development. It also makes it possible to produce technologies that suit local agro-ecological and socio-economic conditions and therefore widely adopted (Merrill-Sands and Kaimowitz, 1994).

2.4. 2. Other factors affecting delivery of technical information

Problems affecting the extension system also constrain delivery of information to farmers. Insufficient operational funds and low staff morale were major constraints especially to the government extension system (Leonard, 1977; MALDM, 1997). Poor roads especially in forested areas constrained the extension workers by reducing accessibility to farms and also constrained farmers by reducing accessibility to markets for their produce (Nzondo, 1994). Difficulties in marketing of agricultural products, lack of credit facilities and agricultural inputs and poor returns to the investment after application of a new technology indirectly affect delivery of information in that it affects the farmers interest in seeking technical advice (Barton and Reynolds, 1996).

2.5 ADOPTION OF TECHNICAL INFORMATION

Utilisation of research results at the farm level merits highest priority in technology development and demonstration, hence technology has to be tailored to the social, cultural and economic environment of the end user (Devendra, 1994). Farmers made their selection being fully aware of their environment and they almost always made changes before adopting a technology, based on their level of technical knowledge and socio-economic constraints (Sene, 1994).

Farmers' perceptions of the attributes of an innovation, not necessarily the attributes as perceived by extensionists, scientists or politicians, were shown to influence adoptive behaviour. For instance, despite the apparent benefits of sown forages to animal and crop production, they were generally not adopted, and progress in extending forage crops to livestock producers was slow (McIntire *et al*., 1992). This was because farmers were reluctant to give up land used for food crops to growing of fodder.

2.5.1. Factors affecting adoption of technical information

Bwisa and Gacuhi (1997) defined adoption as the acceptance of innovation or invention by at least a user. The rapid and massive adoption of a recommendation was strongly linked to several factors, which may be economic, technological or social.

2. 5. 1. 1. Relevance, compatibility, simplicity and cost.

The central objective of agricultural extension services is to help farm families acquire knowledge and skills along those lines of their current interests and needs which are closely related to increasing farm production and improving the physical level of living (Mosher, 1979). Farmers must perceive a need for the new technology in order to adopt and many innovations from Research and Development Institutions are not accepted because they are not demand driven (Lionberger, 1968).

Practices compatible with the existing farmers' conditions are most likely to be adopted quickly (Bwisa and Gacuhi, 1997, Lionberger, 1968). These include farmers' economic, technical and social status. Improved technology, adapted to the needs and capabilities of farmers is a necessary condition for agricultural and rural development since the rural farmer can only adopt a technology if it is within his means (Sene, 1994).

An easy to demonstrate and implement practice is more quickly adopted (Lionberger, 1968). Simplicity means that a great number of farmers regardless of their educational background would be able to understand the method and, its advantages and forecast the benefits. Risk avoidance is a characteristic pattern in the survival strategies of small arable farmers and many dairy farmers may base their decisions more on ethical and social motives rather than on economic considerations (Somers, 1991). However, one of the key constraints identified for not adopting improved technologies was non-availability of cash (Bindlish and Evenson, 1993). In Kiambu district, for instance, napier grass was left to overgrow although there was a general shortage of forage (Mwangi, 1995). According to the farmers, the napier was left as a security against the times of shortage. During rainy seasons when there was plenty, farmers purchased fodder off-farm since the price was low rather than go into fodder conservation, which involved expenditure on materials and labour. This indicates that technologies that cost little to implement are likely to be adopted quicker than those requiring a large expenditure (Saylor, 1970, Bwisa and Gacuhi, 1997, Mosher, 1979).

2. 5. 1. 2. Other factors

Changes in production systems due to external factors could necessitate adoption of certain technologies. In Kenya, where there was a rapid move towards zero grazing, high-yielding fodder crops such as napier grass and farm by-products inevitably became more popular with farmers due to the high demand for roughage (Morton and Matthewman, 1995). In this case, adoption of zero grazing and napier grass production was caused by external factors namely land and population pressure. Crop residues consisting mainly of maize stover and bean haulms became an important feed resource in this system, providing an average of 35-45% of the total livestock feed requirements (Orodho, 1990).

A survey conducted by the Ministry of Agriculture in Kenya indicated that only 24% of the available technology had been adopted (Muhoho, 1991). There was thus, great need to get the undelivered technologies moving through national research systems and onto farmers' fields (Sansoucy *et al*., 1995). Technologies selected by researchers for propagation should have been carefully tested and considered in terms of their perceived attributes from the farmers' point of view. Differences in perceptions between researchers and farmers could help explain differences in adoption rate expected by scientists and that observed on farms (Shapiro *et al*., 1992).

2. 6. IMPACT OF EXTENSION PROGRAMMES ON THE DAIRY ENTERPRISE

Use of improved technology was found to result in increased feed supply, and hence in improved productivity of ruminants. In the Kilimanjaro highlands, Phase I of the Dairy Farming Systems (DFS) project had a positive impact on the performance of dairy cattle. Other benefits in dairy management were keeping records, use of molasses, better utilisation of maize stover by chopping, increased use of crop residues and improved pasture management practices (Mdoe and Mlay, 1990). Combining the use of straw treatment with that of locally produced oil seed cakes increased daily live-weight gains of the cows by a factor of four and reduced the need for imported feed in China (Sansoucy *et al*., 1995). Work done in Asia showed that the three strata forage system (which involved combining trees, leguminous shrubs and grasses to supply forage from three levels) was very beneficial to low rainfall and drier upland areas such as Eastern Indonesia. The benefits included increased availability of forages, less infestation by endo-parasites in cattle, reduced soil erosion by as much as 57% and improved soil fertility due to introduction of legumes and increased supply of firewood (Devendra, 1994).

2.6.1. Impact on nutrition and productivity

Relevant and adequate information is an essential ingredient for efficient decision-making process aimed at optimising the performance of livestock enterprises (de Leeuw et. al., 1995). The impact of extension may take a long time to be realised in terms of productivity but it is acknowledged that increasing the rate of diffusion of knowledge of improved practices is one way in which extension increases the growth of farm productivity. In the study conducted in Kilimanjaro Highlands by Mdoe and Mlay (1990) improved feed supply and utilisation in dairy enterprise as a result of the use of improved technology had a positive impact on the performance of dairy cattle. This was reflected in the improvement in growth rate of young animals, better body condition of mature animals, better health status and increased milk production. Improved performance, measured in terms of increase in milk yield was as a result of better nutritional status of the animal.

Schreuder, *et al.*, (1995) assessed the impact of veterinary interventions in terms of delivery of disease control messages in Afghanistan. Livestock mortality in districts that received veterinary services was lower than in districts without any veterinary services. The decreased mortality resulted from using better disease control methods.

Farms involved in an extension programme have greater access to information to improve their farm performance. Studies conducted by Gerdien van Schaik *et al*. (1996) on smallholder dairy farms in Murang'a District showed that farms involved in the National Dairy Development Project had higher milk production and a shorter calving interval. Milk production and calving interval were influenced by the amount of concentrates fed. Although average-performing farms incurred more costs on concentrates than the high performing farms, they did not produce more milk and this was thought to be as a result of an inefficient feeding strategy. It was concluded that milk production, as well as fertility, benefited from a good feeding strategy.

Leonard (1970) conducted a survey in Vihiga Division to assess the impact of extension on small farmers. Results of the study showed that there was a very strong relationship between contact with extension workers and the quality of the farmers' knowledge and practice. There was a clear and statistically significant relationship between the quality of a farmer's knowledge and his receipt of one or more extension visits in the last year. A clear relationship between a farmers' use of modern practice and his contact with extension workers was also shown, and contact with extension affected what the farmer put into practice.

Use of improved feeding strategies should lead to an improvement in nutritional status of the animal and to improved productivity. Optimum feeding involves feeding of adequate amounts relative to requirements and balance of energy and protein (Waldner, 1997). To maximise on the returns, the nutritional status of animals should be closely monitored. Regular assessment of nutritional status would ensure that the animals' nutritional requirements are precisely met without incurring unnecessary feed costs.

2. 6. 1. 1. Assessment of Nutritional status

Nutritional stresses are the primary direct or indirect cause of failed or marginal performance, whether it be poor re-breeding, weak unhealthy calves, low milk production and low weaning weights, or high incidences of disease and poor health (Dhuyvetter, 1997). As much as the farmer may have knowledge and adopt technologies on feeding, it is important that the nutritional status of cattle to be assessed in order to make sound management decisions. This could be done subjectively through visual assessment for body condition or through such metabolic profile testing as analysis of blood or liver content in case of minerals, ß-hydroxybutyrate levels for dietary energy content and urea concentrations in case of protein-energy balance (Hammond, et. al., 1995, Ferguson, 1996, Dhuyvetter, 1997, Whitaker, et. al., 1999).

2. 6.1. 2. Use of milk urea nitrogen (MUN) concentration

Protein and energy are of paramount importance in ruminant nutrition and assessing these two nutrients in the diet can be used to indicate the nutritional status of animals. The optimum ratio of digestible organic matter:crude protein (DOM:CP) is about 7:1 in cattle (Moore, et. al., 1995: quoted by Hammond and Chase, 1995). Under conditions where forage composition and precise intake are unknown, a metabolic indicator of the protein and energy status in the body could be helpful as a measure for nutritional status in cattle. Such an indicator is milk urea nitrogen. However, this is used as an adjunct to other measures such as body weight and body condition score that reflect the integrated effects of nutrition over time (Hammond and Chase, 1995).

Protein digestion in ruminants results in unused ruminal ammonia being transported to the liver via the portal blood where it is converted to urea. This together with urea from deamination of amino acids arising from post-ruminal digestion and systemic protein turnover then circulates in the blood (Hammond and Chase, 1995). This urea may be excreted in the urine via the kidneys or it can diffuse from the blood back into the rumen, via the saliva, or diffuse from the blood into milk in the case of lactating females. In healthy ruminants Blood Urea Nitrogen (BUN) and Milk Urea Nitrogen (MUN) concentrations (which are highly correlated) indicate the protein to energy (DOM:CP) ratio in the diet (Thornton, 1970; Hammond, 1983a; Roseler, *et. al*., 1993;

Baker, *et al*., 1995). This method of nutritional assessment was used by Refsadal *et al.* (1985) Kirchgessner and Dora (1986), Cannas *et al.* (1998) and has been adopted by groups such as the Pennsylvania Dairy Herd Improvement Association as a routine management practice.

Balanced diets for lactating cows were associated with average MUN concentrations of 15 to 16 mg/dl (Baker, *et al*., 1995). Increased dietary protein with constant energy intake, increased solubility or degradability of dietary protein resulted with high (>19 mg/dl) MUN while increasing energy with constant protein intake and increased level of feed intake led to a decrease (< 7 mg/dl) in MUN (Hammond, 1983a; Roseler *et. al*. 1993; Baker, et. al. 1995, Kirchgessner, and Dora, 1986). Efficiency of protein utilisation, health of the animal, physiological state and breed of the animal also affect MUN but the impact of these is minor. Severe under-nutrition or disease may also result in high MUN (Ward, *et. al*., 1992).

Investigations by Kirchgessner and Dora (1986) showed that using urea content of milk as the criteria, a means for the diagnosis of the kind of malnutrition could be established. A scheme of diagnosis for various types and combinations of malnutrition of nutrients based on changes in the urea content of milk was established (Table 1).

2. 6. 2. Use of Body Condition Score

Body condition scores are estimates of fatty tissue under the skin of certain areas of a cow's body and are an indication of body reserves (Ferguson, 1996). At farm level where farmers do not weigh their animals at regular intervals, the farmer could determine the body condition of each cow within the herd simply and quickly and make management decisions accordingly. Body condition in maiden heifers has been found to affect conception rate, and the score at calving also affect subsequent lactation yield (MOA, UK, 1978).

Table 1: Diagnosis scheme for malnutrition depending on urea content of milk.

Kind of malnutrition	**Range of MUN (mg/100ml)**
Restriction of energy	> 25
Energy in excess	7 - 12
Restriction of protein	<7
Protein in excess	19 - 25
Restriction of energy and protein	12 - 18
Energy and protein in excess	> 25
Restriction of energy, protein in excess	> 25
Restriction of protein, energy in excess	< 7

(*Adapted from Kirchgessner and Dora, 1986*)

A five-point scoring system of MOA-UK (1978) is simple and can be carried out quickly and with little practice providing consistent scores. Another chart developed by Edmonson *et. al*. (1989) using an interactive process gave consistent results with small variability among assessors. The scoring was done with the cow standing restrained in a structure and the scorer standing directly behind the cow. There was a relationship between condition score and live-weight change and a change in body condition score of one unit was found to represent a change in body live weight of 15 kg in heifers or 30 kg in early lactation. Although this relation could be complicated by pregnancy, body condition scoring nevertheless could give the farmer a quick indication of a longstanding nutritional status of the animals.

CHAPTER 3. DELIVERY OF TECHNICAL INFORMATION TO SMALLHOLDER DAIRY FARMERS IN KIAMBU DISTRICT.

3.1 INTRODUCTION

Currently, the smallholder dairy farms in Kenya account for over 80% of the milk marketed in the country. However, milk production even in high potential areas like Kiambu District is below the animals' expected potential. One of the factors attributed to this is lack of technical information, arising from inadequate extension services. The two latest donor-assisted government projects reached less than 50% of the farmers. Farmers may obtain information from sources other than the government extension service but these have neither been documented nor categorised, nor their effectiveness assessed. The purpose of this study therefore, was to document the sources of information, their messages and methods of delivery to the smallholder dairy farmers in Kiambu District, and to assess their impact on productivity.

