R6619: Husbandry strategies for improving the sustainable utilisation of forages to increase profitable milk production from cows and goats on smallholder farms in Tanzania

Final Technical Report on a Research Project Funded by the Department for International Development's Livestock Production Programme.

The University of Reading

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List of Abbreviations

ARNAB	African Research Network for Agricultural By-products
BRALUP	Bureau of Resource Assessment and Land Use Planning
CP	Crude Protein
d	day
DALDO	District Agriculture and Livestock Development Officer
DFID	Department for International Development
DM	Dry matter
DRD	Department of Research and Development
DRT	Department of Research and Training
ESRF	Economic and Social Research Foundation
FAO	Food and Agricultural Organisation
FPR	Farmer participatory research
FSR	Farming System Research
GLM	General Linear Model
ha	Hectare
HIS	Heifer In-trust Scheme
HPI	Heifer Project International
ICRA	International Centre for Development Oriented Research in Agriculture
IDS	Institute of Development Studies
IIED	International Institute for Environment and Development
ILCA	International Livestock Centre for Africa
ILRI	International Livestock Research Institute
ITK	indigenous technical knowledge
kg	Kilogram
km	Kilometer
KARI	Kenya Agricultural Research Institute
KSHDEP	Kagera Small Holder Dairy Development Project
l	Litre
LSH	leaf, sheath and husks
LPRI	Livestock Production and Research Institute
LRO	Livestock Research Officer
LW	live weight
MALD	Ministry of Agriculture and Livestock Development
MARTI	Ministry of Agriculture Research and Training Institute
ME	Metabolisable energy
MIRPP	Mwanza Integrated Rural Planning Project
MJ	Megajoule
MoAC	Ministry of Agriculture and Co-operatives
MPTs	Multi-purpose trees

N	Nitrogen
NALRP	National Agricultural and Livestock Research Project
NALERP	National Agricultural and Livestock Extension Rehabilitation Project
NFSR	National Farming Systems Research
NGO	Non Government Organization
NORAD	Norwegian Agency for International Development
NRI	Natural Resources Institute
NRIL	Natural Resources International Limited
ODA	Overseas Development Administration
PANESA	Pasture Network for Eastern and Southern Africa
PLA	Participatory Learning and Action
PRA	Participatory Rural Appraisal
PRC	Pasture Research Centre
RPF	Resource poor farmers
RRA	Rapid Rural Appraisal
SAREC	Swedish Agency for Research Co-operation
SARI	Selian Agricultural Research Institute
SAS	Statistical Analysis System
SCAPA	Soil Conservation and Agroforestry Project Arusha
SDEP	Smallholder Dairy Extension Project
SR	Stocking rate
SSDDP	Small Scale Dairy Development Project
SUA	Sokoine University of Agriculture
t	Tonne
TALIRO	Tanzania Livestock Research Organization
TDL	Tanzania Dairies Limited
TLU	Tropical Livestock Unit
TNFSRP	Tanzania/Netherlands Farming System Research Project
TSAP	Tanzania Society of Animal Science and Production
TVC	total variable costs
UDSM	University of Dar es Salaam
UNDP	United Nations Development Programme
URT	United Republic of Tanzania
WFP	World Food Programme
ZDRT	Zonal Director
ZRTC	Zonal Research and Training Centre

1. EXECUTIVE SUMMARY

This project was designed around the hypothesis that feed resources were a major limiting factor to milk production in the high potential areas of Tanzania and that by taking a farmer-oriented approach to technological research, practical solutions to the most