3. 2. METHODOLOGY

3. 2. 1. The study area

The study was conducted in Kiambu District of Central Province, Kenya in a randomly selected sample of smallholder dairy farms. Kiambu District is located to the North of Kenya's capital city, Nairobi, bordering Nyandarua District to the North, Thika to the East and Nakuru and Kajiado to the West. The district covers an area of 1448 square kilometres, out of which 1422 square kilometres constitute the agricultural land. The District's population was estimated at 768,000 people who occupy approximately 103,800 farm holdings with an average farm size of 0.8 Ha. The district is divided administratively into six divisions, 29 locations and 106 sub-locations (OVP, 1994; DLPO, 1996).

The district lies at an altitude ranging from 1350-2300m above sea level, with an average annual rainfall of 1200 mm., most of which was received in two seasons. The long rains occurred in March to June and the short rains in September to November. The high altitude areas, particularly those close to forest, also received drizzles in July-August, which allowed growing of horticultural crops.

Over 80% of the farms in the district were small holder mixed farms based on crop and livestock production, the rest being large-scale coffee, tea estates and flower farms. The main livestock enterprises in terms of numbers and occurrence were Dairy, Poultry and Pig production. Other enterprises like sheep, goats, rabbit production and bee keeping were evident but on a low scale. The common dairy cattle breeds kept were Friesian, Ayrshire, Guernsey, Jersey and their crosses. Limuru Division was selected for this study due to its accessibility and diversity in exposure to extension services.

3. 2. 1. 1. The dairy enterprise in Limuru Division

Dairying was the most common livestock enterprise to smallholder farmers in Limuru Division. The population of dairy cattle at the end of 1996 was estimated at 50,000 producing an estimated 14 million kilograms of milk. About 79% of the small-scale farmers practised dairy farming and to 43% of these, dairying was the main source of income (DLPO, 1997).

There was only one Dairy Co-operative Society, which served the whole division, with a membership of 7,000 out of which 4,500 were active. The co-operative also owned a milk processing plant, which had a capacity of 40,000 litres. Apart from milk marketing, the dairy co-operative offered other services on credit including supply of farm inputs, veterinary clinical and artificial insemination services and even cash loans to the members.

Most dairy farmers relied on napier grass (*Pennisetum purpureum)* as the basal feed, while a few relied on native pastures. Only a few, mainly large scale farmers, had established ley pastures comprising Rhodes (*Chloris gayana)* and Kikuyu (*Pennisetum clandestinum)* grasses which were either grazed or cut for hay. The area under pasture was estimated at 3550 Ha (DLPO, 1996). Fodder trees and legumes such as Calliandra, Sesbania, Desmodium and Lucerne were grown to a very small extent. Use of crop residues as feed (e.g. maize stover, sweet potato vines, and banana pseudostems) and purchasing of fodder was also widespread.

Commercial concentrates and milling by-products were also used. These included the dairy concentrate (dairy meal), maize germ, bran and poultry litter. The majority of farmers fed dairy concentrate to the lactating animals only, at the rate of about 2 kg per cow per day throughout the lactation. Other products e.g. maize germ, wheat/maize bran were fed to compensate for fodder shortage.

3. 2. 2. Data collection

Three locations were selected within Limuru Division based on exposure to government extension service. In Ngecha Location, there had been a resident frontline extension worker in charge of livestock for many years and so the farmers had been greatly exposed to government extension service and several other extension agencies, hence high extension contact level (HCL) was expected. Farmers in Rironi Location had not had a resident government extension worker but had been exposed to a Non Governmental Organisation (NGO) and hence medium extension contact level (MCL) was expected. Farmers in Limuru Location had neither had a resident government livestock extension worker, nor an NGO operating in the area (DLPO, 1998) and hence were expected to have had low extension contact level (LCL). Budgetary constraints did not permit coverage of entire locations and hence a sub-location, from each location was randomly selected for the study. The sub-locations selected were Kabuku in Ngecha, Rironi in Rironi and Bibirioni in Limuru location (Appendix 1). Farmers' lists of the extension agencies present in their area confirmed the expected levels of extension contact. Farmers drew the lists during informal meetings in which they also ranked the extension agencies on the basis of how closely the agent had worked with the farmers. The farmers in the three Locations were compared on the basis of involvement in extension activities, knowledge and practice of dairy technologies and dairy cattle performance.

3. 2. 2. 1. Questionnaire development

Three informal meetings were held, one in each of the three sub-locations with groups of 20 to 30 farmers. The farmers were invited to the meetings through announcements made in the local primary schools hence no selection was done. These meetings were held to:

1. List identifiable technologies related to dairying (e.g. production of fodder, management of cattle etc).
2. List sources of dairy production information available to farmers in each Location.
3. List the methods used in information transfer in the Locations.
4. Discuss factors relating to adoption of technologies related to dairy.
5. Compare what farmers and the researchers consider as important production parameters in dairy.

The information gathered was used to design a questionnaire for the formal survey. The questionnaire was pre-tested and adjusted accordingly to make sure it would extract all the information required without engaging the farmer for too long.

3. 2. 2. 2. Community map

During the informal meetings, each group of farmers sketched a map of their sub-location. One farmer, who was appointed by the group, did the actual sketching while all the members participated in giving the information to be included on the map. The features included in the maps were the infrastructure and all the households that had dairy cattle (appendix 1). The households were numbered on the map and names of the household heads listed separately against the numbers.

3. 2. 2. 3. Wealth ranking

The farmers developed a wealth ranking system, with guidance from the researcher (ILCA, 1990). The criteria used to determine the wealth status of each farmer were land-size, type of house, crops grown, type and number of animals, form of transport and estimated income from off-farm activities. For each criterion, different alternatives were set to represent three wealth categories i.e. rich, medium and poor. Scores were given according to the wealth status such that for rich, a score of three was given, for medium two and for poor a score of one. Ranges of total scores were set for the three wealth categories (Table 2).

All the households indicated on each map were considered individually. The farmers gave information based on the wealth ranking criteria as the researcher did the scoring. The scores were then summed up and the wealth rank determined and listed. The names of household heads were then listed again, grouped according to the wealth rank.

Table 2: Criteria and scoring system used in ranking the households by wealth

Household resource	Measure	Level for each wealth rank and score*		
		Rich (3)	**Medium (2)**	**Poor (1)**
Land size	Acres	> 5	1 – 5	< 5
Cash crops	Objective	For exports	For local sale	None
Land under Napier grass	Acres	> 3	1 – 3	< 1
Residential house	Construction inputs	Stone walls, tiles/iron roof	wooden walls, concrete/earth floor	Earth walls
Poultry	Flock size	> 500 birds	100 – 500 birds	< 100 birds
Pigs	Breeding stock	> 10	2 – 10	< 2
Mode of transport	Type	Tractor/pick-up/ Saloon car	Motorcycle/Bicycle/ Donkey cart	Hand cart/ Wheelbarrow/none
Off-farm business	Type	Wholesale shop/store/ supermarket	Retail shop	Kiosk/none
Off-farm employment	Estimated monthly Salary in Ksh.	> 15,000	5,000 – 15,000	< 5,000/none

* Total score: Rich = > 23, Medium = 14 – 23, Poor = < 14
Figure in brackets is the score for each wealth rank.

3. 2. 2. 4. Selection of farmers

For each location, a list of farmers was made. The names were put in three groups, according to the wealth rank, and numbered independently. Using a calculator, random numbers were generated and successively allocated against each name. By picking the names represented by random numbers in ascending order, sixty-three households (HH) were selected, stratified by level of exposure to extension service and wealth status such that from each location (representing level of extension contact), 21 farmers were selected, 7 from each of the three wealth categories (Table 3).

3. 2. 2. 5. Survey

The households selected were visited without prior appointment and either the manager or owner interviewed. In cases where none of these people were available, an appointment was made for the following day. Using a structured questionnaire (Appendix 2), information on household/farm characteristics and resources, sources of technical information and activity involvement was collected. The distance from the farm to an all weather road was estimated using the average researcher's walking speed of 4 km/hr. Using a scale of 1 – 4, farmers were asked to rank the sources of information available to them, based on their perception of effectiveness (i.e. a score of 4 for the most effective and 1 for the least effective).

Participatory assessment of level of knowledge and adoption of technologies related to dairying (determined during the farmers' meetings) was carried out. Farmer's knowledge and adoption of each technology, what was scored against recommendations by the Ministry of Agriculture. Study observations plus farmers' reports on the farm were assumed to be the farmer's practice of a particular technology. A scale was developed to show how far the farmers' level of knowledge or practice deviated from the recommendations. The farmer

Table 3: Distribution of farmers selected for the cross-sectional survey by location and wealth.

Location	HCL (Ngecha)			MCL (Rironi)			LCL (Limuru)		
Extension Projects present	NEP, NDDP, Plan International			Plan International					
Wealth rank	R	M	P	R	M	P	R	M	P
Number of HH selected	7	7	7	7	7	7	7	7	7

HCL, MCL, LCL = High, Medium and Low contact Locations
R = Rich, M = Medium, P = Poor.
NEP = National Extension Programme
NDDP = National Dairy Development Project

scored zero if his/her knowledge or practice met the recommendations. A positive score was not expected since the recommendations were expected to be ideal. An independent scale was developed for each of the technologies (appendix 3).

To assess productivity of the dairy herd, calving interval was calculated from the last and previous calving dates as given by the farmers from recall. Peak and current milk yields were also recorded from farmers' recall. The survey was carried out in February 1998.

3. 2. 3. Data management and analysis

All data were summarised on a spreadsheet using the computer package Microsoft Excel (Microsoft Corporation, 1985–1996). Variables were grouped into farm/farmer description, extension activity involvement, technology adoption, animal performance and management variables. Separate files were created for each group of variables as follows:

i) *Farm description* - Land size, proximity, proportion planted with napier grass/maize, number of animals, transport and communication facilities.

ii) *Farmer description* - Farming experience, education level and co-operative membership.

iii) *Management* – Knowledge and practice indices on amount of napier grass planted and offered, amount and type of concentrate fed, amount and type of minerals fed, housing, dipping and de-worming frequency.

iv) *Productivity* - Calving interval, calving/peak milk yield and current milk yield.

Descriptive statistics of all the variables were calculated using SAS statistical software (SAS, 1988). Using the general linear model (GLM) procedure of SAS, analysis of variance was done on all the variables listed above with level of extension and wealth rank as the sources of variation. The effect of level of extension and wealth on knowledge and practice indices and productivity was tested using the following fixed effect model:

$$Y_{ij} = \mu + \beta_i + \rho_j + \beta\rho_{ij} + \varepsilon_{ij}$$

Where:

Y_{ij} = Peak milk yield, current milk yield, calving interval, knowledge index and practice index at the i^{th} level of extension and j^{th} wealth rank

μ = Overall mean

β_i = Fixed effect of i^{th} level of extension

ρ_j = Fixed effect of j^{th} wealth rank

$\beta\rho_{ij}$ = Effect of interaction between level of extension and wealth rank

ε_{ij} = Random error associated with the model

Where any of the factors were significant, the means were separated by least significant difference (LSD) method (Appendix 4). The results were summarised in table of means and SE.

3. 3. RESULTS AND DISCUSSION

3. 3. 1. Farm characteristics

3. .3. 1. 1. Distance from the road

The distance of selected farms from an all-weather road ranged from a few metres to 3 km (average 1 km). Farms in the MCL were the closest to an all-weather road and farms in the LCL the furthest but this was just by chance (Table 4). Extension level did not have a significant ($P > 0.05$) influence on the distance. Farms in the medium wealth rank were the

Table 4: Descriptive statistics of Kiambu small-holder dairy farm variables

Variable	Means[1] for Level of extension			
	HCL	**MCL**	**LCL**	**Pooled SE**
Distance from all-weather road in km	1.1[ab]	0.8[a]	1.4[b]	0.10
Total land available in ha	1.2[a]	2.0[a]	1.6[a]	0.52
Proportion total land that is rented	0.3[a]	0.1[b]	0.1[b]	0.03
Number of HH adults working on the farm	1.6[a]	1.5[a]	1.4[a]	0.16
Experience in dairying in yrs	16.8[a]	22.8[a]	21.2[a]	1.51
Index for education level* of dairy manager	2[a]	2[a]	2[a]	0.14
Land under napier grass in ha	0.5[a]	0.4[a]	0.3[b]	0.02
Land under maize in ha	0.4[a]	0.4[a]	0.4[a]	0.07
Number of mature cows	1.0[a]	1.6[b]	1.5[b]	0.16

Variable	Means for Wealth Rank			
	R	**M**	**P**	**Pooled SE**
Distance from all-weather road in km	1.1[ab]	0.9[b]	1.4[a]	0.10
Total land available in ha	2.5[a]	1.5[b]	0.8[b]	0.52
Proportion total land that is rented	0.2[a]	0.2[a]	0.2[a]	0.03
Number of HH adults working on the farm	1.5[ab]	1.3[a]	1.6[b]	0.16
Experience in dairying in yrs	20[a]	22[a]	19[a]	1.51
Index for education level of dairy manager	1.6[a]	1.2[b]	0.8[b]	0.14
Land under napier grass in ha	0.4[a]	0.4[a]	0.4[a]	0.02
Land under maize grass in ha	0.4[a]	0.4[a]	0.5[a]	0.07
Number of mature cows	1.7[a]	1.2[b]	0.9[b]	0.16

**Education levels: 0 = No formal education, 1 = Adult literacy, 2 =Primary school, 3 =Secondary school, 4 = Post Secondary (A-Level), 5 = University/Technical College, 6 =* Other

---

[1] *Variable means with the same superscript are not significantly different.*

closest to an all-weather road and farms in the poor wealth rank the furthest again by chance, but wealth rank did not have a significant ($P > 0.05$) influence on the distance (Table 4).

3. 3. 1. 2. Farm size

Farm size, was between 0.2 and 6.4 ha (average 1.6 ha). Although farm size did not vary by location it varied ($P< 0.05$) by wealth rank. The total farm size comprised owned and rented land. The proportion of land that was rented ranged from farm to farm but averaged 0.3 ha. Farmers in the HCL rented more land (average 0.4 ha) compared to those in the MCL (average 0.2 ha) and LCL (average 0.2 ha). Renting of land for growing napier grass and maize was a common practice in this area because of the intensity of production systems (DLPO, 1998). The rich farmers rented more ($P < 0.05$) land (average 0.5 ha) than the medium (average 0.3 ha) and poor (average 0.2 ha) since they could afford.

3. 3. 1. 3. Human resources

An average of two adults per household, with an average experience of 20 years in dairy farming, worked fulltime on the farm. Both the number and experience were not influenced by location or wealth ($P > 0.05$). Most adults in this area preferred to seek employment in the urban centres rather than to work on-farm because of proximity to the city. On average, the dairy farm managers were of primary level education, although richer farmers had managers with higher education level. Rich farmers could afford to educate their household members to higher level and/or hire a highly educated manager.

3. 3. 1. 4. Land use

All the farmers in the study practised mixed farming. The major crop enterprises were maize, beans, potatoes and vegetables. The main livestock enterprises were dairy with an average of two mature cows per farm and poultry. The average area under napier grass was 0.4 ha per farm, which represented an average of 25% of the total cultivated land. Farmers in HCL and MCL allocated more land to napier grass ($P < 0.05$). Wealth rank did not influence allocation of land to napier grass production. Farmers ranked dairy as the most important enterprise and thus allocated a big proportion of their land to napier grass production. However, the recommendation of one acre per mature cow and heifer (MLD, 1991) was not achieved. Purchased fodder and feed were a crucial component of smallholder dairy production systems in Kiambu district, with 60% of the zero-grazing farmers relying on feed purchases (Staal et. al., 1997). The average land allocated to maize was 0.4 ha which equalled that under napier grass. However, it did not vary either by location or by wealth rank ($P < 0.05$). Although maize was grown mainly for food, it also contributed to fodder supply in terms of thinnings, green/dry stover and the salvage value (Methu, 1998, Lukuyu, 2000).

3. 3. 1. 5. Transport means and communication

Farmers required transport to move fodder from the plots and/or other farms (in case of purchased fodder) and from the farm stores to the feed troughs. They also required to transport commercial concentrates and other farm inputs from the stockists. Where there was no on-farm water source, the water would be purchased off-farm and then be transported to the farm. Various transport means were therefore required for the various tasks.

Transport means recorded on the farms included motorised transport, draft animals (donkey carts) and manual transport (hand-carts and wheelbarrows) (Table 5). Manual transport was the most commonly used. Only 47% of the rich farmers had motorised means of transport across all the locations, which may be due to the fact that farmers' priorities differed from farmer to farmer. However, more rich farmers in the LCL (71%) owned motorised transport

Table 5: Households with various means of transport and communication and dairy co-operative membership.

Variable	% for Level of extension		
	HCL	**MCL**	**LCL**
HH that were members of the dairy co-operative	75.5	76.2	56.8
HH with motorised transport	57.1	14.3	71.4
HH with draft animal transport	14.3	57.1	14.3
HH with TV	61.9	61.6	47.3
HH with Radio	94.9	89.8	75.9

Variable	% for Wealth Rank		
	R	**M**	**P**
HH that were members of the dairy co-operative	85.4	75.5	47.6
HH with motorised transport	47.6	0	0
HH with draft animal transport	28.6	28.6	19.1
HH with TV	89.8	57.1	38.1
HH with Radio	94.9	84.7	81.0

than those in the HCL (57%) and MCL (14%). Unlike the other locations, the LCL was further from a major highway and hence not well served by public transport. Hence, buying a car may have been a priority. Use of drought animals, as means of transport was more common in the MCL (57%) than in the HCL (14%) and LCL (14%). These areas experienced serious water shortage and drought animals were commonly used to ferry water. Overall, 87% of the farmers owned radios and 62% owned TVs because radios were more affordable and could be used even in areas not served with electricity.

3. 3. 2. Information delivery

3. 3. 2. 1. Sources of information

The government extension service, the dairy co-operative society, private veterinarians and traders, mass media, non-governmental organisations (NGOs) and neighbours were cited as sources of technical information (Table 6). Dairy co-operatives and neighbours were the most commonly cited sources of information to farmers in the three locations. At least 50% of the farmers across all the locations were members of the dairy co-operative society, out of which 69% were active (i.e. they were delivering milk to the dairy at the time the study was carried out). Reasons for non-delivery of milk included temporarily dry cows and death of cows. However, the non-active members still sought other services from the dairy. Such services were artificial and clinical services, and they also procured inputs from the co-operative stores. Staal *et al*. (1997) observed that 59% of the dairy farmers in Kiambu District were members of a dairy co-operative society and out of these 68% were active. The farmers kept close contact with the dairy co-operative society because of the variety of services it offered i.e. milk marketing feed supply, A.I. and veterinary clinical services. Therefore the co-operative was an important source of information to farmers in all locations and wealth groups.

Table 6: Count* of farmers who cited different extension agencies as important sources of technical information.

Extension agency	Extension level				
	HCL	MCL	LCL	Total	Percent
Government	17	3	0	20	32%
Co-operative	19	20	3	42	66%
Private	11	5	10	26	41%
NGOs	0	1	0	1	2%
Mass media	8	4	1	13	21%
Neighbours	16	9	8	33	52%

Extension agency	Wealth rank				
	R	M	P	Total	Percent
Government	9	5	6	20	32%
Co-operative	16	14	12	42	66%
Private	12	7	7	26	41%
NGOs	0	0	1	1	2%
Mass media	7	3	3	13	21%
Neighbours	9	13	11	33	52%

* *Count for each information source was independently taken.*

More farmers in the HCL sought information from neighbours as compared to those in MCL and LCL and this was due to the fact that the government extension encouraged farmer-to-farmer extension approach. Government extension service had for a long time used contact farmers who would be the frontline extension worker's delivery and dissemination point of new technologies. It was in such a farm that all the new technologies were tried out and the neighbours, designated follower farmers, would be called in to learn. The farmers were encouraged to pass on the message to others.

Farmers of medium and poor wealth ranks depended more on neighbours for information than the rich since the rich could afford more of the alternative sources. Delivery of information through neighbours was facilitated by the proximity of farms to each other and the social behaviour of farmers of exchanging news. Metz *et al*. (1995) and Miheso, (1998) observed that more than 50% of dairy farmers obtained information on feeding and breeding of dairy cattle from their neighbours.

Government extension mainly covered farmers in the HCL where it was active. It was cited by 17 farmers (out of 21) in the HCL, three in the MCL and none in the LCL. The government extension service should have covered the whole range of farmers from the best to the poorest through individual contact, but there was concern that this service was not being delivered to dairy producers effectively (Leonard, 1970; Barton and Reynolds, 1996). The frontline extension workers with orientation towards dairy production were still too few to reach the vast number of farms with dairy cattle and hence some areas remained without extension workers. In the areas where they were present, they were able to make only a few individual contacts (Leonard, 1974).

Private extension services and schools were not a common source of technical information. Schools tended to concentrate their efforts more on academic topics and ignored practical information that the pupils could pass on to their parents. The private stockists were not pro-active in giving farmers information, and farmers viewed them as traders only. However, because of the close contact with farmers as they procure inputs, private stockists have potential as a delivery channel for technical information. The rich farmers used the private veterinary service more because they could afford it.

Though a large proportion of the farmers owned TVs (56.9%) and radios (86.9%), only 21% of the farmers cited them as a source of information. Although mass media is considered the least expensive method of delivering messages to a large number of people (van den Ban and Hawkins, 1996), few farmers used it. With farming activities running throughout the day, the farmers were unable to set aside time to listen to the TV or radio. Also, the messages on offer were so general that farmers found them inappropriate to their specific needs. The farmers also, had preference for dialogue, which the mass media could not provide.

3. 3. 2. 3. Ranking of information sources.

The sources of information cited were ranked from excellent (4) to poor (1) based on farmers' opinions on the effectiveness of different information sources (Table 7). The dairy co-operative was ranked the best source of information followed by neighbours. The farmers contacted the co-operative on a daily bases when delivering milk and hence were able to seek and/or obtain information easily. The co-operative also facilitated meetings between the farmers and other extension agencies such as the government extension and private manufacturers by organising field days. Neighbours were in close proximity and gave

Table 7: Mean scores* of farmers' opinions on the effectiveness of different information sources.

Extension agency	Extension level			
	HCL	MCL	LCL	Av. Score
Co-operative	3	3	3	3.0
Neighbours	3	3	2	2.6
Government	2	1	0	2.0
Private	2	2	2	2.0
NGOs	0	2	0	2.0
Mass media	2	2	2	2.0

Extension agency	Wealth rank			
	R	M	P	Av. Score
Co-operative	3	3	3	3.0
Neighbours	2	3	3	2.6
Government	1	2	2	2.0
Private	3	2	1	2.0
NGOs	0	0	2	2.0
Mass media	3	2	1	2.0

** Each information source was independently scored:*
4= Excellent, 3= Good, 2= Average, 1= Poor, 0= No contact.

practically reliable information based on their experiences. The farmers could gauge the value of their neighbours' advice directly from the performance of their dairy cows.

The private sector (both private veterinarians and stockists) was ranked average in effectiveness because although it was potentially available, the farmer had to pay for the services. Hence it was available only to those who could afford. The rich farmers ranked the private veterinary service as good due the fact that the private veterinarians were very prompt when called upon to attend to a health problem. However, the veterinarians offered technical advice only when farmers requested for it. The charges given by the private veterinarian covered the clinical services only and this may explain their reluctance to offer advisory services. However, this may suggest that private veterinarians could be used effectively as information delivery channel particularly if the farmer could pay for the advisory service. Historically, extension services in Kenya have always been offered free. This has proved to be unsustainable under the current economic trend and other ways such as cost sharing and privatisation need to be sought.

The government extension service was ranked average in effectiveness. Although government extension staff provided personal attention with relevant messages, the frequency of farm visits was very low. This contrasted with Rees *et al*. (1999) observations in Trans Nzoia and West Pokot Districts where farmers cited the government extension service as the most important source of technical information, which may have been due to lack of alternative information sources.

3. 3. 2. 4. Ranking of information delivery methods

The common information delivery methods were ranked from excellent (4) to poor (1) based on farmers' opinions on their effectiveness (Table 8). Farmers' field days were ranked the best followed by farmers' tours. Field days not only gave farmers an opportunity to share their experiences and exchange ideas, but they also enabled farmers to meet several extension agencies in one activity. Farmers in HCL and MCL ranked field days higher than farmers in LCL. Having been in contact with the government extension and an NGO, these farmers may have had greater exposure to field days. The rich farmers did not value field days as highly as the medium and poor farmers and this may be attributable to the fact that they seemed to value individual contact more.

Farmers' tours were highly valued because they gave the farmers a chance to see the results of adoption of a technology. Tours were therefore more effective in convincing farmers to try out the technology. Farmers in the HCL and MCL may have been exposed to tours more than LCL farmers due to their contact with the government extension and NGO. Hence they ranked them higher. In most cases, farmers were required to contribute towards the cost of tours and so only those who could afford were able to participate. This may explain the low rank given by the poor farmers.

Farmers' residential courses were given an average rank of 3. They afforded the farmers enough time to learn and enabled them to have close interaction with one another and with the extension agents. However the farmers felt that residential courses required them to be away from the farm and this was not favourable to them. There was however no variability in ranking among the locations or wealth groups, which could indicate that farmers participated in residential courses equally regardless of location or wealth status.

Table 8: Mean scores* of farmers' opinions on the effectiveness of different information delivery methods.

Extension method	Extension level			
	HCL	MCL	LCL	Av. score
Farmers' field day	4	4	3	3.6
Farmers' tour	4	3	3	3.3
Farmers' residential course	3	3	3	3.0
Visit by co-operative veterinarian	3	3	2	2.6
Visit by government extension	3	2	1	2.0
Visit by government veterinarian	3	2	1	2.0
Visit by private veterinarian	2	2	2	2.0
Farmers' informal discussions	2	2	2	2.0
Agricultural show	2	1	1	1.3

Extension method	Wealth rank			
	R	M	P	Av. score
Farmers' field day	3	4	4	3.6
Farmers' tour	4	4	2	3.3
Farmers' residential course	3	3	3	3.0
Visit by co-operative veterinarian	3	3	3	2.6
Visit by government extension	3	2	2	2.0
Visit by government veterinarian	2	2	3	2.0
Visit by private veterinarian	3	2	1	2.0
Farmers' informal discussions	2	2	2	2.0
Agricultural show	2	2	1	1.3

** Each information delivery method was independently scored:*
4= Excellent, 3= Good, 2= Average, 1= Poor.

Overall, visits by the government extension and veterinarian were ranked average in effectiveness. Though the farmers received individual attention and relevant messages, the visits were infrequent. Farmers in the HCL where the government extension service was active ranked the visits higher than the farmers in MCL and LCL. The rich farmers ranked the visits higher than medium and poor farmers, which may suggest a bias by the government extension workers towards the more progressive farmers. Leonard (1977) observed that the provision of extension services through individual farm visits was greatly skewed in favour of the progressive farmers.

Overall, visits by the co-operative veterinarian ranked higher than visits by the private veterinarian, probably because members of the co-operative could receive services from the co-operative veterinarian on credit. Farmers in the LCL gave visits by the co-operative veterinarian a lower score than farmers in the HCL and MCL, but the area recorded lower co-operative membership. The rich farmers ranked visit by private veterinarian higher than the medium and poor farmers, since they could afford.

Farmers in all the locations and wealth groups ranked informal discussions as average. Though they reached many farmers, the technical content of the messages was not reliable due to 'watering down' effect as the message was passed from one farmer to another. Van den Ban and Hawkins (1996) stated that one disadvantage of farmer-to-farmer communication was that there was a high probability to adjust the message. However many farmers felt that these discussions were beneficial because they were based on farmers' experiences.

Agricultural shows received the lowest average score. Apart from being infrequent, farmers felt that most of them could not afford the travelling costs and entry fee. Farmers in the HCL ranked agricultural shows higher than farmers in MCL and LCL probably because government extension workers with whom they had contact played a role in advertisement for shows. Although agricultural shows accorded farmers a chance to learn many new agricultural technologies, this objective was marred by inclusion of non-agricultural commercial displays, which apparently tended to be very attractive. These distracted farmers' attention from agricultural displays.

3. 3. 2. 4. Farmer participation in extension activities.

Extension activity, in this study, was defined as an interaction between a farmer and an extension source for the purpose of sharing or exchanging of information on farming technology. Such activities included visits by or to an extension agent, field days, tours, courses/seminars and informal discussions. Although most farmers said they had access to information on both animal production and health, during the year 1997 less than 25% had been involved in any extension activity (Table 9).

Only two farmers (5%) from the HCL (overall, 2%) reported having been visited by a government extension worker/veterinarian, and none in the other locations. This shows a deterioration of the government extension service over the years. In the past, great emphasis was laid in individual farm visits as it was felt that the farmer was less likely to be "mis-informed". Individual farm visits depended heavily on efficient transport means and staff remuneration. The public extension service was constrained by insufficient operational resources (money and transport) particularly at the field level (Leonard, 1974). Though there was equipment and transport means provided by the donor-assisted projects, they were not

Table 9: Count* of farmers who participated in different extension activities during the year 1997.

Variable	Extension Level		
	HCL	MCL	LCL
Visit by government extension worker	1(5)	0	0
Visit by government veterinarian	1(3)	0	0
Government funded field day	4(2)	2(1)	0
Co-operative funded field day	4(1)	10(1)	2(1)
Visit by co-operative veterinarian	12(2)	2(3)	0
Visit by private veterinarian	9(2)	2(3)	2(2)
Visit by co-op extension worker	0	0	2(1)
Visit by private extension worker	0	1(1)	1(2)
Visit to NGO	0	2(4)	0
Mass media	5(4)	0	2(5)
Informal discussions	13(5)	10(3)	7(4)

Variable	Wealth Rank		
	R	M	P
Visit by government extension worker	0	1(5)	0
Visit by government veterinarian	0	0	1(3)
Government funded field day	1(1)	3(2)	1(1)
Co-operative funded field day	4(1)	6(1)	6(1)
Visit by co-operative veterinarian	9(3)	2(2)	3(2)
Visit by private veterinarian	(3)	5(2)	2(2)
Visit by co-operative extension worker	1(1)	1(1)	0
Visit by private extension worker	2(2)	0	0
Visit to NGO	2(4)	0	0
Mass media	6(5)	0	1(4)
Informal discussions	8(3)	11(4)	11(5)

** Count for each extension activity was independently taken.*
*** Figures in brackets represent the mean frequency of the extension activity.*

operational due to lack of maintenance (MALDM, 1996). This, coupled with low staff farmer ratio resulted in low farm coverage. Therefore, under such circumstances individual farm visits were not an effective extension approach. Leonard (1977) observed that individual farm visits were not a suitable method of agricultural extension for a developing country.

Greatest participation was recorded in farmers' field days, although they were held only once or twice a year. One field day organised by the dairy co-operative reached farmers in all the locations (19% in HCL, 48% in MCL and 10% in LCL) and wealth categories (19% rich, 29% medium and 29% poor). There was higher attendance by farmers from the MCL and this suggests that the venue may not have been central. The overall coverage was, however, low and this could probably be due to the low frequency of the activity and poor advertisement. Leonard (1977) observed that extension to a group of farmers was a more desirable method of agricultural extension for a developing country. Unlike farm visits, where the frontline extension worker had to make a large number of visits in order to contact more farmers, the frequency of well advertised field days could be low and yet, reach a large number of farmers. Although farmers' field days were constrained by availability of resources (MALDM, 1996), they should be encouraged as they reached more farmers and facilitated contact with many sources of information. The dairy co-operative tended to pay more attention to milk marketing and input supply and less to extension service as indicated by the few visits made by co-operative extension worker. Nevertheless, because of its great contact with farmers, it had great potential in facilitating group extension activities.

Neighbourhood discussions were the major extension activity the farmers were involved in. Morris (1991) observed that when a client desired an activity promoted by an extension agency, contacts between farmers and the agency became synergistic and generated additional activities beyond that supported by the agency. With dairy being the most important enterprise in the area of study, farmers were keen to seek new technologies and since government extension contact was becoming more and more scarce (Barton and Reynolds, 1996, MALDM, 1997), farmers tended to seek information from their neighbours. Informal discussions did not require any prior arrangement and took place at the farmers' convenience. They also addressed specific individual problems and since the farmers' had total control over the activity, the frequency was higher compared with other extension activities.

Most of the visits by veterinary personnel reported in the study were made to rich farmers (56%). The veterinary service was essential since the consequences of disease were more immediate and drastic than those of poor nutrition. Because of the costs involved, rich farmers could afford to call the veterinarian more frequently than the medium and poor farmers. In 1997, most of the visits (78%) by veterinary personnel were made to farmers in the HCL. This may be attributed to farmers in the HCL having greater awareness of the consequences of disease or ability to detect sickness.

Activities organised by NGO and private extension services were very few. The NGO was winding up its activities in the area and private agencies did not give priority to provision extension service. Nevertheless, with government funding for public extension service dwindling, there was potential to use private agencies and especially input manufacturers and stockists as a channel for delivery of technical information. Due to their commercial nature, returns on information delivery could be obtained through product pricing. Simple targeted messages that were related to the products being marketed could be delivered during sales.

3. 3. 3. Knowledge of dairy cattle feeding and management technologies.

Under the zero grazing system of dairy production, which was predominant in the study area, the MOA recommended that farmers should plant 0.3 – 0.4 ha of napier grass for each combination of a cow, heifer and a calf. The napier grass should be planted at a spacing of 0.5m by 1m. With an average annual rainfall of 1250 mm, the napier grass yields could be at least 12 tons DM/ha per year, and this could supply at least 10 kg DM/cow per day. A cow fed about 50 kg fresh napier grass (approx. 10 kg DM) per day could be expected to produce 7 kg of milk daily. It was also recommended that cows should be supplemented with a dairy concentrate at the rate of 1 kg for every 1.5 kg milk produced above 7 kg (Wouters, 1987; MLD, 1991).

The average level of farmers' knowledge of all the technologies was below the MOA recommendations across all the locations and wealth groups (Table 10). Farmers in HCL and LCL scored highest and lowest, respectively, in knowledge of most of the dairy technologies. The lowest scores were obtained in knowledge of technologies associated with feeding but nevertheless farmers in the HCL had the highest scores while farmers in LCL had the lowest. Government extension agents put a lot of emphasis on feeding since it had been shown to be a major factor limiting milk production in the district (Omore *et. al*., 1996; Omore, 1997; Staal *et. al*., 1997). However, the large deviation showed that there was a wide knowledge gap even where government extension was present, implying that it had not been fully effective. Level of exposure to extension service did not influence ($P > 0.05$) the knowledge of technologies associated with mineral feeding and animal housing. Information on utilisation of minerals was available from the labels on the package. Farmers may also have acquired knowledge of mineral feeding directly from local stores/stockists, who offered the

Table 10: Mean deviations* of farmers' knowledge of dairy cattle feeding and management from the recommendations of the government extension service.

Technology	Extension contact level		
	HCL	MCL	LCL
Napier grass acres /cow	-2.1^{a}	-2.8^{ab}	-3.0^{b}
Napier grass spacing	-1.7^{a}	-1.9^{ab}	-2.8^{b}
Napier grass cutting height	-1.1^{a}	-1.8^{ab}	-2.4^{b}
Napier grass offered /cow/day	-3.2^{a}	-3.6^{ab}	-4.0^{b}
Concentrates offered /cow/day	-3.0^{a}	-3.0^{ab}	-3.7^{b}
Mineral type offered	-0.5^{ab}	-0.2^{a}	-0.7^{b}
Amount of minerals offered	-1.2^{a}	-1.2^{a}	-1.7^{a}
House plan	-1.6^{a}	-2.4^{b}	-2.1^{ab}
Type of roof	0.0^{a}	-0.8^{b}	-0.1^{a}
Type of floor	0.0^{a}	-0.6^{a}	-0.1^{a}
Trough	-0.4^{a}	-1.1^{a}	-0.6^{a}
Dipping frequency	-2.3^{ab}	-2.0^{a}	-2.8^{b}
De-worming frequency	-0.8^{a}	-0.1^{b}	-0.5^{ab}

Technology	Wealth Rank		
	R	M	P
Napier grass acres /cow	-2.3	-2.9	-2.7
Napier grass spacing	-2	-2.2	-2.1
Napier grass cutting height	-1.4	-2.3	-1.5
Napier grass offered/cow/day	-3.4	-3.8	-3.4
Concentrates offered/cow/day	-3.2	-3.1	-3.6
Mineral type offered	-0.3	-0.5	-0.7
Amount of minerals offered	-1.1	-1.5	-1.5
House plan	-2.5	-2.0	-1.6
Type of roof	-0.3	-0.7	-0.1
Type of floor	-0.3	-0.6	0.0
Trough	-0.4	-1.0	-0.5
Dipping frequency	-2.3	-2.6	-2.1
De-worming frequency	-0.1	-0.6	-0.7

* *Deviations within a technology with the same superscript are not significantly different at $P < 0.05$.*

information as a strategy for sales promotion. However, information on general nutritional strategies was not available from stockists. Housing designs were copied from neighbours and/or prepared by artisans who did the construction.

The level of exposure to extension service significantly ($P < 0.05$) affected the level of knowledge of all technologies related to napier grass production. Farmers in the HCL were more knowledgeable about acreage requirements, agronomical aspects and even feeding recommendations. Being the main basal feed, napier grass production and utilisation was a major topic of discussion during most extension activities. For most of the technologies, knowledge declined as the level of contact with extension agents decreased, implying that extension contact had a significant ($P<0.01$) influence on knowledge. Wadsworth (1994) also, showed that there was a trend for increase in knowledge with increased extension agency activity.

Wealth rank did not influence knowledge of most of the technologies since livestock extension services were offered free of charge. Hence wherever it occurred, variability in knowledge was random.

3. 3. 4. Adoption of dairy cattle feeding and management technologies.

All the farmers had planted Napier grass as the main source of fodder and in the district, napier grass was estimated to occupy 15% of all arable land (Staal *et. al*., 1997). In the study area, farmers had allocated an average of 30% of the total land to napier grass production and this highlighted the importance of the dairy enterprise. Irungu *et al.* (1998) reported that adoption of Napier grass was not influenced by exposure to extension advice but by household income and co-operative membership. Extension efforts may have been directed towards progressive farmers through the dairy co-operative, with the hope that other farmers in the neighbourhood would learn and obtain planting material from them. In this study, presence of napier grass on farms was neither influenced by level of extension, nor wealth rank and this was likely due to the fact that the dairy production system was intensive in all the farms and hence planting of napier grass was inevitable to all. In this study, adoption of most technologies was below the government recommendations (Table 11). Napier grass acreage was higher among the rich farmers and this was likely because they had significantly bigger land size (Irungu *et al.,* 1998). But when the acreage was considered as proportion of total land, the proportion was 30% and did not vary by location or wealth rank. The high proportion of land allocated to napier grass production was most likely a result of good milk price offered by the dairy co- operative society and/or other buyers.

The napier grass acreage per cow was below recommendations of the MOA. Of the farmers surveyed, 71% in HLC, 86% in MCL, 96% in LCL had less than 0.5 acre of napier grass per cow. On-farm dry matter yields from different regions in Kenya averaged 16 tons per hectare per year (Wouters, 1987). With an average of 0.4 ha under napier grass, most of the farms supplied less than 6.4 tons of napier grass dry matter per year. Each cow therefore had less than 3.2 tons of dry matter per year (9 kg DM/animal/day) available for an average herd of two cows per farm. Spacing varied widely and in many cases was too wide because farmers did not replace the plants that dried off, and this resulted in low output per unit land. To try and meet the fodder requirements some farmers resorted to frequent harvesting of napier grass. The long-term implications were reduced yields and premature death of napier grass (Mwangi, 1995; Lukuyu 2000). Results of the survey showed that 64% of the farmers harvested napier grass when less than 3 ft tall. Napier grass cutting height was significantly

Table 11: Mean deviations* of farmers' practice of dairy cattle feeding and management from the recommendations of the government extension service.

Technology	Extension contact level		
	HCL	**MCL**	**LCL**
Napier grass acres/cow	-1.7[a]	-1.9[a]	-1.9[a]
Napier grass spacing	-1.2[a]	-1.1[a]	-1.4[a]
Napier grass cutting height	-0.7[a]	-1.2[a]	-1.0[a]
Napier grass offered/cow/day	-1.9[a]	-2.6[b]	-2.7[b]
Concentrates offered/cow/day	-2.2[a]	-2.4[a]	-3.1[b]
Mineral type offered	-0.1[a]	-0.3[a]	-0.3[a]
Amount of minerals offered	-0.5[a]	-0.6[a]	-0.8[a]
House plan	-0.7[a]	-1.9[b]	-1.7[b]
Type of roof	-0.1[a]	-1.1[b]	-0.9[b]
Type of floor	0.4[a]	-1.3[b]	-1.3[b]
Trough	-1.0[a]	-2.1[b]	-2.1[b]
Dipping frequency	-1.8[a]	-1.0[b]	-1.7[ab]
De-worming frequency	-0.8[a]	-0.4[a]	-0.8[a]

Technology	Wealth Rank		
	R	**M**	**P**
Napier grass acres/cow	-1.8[a]	-1.9[a]	-1.8[a]
Napier grass spacing	-1.1 [a]	-1.4[a]	-1.4[a]
Napier grass cutting height	-0.5[a]	-1.0[ab]	-1.5[b]
Napier grass offered/cow/day	-2.3[a]	-2.5[a]	-2.4[a]
Concentrates offered/cow/day	-2.1[a]	-2.7[b]	-3.0[b]
Mineral type offered	-0.0[a]	-0.2[ab]	-0.4[a]
Amount of minerals offered	-0.5[a]	-0.7[a]	-0.7[a]
House plan	-1.3[a]	-1.7[a]	-1.3[a]
Type of roof	-0.4[a]	-1.1[b]	-0.6[ab]
Type of floor	-0.6[a]	-1.4[b]	-1.1[ab]
Trough	-1.1[a]	-2.1[b]	-2.0[b]
Dipping frequency	-1.7[ab]	-1.1[a]	-1.8[b]
De-worming frequency	-0.5[a]	-0.6[a]	-0.9[b]

** Deviations within a technology with the same superscript are not significantly different.*

($P < 0.05$) influenced by wealth rank. Owing to the low acreage per cow, farmers were forced to either rent land for growing or purchase napier grass off-farm. The alternative sources were limited by financial capability of the farmer. Without these alternatives, farmers resorted to a low cutting height in order to make more frequent harvests of the on-farm napier grass. Rich farmers could afford to rent more land and/or purchase napier grass from non-dairy farmers who grew it specifically for sale and therefore what was on the farm was cut less frequently. Poor farmers relied on the proceeds from milk sales, which were paid monthly. They could not therefore afford to buy napier grass due to cash flow problems.

Very low scores were obtained in amount of napier grass offered per cow per day and this suggested that feed supply was a major constraint on most of these farms. However, farmers in HCL scored significantly ($P < 0.05$) higher than the rest. On-farm napier grass was not sufficient and most farmers depended heavily on purchased fodder. Staal *et al.* (1997) showed that 60% of Kiambu dairy farmers practicing zero grazing relied on purchased fodder. The amount purchased was limited by cost and some farmers therefore resorted to feeding less than what was recommended. Of the farmers involved in the study, 29% in HCL, 71% in MCL and 76% in LCL offered about 40 kg fresh napier grass (average DM content 20%) per cow per day, supplying approximately 8 kg DM which was below the expected minimum requirement of about 10.5 kg per cow per day (NRC, 1989). Amount of napier grass offered per cow per day was significantly ($P < 0.05$) influenced by level of extension, implying that knowledge of the animals' requirements influenced the amounts that farmers actually offered to the animals. However, whereas farmers had knowledge, the full requirements were not met probably due to insufficient feed supply. Whereas the ministry offered advice on matching of stock to feed, farmers insisted on keeping more animals as an insurance against risks.

The lowest scores were obtained in amounts of concentrates offered per cow per day though farmers in HCL and the rich scored significantly ($P < 0.05$) higher. Farmers fed a wide variety of concentrates either in an attempt to cut down on costs by use of cheaper ingredients or because that was what was available in the market (Abate and Abate, 1991). Commercial concentrate supplementation could boost milk yield by up to 50% under Kenyan conditions but the full returns were not realised (Anindo and Potter, 1986; Van der Valk, 1992). The level of nutrition during the first few weeks of lactation has a major effect on total lactation performance. This period, during which the cow achieves peak milk yield, causes a negative energy balance (NRC, 1989). This implies that feeding high nutrient density feed is necessary in order to meet the high nutrient demand. In addition to feeding sub-optimal amounts of the basal feed, most farmers fed the dairy concentrate at a flat rate of 2 kg per cow per day throughout the lactation, which contrasted with the MOA (1991) recommendation of feeding according to production (Staal *et al.,* 1997; Omore, 1997). The concentrate was therefore utilised for maintenance rather than for milk production (Garnsworthy and Jones, 1987).

Although it costs more to feed concentrates, milk income is much higher and the net returns are increased. Poor farmers who depended entirely on milk money to purchase concentrates were not able to buy during the first month of lactation before receiving the milk money hence they fed very little or no concentrates at this time. This cash flow problem resulted in poor feeding and low milk yields. Rich farmers with alternative sources of income could purchase concentrates during the first month of lactation with income from other sources and hence they were able to feed high amounts soon after calving, even to compensate for fodder shortage. However, the fact that the amount of concentrates offered per cow per day was influenced ($P < 0.05$) by both extension level and wealth rank, this implies that knowledge of the animal's requirements, benefits of concentrate feeding and the ability to purchase influenced the amount offered.

Extension level significantly ($P < 0.05$) affected adoption of technologies associated with animal housing. Farmers could acquire knowledge of housing technologies and obtain plans from government extension, neighbours and artisans. The government extension provided a design but there were no artisans trained on how to interpret this design. Farmers therefore gave the design to various artisans, who made different interpretations and this may have caused variation on the resultant structures. Supervision of the construction process by farmers was inadequate since they probably lacked knowledge and/or time. Apart from supplying farmers with the recommended plan, the government extension workers also supervised the construction work to ensure that the requirements of the plan were followed. Over the years, many farmers in the HCL had construction of their housing structures supervised by extension workers.

There are many reasons that may be attributed to adoption or non-adoption of technologies, some of them being the cost, appropriateness, simplicity and even farmers' level of knowledge (Mosher, 1979; Bindlish and Evenson, 1993; Sene, 1994). Contact with extension not only accounts for farmers having certain information but also affects what they put into practice. An extension visit ensures that a farmer will have some conviction of the benefit of a new practice and increases the likelihood that he will have a specific idea to the amount of increase that can be achieved (Leonard, 1970). Hence where knowledge is the main limiting factor, extension will influence both knowledge and adoption of the specific technology. Wadsworth (1994) observed a significant upward trend of improvement in practice in response to increased knowledge.

3. 3. 5. Nutrition and Productivity

The performance of an animal depends on intake of digestible nutrients, efficiency of utilisation of the nutrients, genetic make-up of the animal and environmental factors (Kaitho and Kariuki, 1990). A cow of 400 kg supplied with 14 kg DM/day (5 kg concentrate) with energy and protein content of 13MJ/kg DM and 16% CP (crude protein) is expected to produce 15 kg milk/day at peak production, which is during the 8^{th} week of lactation (Alderman and Cottrill, 1993). Intake is determined by quality of the feed and the physiological status of the animal (NRC, 1989). Therefore, the ultimate measure of nutritive value of feeds is animal performance (Kariuki, 1998).

Post-calving (peak) average milk yield per cow per day was 15±3.12 kg in HCL, 12.8±3.14 kg in MCL and 12.5±2.71kg in LCL (Table 12). Level of extension, wealth rank and interaction of the two factors significantly ($P< 0.01$) influenced post-calving peak milk yield whereby higher yields were recorded as extension contact and wealth status increased. With better knowledge of dairy cattle nutrition and greater ability to purchase inputs rich farmers in the HCL were able to supply the cows with sufficient amount of quality feed and hence they achieved comparatively higher average peak yields. Genetic potential of the animal and the plane of nutrition prior to calving were shown to greatly influence post-calving milk yield (Abate and Abate, 1991). Knowledge of feeding requirements and the ability to purchase extra concentrates for the in-calf animal resulted in higher lactation milk yields. This implied that higher productivity was achieved where there was higher level of both knowledge and resources.

Average current milk yield (milk recorded the day prior to the interview) was 8.2 ±3.47 kg in HCL, 7.1±3.03kg in MCL and 5.9±2.28kg in LCL (Table 12). Level of extension contact

Table 12: Mean post-calving peak and daily milk yields, and calving intervals of farms in Limuru Division.

Variable	Extension contact level		
	HCL	MCL	LCL
n	32	51	36
Post-calving (peak)	$15.0^{a} \pm 3.12$	$12.8^{b} \pm 3.14$	$12.5^{b} \pm 2.71$
Current	$8.2^{a} \pm 3.47$	$7.1^{ab} \pm 3.03$	$5.9^{b} \pm 2.28$
Calving interval	$512.3^{a} \pm 152.64$	$514.2^{a} \pm 197.25$	$578.7^{a} \pm 154.22$

Variable	Wealth rank		
	R	M	P
n	58	28	33
Post-calving (peak)	$14.3^{a} \pm 3.30$	$13.4^{a} \pm 2.25$	$11.2^{b} \pm 3.16$
Current	$7.5^{a} \pm 3.10$	$6.8^{ab} \pm 2.95$	$6.0^{b} \pm 3.07$
Calving interval	$529.4^{a} \pm 171.35$	$605.4^{ab} \pm 195.42$	$486.1^{b} \pm 151.24$

$^{a\,b}$ *Variable means with the same superscript are not significantly different.*
n = *Number of lactating cows*

significantly ($P<0.05$) influenced current milk yield was. The sustainability of high milk yields after calving largely depends on feeding. MOA's NDDP studies showed that it was possible to achieve 7 – 10 kg milk per cow per day with good quality napier grass alone (well manured, harvested at 1 meter high), fed at the animals' DM requirement. This then ensured that any supplementation with dairy concentrate would go towards increasing milk production at the rate of 1.5 kg milk/kg concentrate (MALDM, 1993). This recommendation was reasonable where napier grass acreage was sufficient (1 acre/mature cow, heifer and calf). Where napier grass acreage was low hence animals were offered insufficient amounts and harvesting was done at varying heights, the concentrates fed served to compensate for the fodder shortage. Thus most of the nutrients may have been diverted to improving or attempting to maintain body condition at the expense of milk production and the effect on milk yield was not achieved. Where the animals were fed higher amounts of napier grass as in the case of HCL, concentrate feeding resulted in increased milk production. Although rich farmers offered high amounts of concentrates, response in milk production may have been hampered by the fact that the amounts of basal feed offered were insufficient.

Insufficient roughage was a major constraint to increased milk production in the smallholder dairy production system (Omore, 1997). Very low napier grass acreage (average, 0.2 ha/cow) was recorded in the present study and hence the available on-farm napier grass which was the main source of basal feed hardly met the animals' DM requirements (Wouters, 1987). Feed purchases were limited by cost and availability (DLPO, 1998). The nutritive value of napier grass was found to decline with delayed cutting. Kaitho and Kariuki (1990) showed a decline in crude protein levels from 10.3% at 6 weeks to 5.4% at 12 weeks while crude fibre rose from 24.9% to 36.2% at 6 and 12 weeks respectively. *In vitro* digestibility dropped from 71.7% at 6 weeks to 61.7% at 12 weeks. Kariuki (1998) also, showed that the mineral content declined significantly with maturity except for cobalt. Napier grass has low protein and metabolisable energy and supplementation with protein and energy sources has been recommended (Kariuki, 1998).

Other forages reportedly used on farms were maize stover, cut grass, weeds and vegetable waste. This study laid emphasis only on napier grass since it was the principal basal feed, and in addition, most of the other feeds were used seasonally. However, it was observed that most farms experienced insufficient supply of fodder, which agrees with the findings of Romney *et. al*. (1998).

Concentrates fed to cows receiving inadequate forage were used to satisfy maintenance rather than production requirements. Therefore inadequate feeding observed on most farms in this study resulted in lack of response to concentrate feeding in terms of milk yield. However, in situations of severe fodder shortage, farmers were encouraged to feed concentrates to maintain the animals' body condition. The benefits were long term in that severe loss of body condition affected future performance of the animals (Dhuyvetter, 1997). Farmers in the HCL had achieved reasonable yields but this could be further improved by greater efficiency.

The average calving interval was long as previously reported (Van der Valk, 1992; Odima et. al. 1994; MALDM, 1993; Omore, 1997; Staal et. al., 1997) with an overall mean of 535±168 days (range: 370-893). It was neither influenced by level of extension contact nor wealth rank (Table 12). Among the reasons for long calving interval were poor nutrition, poor heat detection and inefficient delivery of artificial insemination (Odima et. al., 1994). Poor nutrition could lead to long calving intervals since undernourished animals took long to recover after calving and hence a long period of postpartum anoestrus. The condition of the cow at parturition is of paramount importance. Cows that are undernourished after calving down end up in a negative energy balance. During this time the cows mobilise body reserves to support milk production (Bauman and Curie, 1980) and hence reproductive performance is depressed. Continued underfeeding in dairy cows may lead to endocrine disturbance, which result in silent heat, low conception rate and/or early embryonic death (McDonald, *et al.,* 1988). This could have applied in the case of the farms in this study, owing to the low DM offered with little or no supplementation, which could have led to under-nutrition. Bebe (1997) showed a strong positive relationship between calving interval and postpartum anoestrus and that feeding interventions improved feed intake, increased the conception rate and shortened the calving interval.

Inefficient delivery of artificial insemination (AI) services may lead to poor timing of service, hence resulting in low conception rate. However, this was unlikely to be the cause of the long calving interval recorded in this study since reliable AI service was available from the local (Limuru) dairy co-operative society. In a study of ninety farms affiliated to six dairy co-operative societies in Kiambu District, Odima *et al.* (1994) noted a comparatively shorter calving interval in farms affiliated to the Limuru dairy co-operative society in comparison to farms affiliated to the other dairy co-operatives in the district, the reason being that Limuru was the only dairy co-operative offering AI services.

Poor heat detection was shown to be responsible for the long calving intervals in many smallholder dairy farms. This could be due to lack of knowledge of heat signs and poor record keeping, such that the farmers were not able to predict or detect the cows on heat. The animals were therefore not served on time. However, in some farms, service was delayed as management strategy to stagger milk production, and therefore household income and/or counteract uncertainties in feed supply (MALDM, 1993; Odima *et al,* 1994; Dewi *et al,* 1998).

3. 3. 6. Conclusion

1. There were six extension agencies in the area of study namely government extension, dairy co-operatives, private agents, NGOs, mass media and neighbours.
2. The dairy co-operatives effectively reached the highest number of farmers.
3. The study showed that farmer-to-farmer contact played a big role in information delivery across all locations and wealth groups.
4. The government extension, which was expected to be the main source of technical information, reached a very small number of farmers.
5. Farmers' field days were the most effective information delivery method as they reached a big number of farmers across all locations and wealth ranks when properly advertised.
6. Contact with extension agents influenced farmers' knowledge and practice of dairy technologies.

CHAPTER 4. EVALUATION OF THE USE OF MILK UREA NITROGEN (MUN) AS AN INDICATOR OF NUTRITIONAL STATUS OF DAIRY CATTLE IN SMALLHOLDER FARMS IN KIAMBU DISTRICT

4. 1. INTRODUCTION

Under smallholder farm conditions where there is a wide variation in forage types and amounts fed, it is difficult to determine the precise feed composition and intake. Improved feed supply and utilisation leads to better nutritional status of cows and an improvement in performance. Energy and protein are of paramount importance in dairy cattle nutrition and the amounts offered as well as the ratio is important. Knowledge of the protein/energy status of a cow would enable the farmer to correct for nutritional deficits. Blood and milk urea nitrogen (MUN) concentrations have been used elsewhere as metabolic indicators of protein-energy balance, in combination with body weight and body condition score. A relationship between MUN and energy protein ratio in the diet has been reported (Thornton, 1970; Hammond, 1983a; Roseler, *et. al*., 1993; Baker, *et al*., 1995). Though MUN concentrations may be affected by such other factors as health of the animal, breed and severe under-nutrition, it may still be helpful in making nutritional management decisions. The purpose of this study therefore was to evaluate the use of MUN concentration as an indicator of nutritional status under smallholder dairy farm conditions.

4. 2. METHODOLOGY

4. 2. 1. Milk samples

Twenty-seven lactating cows in a randomly selected sample of twenty-one farms were monitored for twelve weeks between March and June 1998. Milk samples were collected weekly and analysed for Milk Urea Nitrogen (MUN) using the Urease Berthelot Method (Diagnostica Worldwide Human, 1998), using a kit supplied by 'HUMAN' Diagnostics® Ltd.

Samples were collected from the morning milk and transported to the laboratory in a cool box (with dry ice as the coolant). The milk samples were centrifuged at 2,500 rpm for 20 min. The fat layer was aspirated and the supernatant withdrawn for analysis or frozen at $-20^{o}C$ until the time of analysis.

4. 2. 2. Farm data

Once a fortnight, amounts and types of feeds offered to the animals were recorded in specially designed forms (Appendix 5). This exercise involved the use of trained enumerators. The enumerator reported at the farm at 6.00 am or before the morning milking and feeding had been done and stayed until 6.00 pm or after the evening milking and last feeding had been done. The enumerator weighed and recorded all the feeds and feed types offered during the day of visit. Matters relating to feed quality e.g. the stage of harvest or form in which the feed was offered, were also recorded. Milk production and heart girth measurement (estimated using a weighing band) for each animal on that day were also recorded. Body condition was scored using the five-point scoring method of Edmonson *et. al.*, (1989).

Using feed composition tables and results of analysis of various feedstuffs carried out by other investigators, the nutrient composition of the feeds offered was estimated in terms of dry matter (DM), crude protein (CP) and energy (ME) in Mcal/kg. The heart girth measurements were used to estimate the animal's body weight. The total weight of the animals in the farm was used to calculate the feed offered (on DM basis) per 100 kg. body weight.

4. 3. DATA ANALYSIS

The data was summarised in a spreadsheet using Microsoft Excel. Descriptive statistics were calculated and correlation analysis done using SAS statistical software (SAS, 1988).

4. 4. RESULTS AND DISCUSSION

Animals were offered a wide variety of feeds, varying in both species and amounts between and within farms and between days since feed on offer depended on availability. The most common feed both in occurrence and amounts was napier grass, which comprised 65% to 84% of the feed offered followed by crop residues mainly green maize or dry maize stover and banana pseudo-stems. Concentrates constituted 1% to 3% of the feed offered to the dairy cows. A commercial mixed dairy concentrate 'dairy meal' (offered to lactating animals only) was the most common concentrate offered. Other concentrates used were maize/wheat bran and maize germ. Weeds and cut grass also formed a substantial proportion of the feed offered but the amounts were not consistent (Table 13). The dry matter offered per 100 kg body weight averaged 2.54 kg. Napier grass constituted highest proportion of the total DM offered, followed by concentrates and dry/green maize stover (Table 14). Other feeds contributing a substantial percentage when put together were horticultural crops residues, kitchen waste, banana pseudo-stems, trees and shrubs.

The average daily milk yield for the lactating cows was 5.5 ± 3.55 kg, condition scores 2 ± 0.62 and MUN averaged 17.4 ± 5.14 mg/dl. The level of milk production was similar to that reported by Staal et. al. (1997) and Omore (1997) in Kiambu District (4.12 kg and 5.8 kg per cow per day respectively). Milk Urea Nitrogen concentrations had a negative but non-significant correlation with DM offered and milk yield. Dry Matter offered was positively ($P < 0.01$) correlated with body condition score, milk yield and the energy to protein ratio (ME:CP) of feed offered. Milk yield was positively correlated with body condition score (Table 15).

Table 13: Types of feedstuffs percentages (as-is basis) of the total feed on offer in dairy farms in Kiambu District.

Month	Week	Napier	Green maize thinnings	Dry Maize stover	Cut grass	Weeds	Concentrate	Others
March	4	65.3	5.4	9.4	1	8.5	1.9	8.5
April	2	70.2	1.6	7.6	0.8	5.3	2.3	12.2
	4	72.5	3.9	0.2	5.8	4.2	2.4	11.0
May	2	84.2	1.9	3.2	0.2	0.2	1.3	9.0
	4	72	3.4	3	5	0	2.8	13.8
June	2	68.2	10.2	2.1	3.1	1.7	2.8	11.9
Average % ± SD		72.06 ± 6.51	4.4 ± 3.16	4.25 ± 3.51	2.64 ± 2.35	3.32 ± 3.31	2.25 ± 0.58	11.07 ± 2.01

Table 14: Level of feeding (DM on offer) in dairy farms in Kiambu District

Month	Week	Napier	Concentrates	Dry Maize Stover	Green Maize thinnings	Cut grass	Weeds	Others	Total
March	4	1.07	0.28	0.16	0.3	0.03	0.36	0.06	2.26
April	2	1.31	0.24	0.66	0.25	0.02	0.01	0.14	2.63
	4	1.97	0.29	0.02	0.01	0.23	0.15	0.18	2.85
May	2	1.70	0.23	0.13	0.07	0.03	0.01	0.10	2.27
	4	1.46	0.25	0.12	0.08	0.18	0	0.18	2.27
June	2	1.55	0.37	0.05	0.68	0.11	0.07	0.13	2.96
Average± SD		1.51 ± 0.31	0.28 ± 0.05	0.17 ± 0.25	0.23 ± 0.25	0.10 ± 0.09	0.10 ± 0.14	0.13 ± 0.05	2.54± 0.34

Table 15: Mean values of, and Correlation between MUN, DM (offered), BCS, Milk yield, Energy and Protein ratio.

	MUN	DM	BCS	MILK	CP_ ME
Mean Values	*17.4(5.14)**	*2.7(0.36)*	*2(0.62)*	*5.5(3.55)*	
MUN	1	-0.1	0	-0.01	0.1
DM		1	0.4***	0.4***	0.3***
BCS			1	0.3***	0
MILK				1	0.1
ME_CP					1

* *Figure in bracket is the standard deviation*
*** *Significant at P< 0.01*

Napier grass in smallholder dairy farms in Kenya had a mean crude protein (CP) content of less than 8% DM. Supplementary nutrients were therefore necessary to obtain acceptable levels of performance from cattle fed on napier grass (Wouters, 1987; Abate and Abate and Abate, 1991; Kariuki, 1998). For moderate production of dairy cattle, the CP content in the diet should be more than 12% DM (ARC, 1980) and hence there is need to supplement for protein. The average of 2.54 kg DM/100kg body weight offered in this study was below the recommended 3% DM intake and this, coupled with absence of supplementary nutrients was probably be the main contributing factor to the low milk yields.

Despite a high proportion of improved dairy cattle in smallholder farms, milk yields were low and this suggested that feeding could be the major constraint (Walshe *at al*, 1991). Fodder availability was a problem and hence the average DM on offer was below the animal's DM requirements for maintenance and production. An increase in energy intake would be expected to result in increased milk yield and improved body condition scores (McDonald *et. al*., 1988). Since DM offered showed a positive correlation with body condition and milk yield, the low DM offered to the cows in this study resulted in low body condition score and low milk yield.

The range of MUN concentrations recorded in this study (7.42 - 29.8mg/dl) was outside the normal range of 12 – 25 mg/dl and this suggested an imbalance of protein and energy in diets of the dairy animals (Hof et. al., 1997, Waldner, 1997). Studies conducted in Kiambu District (Staal et. al. 1997, Omore, 1997) showed that dairy cattle in most smallholder farms were fed sub-optimal quantity and quality basal feed and hence could suffer both energy and protein deficiency, which agrees with the results of the present study. Although dry maize stover could have contributed to the total feed offered, dry maize stover was shown to comprise about 6 % CP and over 80 % NDF and hence was classified as poor quality feed (Abate, *et al.,* 1990; Methu, 1998). Concentrations of MUN were more closely related to the ratio of dietary protein to energy than to absolute protein intake (Oltner and Wiktorsson, 1983; Oltner *et al*., 1995; Hof *et al*., 1997). In the study by Oltner and Wiktorsson (1983), MUN concentration altered only slightly when the amount of protein ingested was decreased or increased as long as the ratio between protein and energy was held constant. Energy restriction was shown to result in significantly high MUN concentration and depression in milk production while protein restriction resulted in decreased MUN and also a reduction in milk production (Kirchgessner and Dora, 1986). This implies that there is a negative correlation between MUN and milk yield where there is energy deficiency. Although a similar relationship was obtained in this study, it was not significant.

Though milk urea concentration was shown to provide information on protein/energy relations in the diet, it did not give an indication whether the amounts given were appropriate in relation to the requirements (Oltner, *et al*., 1985). There was evidence of poor nutritional status of the dairy cattle in this study as indicated by direct measurements of DM offered, body condition and milk yield. However, MUN concentration could not be clearly associated to nutritional status since its correlation with other parameters was not significant. This may have been due to the fact that feed types and quantities offered varied highly and animals were often fed below their nutrient requirements. This variability in feed types and composition from day to day probably resulted in inconsistency in energy to protein ratio. Hence, the method did not prove to be useful under such conditions.

CHAPTER 5. GENERAL DISCUSSION

The results of this study show that despite the government having offered extension services for many years, a great proportion of dairy farmers had not been adequately reached. The government extension service, despite having well trained and experienced personnel was limited by inadequate resources and even where funds were available, the mechanisms for acquiring these finances were too bureaucratic and posed serious difficulties (MALDM, 1996). Extension activities had declined due to lack of or inadequate transport therefore weakening the link between extension staff and farmers. Public extension service had heavily depended on donor funds, which did not have counter-funds from the exchequer, and hence the sustainability was highly questionable. With the completion of major extension donor-funded projects (NDDP, NEPII, ASMPII) in 1997, the Ministry of Agriculture was facing serious budgetary constraints.

The co-operative ranked as the most effective extension agency. With over 60 % of the farmers being active members, and the fact that they were in contact with the co-operative on a daily basis as they delivered milk, the co-operative had great potential as an efficient channel for delivering information. Problems of individual farmers could be reported and notice of extension activities given to the farmers at the milk collection centres. Only 3 % of the farmers reported having been visited by the co-operative extension officer in 1997 and this implied that the co-operative needed to pay more attention to provision of technical advice as a service to its members.

Contact with the private veterinarian was made almost exclusively through fee-paying visits and hence most of the visits recorded were to the rich farmers. Notably also, there was very little mention of private extension service. The private sector, through its pervasive and persuasive advertising campaigns represents a sustainable source of financing for the type of extension activities (field days), which were preferred by all classes of farmers in the present study. It was common for the government extension workers or co-operative to organise a field day and invite a private agency (drug or feed company) to fund the event and in so doing, gain an opportunity to promote its products. However, whilst this partnership should be encouraged, caution should be taken to avoid a conflict of ideas where an agent may promote a product, which may not be necessary for all farmers. An example of this is the recommendation for regular use of acaricides/anthelmintics, which was shown to be unnecessary under zero-grazing system, which was predominant in the study area (Bain and Tanner, *et al., 1998)*. Again, veterinarians earning commission on sales of drugs were likely to promote their use.

Private agricultural firms considered expenditure on extension as an investment and part of their production cost, which was normally recovered from farmers through product pricing. This was more sustainable and could continue for as long as a firm remained in business. It was, nevertheless, the government's policy to continue supporting dairy farmers by supporting research and extension on dairy cattle (and other animal species) for dairy development, through the provision of advisory services (MALDM, 1997). However, appropriate and sustainable extension methodologies needed to be devised. Farmers had prepared themselves for accessing technology by joining groups that were used by extension services e.g. dairy co-operative societies (MALDM, 1996). Like private firms some co-operative organisations were also making an effort to acquire their own equipment, transport means and staff and were offering services other than milk marketing (Owango et. al., 1998).

Should their business enterprises succeed, it was likely that the extension services would also be self-sustaining.

There was little mention of NGOs as extension agency. This was probably because the NGO present in the area (PLAN-International) was winding up its activities. There was a tendency for the NGO to involve the local government extension workers in its agricultural based activities and so farmers may have viewed them as government extension activities. This reduced the farmers' perceived effectiveness of the NGO.

Field days were ranked as the most effective extension method. Apart from reaching the highest proportion of farmers, this activity brought together both government and private extension agents and the farmers obtained information on a wide range of subjects. It was noted that despite the popularity, field days were infrequent probably be due to the cost of organizing them (advertisement and preparation of the venue). In actual sense, field days were eventually more cost effective, considering the number of farmers that could be reached through a single activity. Collaboration between the government and private sector should have been encouraged since this, with an element of cost sharing would have made it possible to host field days more frequently.

In the location where the government extension concentrated their efforts, only 10 % of the farmers had been visited within the year of study, and overall 32 % had been reached. This implied that individual farm visits was not an effective means of information delivery.

In this study, extension level was shown to have an influence on the farmers' knowledge and practice in that farmers having contact with extension agents showed better knowledge and practice of most dairy technologies, especially those related to feeding. The lowest scores obtained were on knowledge and practice of technologies related to feeding particularly amount of napier grass and concentrates offered per day. Although both extension level and wealth rank significantly influenced concentrate feeding, this study showed that solving the problem of knowledge gap among farmers would be an important step towards solving the nutritional problem prevailing in small-holder dairy farms.

Various studies conducted on smallholder dairy farms concurred that nutrition i.e. feed availability and utilisation was a major factor limiting animals' performance (Omore et. al., 1996; Omore, 1997; Staal *et. al.,* 1997; Methu, 1998). Some of the identified technologies that could solve the problem of feed shortage were growing of a wide variety of forages and fodder trees, fodder conservation using cost-effective methods, and efficient utilisation of crop and industrial by-products. Adoption of these technologies was constrained by among others, non-availability of planting materials, lack of capital and lack of technical knowledge (Orodho, 1990; Methu *et al,* 1996).

Results of the cross-sectional survey concurred with those of the nutritional monitoring, and it could be concluded that dairy animals in the smallholder farms were in poor nutritional status. The low average (2.54 kg per 100 kg BWt.) DM offered resulted in insufficient dry matter intake, which in turn resulted in poor body condition, low milk yields and a steep drop and absence of peaking in the lactation curve (Omore et. al., 1996; Staal and Omore, 1998). The average body condition score (2) was an indication of thin animals and this showed that there was need to improve on the feeding. Cows with body condition of less than 2.5 had very little fat reserves to meet any additional energy demands in lactation (Ferguson, 1996).

Animals which showed severe nutritional depletion as a result of prolonged under-nutrition were also likely to show high MUN concentrations due to break down of body tissues (Hammond and Chase, 1995). There had been a fair supply of fodder due to the unusual rains during the previous year and therefore it would be unlikely that the animals showed high MUN concentrations due to catabolism of body tissue. The MUN concentrations obtained in this study did not show significant correlation with any of the other parameters and this was thought to be due to inconsistency in protein-energy ratio caused by variability in types and amounts of feeds offered.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

1. Among all the extension agencies present in Kiambu District, dairy co-operative was the most effective.
2. Kiambu District, was well endowed with a wide spectrum of private service agencies (Veterinarians, feed and drug stockists) which had the potential to deliver technical information. However, there was need to draw a fine balance in order to prevent bias against farmer interest.
3. Farmer to farmer communication played a great role in delivery of technical information.
4. Individual farm visits was not an effective information delivery method and there was need to use alternative ones that could achieve wider farm coverage.
5. Field days were a more effective method of information delivery and there was need to increase their frequency.
6. Extension contact had a positive effect on knowledge and adoption of technologies independent of wealth status.
7. This study showed that a great proportion of farmers lacked knowledge of most dairy production technologies.
8. The study also showed that cows in the smallholder farms of Kiambu District were offered inadequate amounts of feed and this was reflected in poor body condition scores and low milk yields.
9. In conditions where types and amounts of feed offered to dairy cows greatly varied, Milk Urea Nitrogen concentration was not a useful indicator of nutritional status.

REFERENCES

Abate, A., Abate, A. N. and Gacugia, S., 1990. Feeding Systems For Milk Production In The High Potential Areas of Kenya: On-Farm Trials. Utilization of Research Results on Forage and Agricultural By-Product Materials as Animal Feed Resources in Africa: 264-279. Proceedings Of The First Joint Workshop Held in Lilongwe , Malawi 5-9 December 1988.

Abate, A. and Abate, A. N., 1991. Wet Season Nutrient Supply to Lactating Grade Animals Managed UnderDifferent Production Systems. East African Agriculture and Forestry Journal 57 (1): 33-39.

Alderman, G. and Cottrill, B.R., 1993. Energy and protein requirements of ruminants. An advisory manual prepared by the AFRC Technical Committee on Responses to Nutrients CAB International, Wallingford (UK)

Anindo, D. O., and Potter, H. l., 1986. Milk Production from Napier grass (*Pennisetum purpureum)* in a Zero Grazing Feeding System. E. Afr. Agric. For. J. 52: 106-111.

ARC, 1980. Agricultural Research Council: The Nutrient Requirements of Ruminant Livestock. Slough Commonwealth Agricultural Bureaux International, Wallingford.

Bain, R. and Tanner, J., 1998. Healthy Cow, More Milk: Extension Comic Produced by KARI/DFID NARP II Project and KARI/MALDM/ILRI Small Holder Dairy Project.

Baker L., Ferguson J. D. and Chalupa, W. 1995. Responses in Urea and True Protein of Milk to Different Protein Feeding Schemes for Dairy Cows. Journal of Dairy Science, 78: 2424-2434.

Barton, D. and Reynolds, L., 1996. The Generation, Assembly and Delivery of Information on Livestock Production: A case study of Kenya. Natural Resources Institute, Chatham, UK.

Bauman, D.E. and Curie, W. B. (1980). Partitioning of nutrients during pregnancy and lactation. A review of mechanisms involving homeostasis. J. Dairy Sci. 63. 1514-1529.

Bebe, B.O., 1997. Consequences of Reducing Reproductive Wastage In Intensive Smallholder Dairying Systems In Kiambu District, Kenya. MSc. Thesis, Wageningen Agricultural University, The Netherlands.

Bindlish, V. and Evenson, R., 1993. Evaluation of The Performance of T and V Extension in Kenya. World Bank Technical Paper No. 208, Africa Technical Department Series. The World Bank Washington, D.C.

Butler W. R., J. J. Calaman, and S. W. Beam, 1996. Plasma and Milk Urea Nitrogen in Relation to Pregnancy Rate in Lactating Dairy Cattle. Journal of Animal Science, 74: 858-865.

Bwisa, H. M. and Gacuhi, A. R., 1997. Diffusion and Adoption of Technologies From Research Institutes and Universities in Kenya: An Empirical Investigation. African Technology Policy Brief, July 1997.

Cannas, A., Pes, A., Mancuso, R., Vodret, B. and Nudda, A., 1998. Effect of Dietary Energy and Protein Concentration on The Concentration of Milk Urea Nitrogen in Dairy Ewes. Journal of Dairy science 81: 499-508.

de Leeuw, P. N., McDermott, J. J., Lebbie, S. H. B., 1995. Monitoring of Livestock Health and Production In Sub-Saharan Africa. Preventive Veterinary Medicine 25: 195-212.

Devendra, C., 1994. Animal Production Technologies for Integrated Small Farm Systems in Asia Pacific region: Relevance and Assessment of Needs for Sustainable Development FAO. Technology Assessment and Transfer for Sustainable Agricultural Development in the Asia-Pacific Region: 87-94.

Dewi, A. P., Nakokonya, G. and Thorpe, W. 1998. Problems Associated with Replacing Cows in Smallholder Dairy Herds. FOOD, LANDS AND LIVELIHOODS. Setting Research Agendas for Animal Science: 171 – 172.

Diagnostica Worldwide Human, 1998. Product catalogue. Silberbachstr.9 D-65282 Taunustein, Germany.

Dhuyvetter. J., 1997. Cattlemen Coping With Winter - Evaluating Cow Nutritional Status. North Dakota State University, NSDU Extension Service.

DLPO, 1996. District Livestock Production Officer, Kiambu, Livestock Poduction Department Annual Report for Kiambu District for 1995.

DLPO, 1997. District Livestock Production Officer, Kiambu, Livestock Production Department Annual Report for Kiambu District for 1996.

DLPO, 1998. District Livestock Production Officer, Kiambu, Livestock Production Department Annual Report for Kiambu District for 1997.

Edmonson, A. J., Lean, I. J., Weaver, L. D., Faever, T. and Webster, G., 1989. A Body Condition Scoring Chart for Holstein Dairy Cows. Journal of Dairy Science 72: 68-78.

Eponou, T., 1994. Linkages Between Research and its Partners in Africa: A brief summary of the activities of ISNAR: 29-42.

FAO, 1966. Food and Agriculture Organization: Report of a Seminar Held in Kenya at Egerton Agricutural College 21st – 30th March, 1965.

Farrington, J. and Nelson, J., 1997. Using Log frames to Monitor and Review Farmer Participatory Research. Agricultural Research and Network Paper No.73, Jan.1997.

Ferguson, D. J., 1996. Implementation Of a Body Condition Scoring Program in Dairy Herds. Feeding and Managing the Transition Cow, The Penn Annual Conference.

Garnsworthy, P.C. and Jones, G. P., 1987. The influence of body condition at calving and dietary protein supply on voluntary food intake and performance in dairy cows. Animal Production 44:347-53.

Gerdien van Schaik, Perry, B. D., Mukhebi, A. W., Gitau, G. K. and Dijkhuizen, A. A.,1996. An Economic Study of Smallholder Dairy Farms In Murang'a District, Kenya. Preventive Veterinary Medicine, 29: 21-36.

Hammond, A.C., 1983a. Effect of Dietary Protein Level, Ruminal Protein Solubility and Time After Feeding on Plasma Urea Nitrogen and The Relationship of Plasma Urea Nitrogen to Other Ruminal and Plasma Parameters. Journal of Animal Science 57(suppl.1): 435

Hammond, A.C. and Chad C. Chase Jr., 1995. Cattle Nutrition and Reproductive Status through Blood and Milk Indicators. Florida Agricultural Experimental Station journal.

Heinrich, G. M., 1993. Strengthening Farmer Participation Through Groups: Experiences and Lessons from Botswana. International Service for National Agricultural Research. Discussion paper No. 3.

Hobbs, S. H. and Taylor, T. A., 1987. Agricultural Research in the Private sector in Africa: The case in Kenya. ISNAR working paper No. 8, December 1987.

Hof, G., Vervoorn, M. D., Lenaers, P. J., and Tamminga, S., 1997. Milk Urea Nitrogen as a Tool to Monitor the Protein Nutrition of Dairy Cows. Journal of Dairy Science, 80: 3333-3340.

Isahak, A.T., 1991. Addressing The Information Needs of Farmers and The Extension Services: The Malaysian Experience. IAALD VIIIth World Congress/QB XXXVI, 1-2.

ILCA, 1990. International Livestock Research Centre for Africa: Working Paper 1. Livestock Systems Research Manual Volume 1.

ISNAR, 1992. International Service for National Agricultural Research, Annual Report for 1991.

Irungu, P., Mbogoh, S. G., Staal, S., Thorpe. W. and Njubi, D. 1998. Factors influencing adoption of Napier grass in smallholder dairying in the highlands of Kenya. Paper presented to an International Conference on FOOD, LANDS AND LIVELIHOODS. Setting Research Agendas for Animal Science, Nairobi, Kenya: 175 – 176.

Islam, N., 1995. Population and Food in the Early Twenty-first century: Meeting future Food Demands of an Increasing Population. International Food Policy Research Institute. Washington, D.C.: 1 – 4.

Kamau, M., 1997. Commodity Program Priority Setting: The Experience of the Kenyan Agricultural Research Institute. ISNAR Briefing Paper No.34.

Kandie, E. K., 1991. Agricultural Research Linkages with the Development Ministries (Ministry of Agriculture). Proceedings of The Workshop on Agricultural Research Policy in Kenya, November 1991, Nairobi, Kenya: 22-30.

Kaitho, R. and Kariuki, J. N., 1990. Nutrient Intake by Friesian Heifers Fed Napier Grass (*Pennisetum purpureum)* Harvested at Two Growth Stages. Paper Presented to The 2nd KARI Scientific Conference, Nairobi, Kenya: 111-115.

Kariuki, J., N., 1998. The Potential of Improving Napier Grass Under Smallholder Dairy Farmers' Conditions in Kenya. PhD Thesis, Wageningen Agricultural University, The Netherlands.

Kirchgessner M., Kreuzer, M. and Dora A. R., 1986. Milk Urea and Protein Content to Diagnose Energy and Protein Malnutrition of Dairy Cows. Arch. Animal Nutrition, Berlin 36: 192-197.

Leonard, D.K., 1970. The Impact of Kenya Government Agricultural Extension on Small Farmers. A Report On a Small Survey Done in Vihiga Division, Kakamega District. Institute of Development Studies, University College, Nairobi.

Leonard, D.K., 1974. Organization Theory for Agricultural Development Agencies: An Analysis of The Management of Kenya's Extension Agents. Dissertation to The University of Chicago for PhD.

Leonard, D.K., 1977. Reaching The Peasant Farmer: Organisational Theory and Practice in Kenya. Midway Reprint. The University of Chicago Press: 3 - 33.

Lionberger, H.F. 1968. Adoption of New Ideas and Practices. A Summary of The Research Dealing With Acceptance of Technological Change in Agriculture, With Implications For Action In Facilitating Change. The Iowa State University Press: 3 - 17.

Lukuyu, B.A., 2000. The Maize Crop as a Source of Food and Feed for Livestock on Smallholder Dairy Farms in the Kenyan Highlands. Mphil dissertation. University of Greenwich: Chatham Maritime, UK.

MALDM, 1993. Ministry of Agriculture, Livestock Development and Marketing, The National Dairy Development Project, Monitoring Unit: Results of The Farm Survey in Kiambu.

MALDM, 1994. Ministry of Agriculture, Livestock Development and Marketing: Department of Livestock Production's Annual Report for 1993.

MALDM, 1995. Ministry of Agriculture, Livestock Development and Marketing, The National Dairy Development Project, Monitoring Unit: Results of The Farm Survey in Kiambu.

MALDM, 1996. Ministry of Agriculture Livestock Development and Marketing: a Draft Report of the Findings by The Consultancy on The Access By Extension Agents and Target Groups to Technical Innovation.

MALDM, 1997. Ministry of Agriculture Livestock Development and Marketing: a Consultants' Report on Evaluation of the Current Performance of The Public and Private Extension Services In The Agricultural Sector.

McDonald, P., Edwards, R. A. and Greenhalgh, J. F. D., 1988. Animal Nutrition, Fourth Edition. Longman Scientific and Technical. John Wiley and Sons, Inc., New York: 284 – 296

McIntire J., Bourzat, D. and Pingali, P., 1992. Crop Livestock Interaction in Sub-Saharan Africa. World Bank Regional and Sectoral Studies: 1-6.

Mdoe, N.S.Y. and Mlay, G.I., 1990. The Kilimanjaro Dairy Feeding Systems: An Attempt at Evaluating the Impact of On-farm Livestock Research. Utilisation of Research Results on Forage and Agricultural By-Product Materials as Animal Feed Resources in Africa: 208-221. Proceedings Of The First Joint Workshop Held in Lilongwe , Malawi 5-9 December 1988.

Merrill-Sands, D. and Kaimowitz, D., 1994. The Technology Triangle: Linking farmers Technology Transfer Agents and Agricultural Researchers. ISNAR.

Methu, J. N., Owen, E., Abate, A., Mwangi, D. M. and Tanner, J. C. 1996. Smallholder dairying in the Central Kenya Highlands: Practices in the Utilisation of Maize Stover as a Feed Resource. Proceedings of the 5th KARI Scientific Conference: 243 – 251.

Methu, J. N., 1998. Strategies for utilisation of maize stover and thinnings as dry season feed for dairy cows in Kenya. PhD thesis, The university of Reading.

Metz, T., Kiptarus, J.and Muma, M., 1995. Diffusion of Dairy Technologies in Six Districts of Kenya: A Survey of Smallholder Dairy Farmers in Kakamega, Uasin Gishu, Nandi, Kiambu, Nakuru and Nyeri Districts. Ministry of Agriculture, livestock Development and Marketing, National Dairy Development Project, Monitoring and Evaluation Unit.

Miheso, V., 1998. Identification and Evaluation of Farmer Breeding Practises and Breed Preferences in Kiambu District of Central Kenya. BSc Project Report to Egerton University.

MLD, 1991. Ministry of Livestock Development, The National Dairy Development Project, Zero Grazing Series: A Handbook on Technical Aspects. Nairobi, Kenya.

MOA, U.K., 1978. Ministry of Agriculture, Fisheries and Food U.K.: Condition Scoring of Dairy Cows: Advisory Leaflet No. 612.

Morris, J., 1991. Extension Alternatives in Tropical Africa. Agricultural Administration Unit Occasional Paper No. 7. Overseas Development Institute: 24 - 37.

Morton, J. and Matthewman, R., 1995. The Generation, Assembly and Delivery of Information in Livestock Production: Lessons for Extension Policy Options. Natural Resources Institute, Catham, UK.

Morton, J. and Matthewman, R., 1996. Improving Livestock Production Through Extension: Information Needs, Institutions and Opportunities. Natural Resource Perspectives (12) Nov. 1996.

Morton, J. and Wilson, R.T., 1996. The Generation, Assembly and Delivery of Information on Livestock Production: A case study of Burkina Faso. Natural Resources Institute, Catham, UK.

Mosher, A. T., 1979. An Introduction to Agricultural Extension. Agricultural

Development Council 1290 Avenue of The Americas, New York: 32 - 45.

Muhoho, G., 1991. Opening Address. Proceedings of The Workshop on Agricultural Research Policy in Kenya, November 1991, Nairobi, Kenya: 1 - 4.

Mwangi D. M., 1995. Factors Affecting The Adoption of Planted Forges in The Nairobi Milk Shed, with Specific Reference to Kiambu District. Field Visits to Kiambu District: Interviews With Key Informants, District and Divisional Extension Staff and Visits to Smallholder farms. MALDM/KARI/ILRI. Unpublished Report.

NRC, 1989. National Research Council, Nutrient Requirements of Dairy Cattle. Sixth Revised Edition Update: 2-20.

Nzondo, M., 1994. Agricultural Extension in Central Africa: An Introductory of The Main Problems: 37-42.

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): 366-368.

Oltner R. and Wiktorsson, H. 1983. Urea Concentrations in Milk and Blood as Influenced by Feeding Varying Amounts of Protein and Energy to Dairy Cows. Livestock Production Science, 10: 457-467.

Oltner R., Emanuelson M. and Wiktorsson, H. 1985. Urea Concentrations in Milk in Relation to Milk Yield, Live Weight, Lactation Number and Amount and Composition of Feed Given to Dairy Cows. Livestock Production Science, 12: 47-57.

Omore, A. 1997. Epidemiology and Economics of Mastitis in the Smallholder Dairy Sector of Kiambu District, Kenya. PhD Thesis, University of Nairobi.

Omore, A., McDemott, J. J., Arimi, S. M., Kyule, M. N. and Ouma, D. 1994. How do you diagnose sub-clinical Mastitis in Low Producing Dairy Cows? Proceedings of the 7th ISVEE Symposium. 15th – 19th August 1994. Nairobi, Kenya. The Kenya Veterinarian 18(2): 116.

Omore, A., McDermott, J. J. and Gitau, G. K. 1996. Factors Influencing Production on Smallholder Dairy Farms in Central Kenya. Proceedings of the 5th KARI Scientific Conference: 370 – 380.

Owango, M., Lukuyu, B., Staal, S., Kenyanjui, M., Njubi, D. and Thorpe, W. 1998. Dairy Co-operatives and Policy Reform in Kenya: Effects of Livestock Service and Milk Market Liberalisation. Food Policy, 23, (2): 173 – 185.

Orodho, A.B.1990. Dissemination and Utilisation of Research Technology on Forages and Agricultural By-Products in Kenya. Utilisation of Research Results on Forage and Agricultural By-Products Materials as Animal Feed Resources in Africa: 70-90. Proceedings Of The First Joint Workshop Held in Lilongwe , Malawi 5-9 December 1988.

OVP, 1994. Office of The Vice President and Ministry of Planning and National Development. Kiambu District Development Plan, 1994-1996: 11-18.

Plucknett, D.L., 1995. Prospects of Meeting Future Food Needs Through New Technology. In: Islam, N. 1995. Population and Food in the Early Twenty-first century: Meeting future Food Demands of an Increasing Population. International Food Policy Research Institute. Washington, D.C.: 207 – 219.

Preston T.R., and Leng, R.A., 1987. Matching Ruminant Production systems with Available Resources in the Tropics and Sub-Tropics. Penambul Books, Armidale: 1 - 9.

Rees, D. J., Momanyi, M., Wekundah, J., Andima, D., Kamau, M., Ndubi, J., Ndung'u, F., Oyure, S. and Odondi, J. 1999. Agricultural Knowledge and Information Systems in Trans Nzoia and West Pokot – Implications for Demand-driven Research and Agricultural Development. Presented at KARI/DFID NARP II End of Project Conference, Nairobi, Kenya.

Refsadal A. O., Baevre L. and Bruflot, R., 1985. Urea Concentration in Bulk Milk as an Indicator of The Protein Supply at The Herd Level . Acta Veterinary Scandinavia, 26: 153-163.

Romney, D., Tanner, J., Chui, J., Kenyanjui, M., Morton, J., Ndegwa, P., Kimari. A. and Thorpe, P., 1998. Feed Utilisation Options for Smallholder Dairy Farms. Paper presented at an International Conference on FOOD, LANDS AND LIVELIHOODS. Setting Research Agendas for Animal Science, Nairobi, Kenya: 175 – 176.

Roseler D. K., Ferguson, J. D. Sniffen, C. J.and Herrema, J. 1993. Dietary Protein Degradability Effects on Plasma and Milk Urea Nitrogen and Milk Non-protein Nitrogen in Holstein Cows. Journal of Dairy Science, 76: 525-534.

Sansoucy, R., Jabbar, M. A., Ehui, S. and Fitzhugh, H., 1995. The Contribution of Livestock to Food Security and Sustainable Development. Proceedings of the Joint FAO/ILRI Roundtable on Livestock Development strategies for Low-Income countries: 9-21.

SAS, 1988. User's Guide. Release 6.12 Edition. SAS Institute Inc. Cary, NC, USA.

Saylor, R. G., 1970. A Social Cost /Benefit Analysis of The Agricultural Extension and Research Services in Selected Cotton Growing Areas of Western Tanzania. University of Dar es Salaam, Economic Research Bureau.

Schreuder, B. E. C., Moll, H. A. J., Noorman, N., Halimi, M., Kroese, A. H. and Wassink, G., 1995. A Benefit-cost Analysis of Veterinary Interventions in Afghanistan Based on

Livestock Mortality Study. Preventive Veterinary Medicine, Vol. 26: 303-314.

Sene, D., 1994. The Role of Research and Training In Agricultural Extension: 21-28.

Shapiro, B. I., Sanders, J. H., Reddy, K. C. and Baker, T. G., 1992. Evaluating and Adapting New Technologies In a High-Risk Agricultural System, Niger. Agricultural Systems Vol 42 (1993): 153 – 171.

Somers, J., 1991. Small Farmers and Agricultural Extension: Surviving on a Small Farm in The Netherlands and Possibilities for Agricultural Extension to Reach a Hard-to-reach Category: 49 - 61.

Staal, S. J., Chege, L., Kenyanjui, M., Kimari, A., Lukuyu, B., Njubi, M., Owango, M., Tanner, J., Thorpe, W. and Wambugu, M., 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.

Staal, S. J. and Omore, A. 1998. Use of farmer recall versus direct measurement in gathering lactation data: Lessons from Kenyan smallholder dairy systems. FOOD, LANDS AND LIVELIHOODS. Setting Research Agendas for Animal Science, pg. 184 – 185.

Thornton, R.F., 1970. Factors Affecting the Urinary Excretion of Urea Nitrogen in Cattle. II. The Plasma Urea Nitrogen Concentration. Australian Journal of Agricultural Research 21: 145-152.

Van den Ban, A. W., and Hawkins, H. S. 1996. Agricultural Extension, Second Edition. Blackwell Sciences Ltd.: 120-174.

Van der Valk, Y. S., 1992. Ministry of Livestock Development, National Dairy Development Project. Review Reports of the Surveys With the Dairy Evaluation and Advice Form During 1991.

Venkatesan, V. and Schwartz, L., 1991. The World Banks Experience with T and V in Africa and issues for the Future. Agricultural Services Initiative. Report Based on The World Bank Workshop held at Lilongwe in February 1991. Agriculture and Rural Development Series No. 4. Technical Department Africa Region. The World Bank, 109 pp.

Wadsworth, J. 1994. Adoption of Innovations by Costa Rican Livestock Producers Under Different Levels of Extension Intensity: Predicted Versus Observed Behaviour. Agricultural Systems 49: 69-109.

Waldner, N.W., 1997, OSU Extension Dairy Specialist. Milk Urea Nitrogen Testing. ANSI Facts, July/August, 1997.

Walshe, M.J., Grindle, J., Nell, A. and Bachmann, M., 1991. Dairy Development in Sub-Sahran Africa. A Study of Issues and Options (Technical Paper No. 135). World Bank, Washington DC, USA.

Ward, J.R., Henricks, D.M., Jenkins, T.C. and Bridges, W.c., 1992. Serum Hormone and Metabolite Concentration in Fated Young Bulls and Steers. Domestic Animal Endocrinology 9: 97-103.

Whitaker, D.A., Goodger, W.J., Garcia, M., Perera, B.M.A.O., Wittwer, F., 1999. Use of Metabolic Profiles in Dairy Cattle in Tropical and Subtropical Countries on Smallholder Dairy Farms. Preventive Veterinary Medicine 38: 119-131.

Wouters, A.P., 1987. Dry Matter Yield and Quality of Napier Grass on Farm Level. Ministry of livestock Development, National Dairy Development Project.

APPENDIX 1:

Farmers' sketches of the sub-location maps used for farmer selection in the cross-sectional survey

APPENDIX 2:

Questionnaire used in the cross-sectional survey

APPENDIX 3:

Scoring system for Farmers' level of knowledge and adoption of dairy technologies

APPENDIX 4:

Summary of analysis of variance on the effect of level of extension and wealth on various parameters under investigation

APPENDIX 5:

Feed monitoring form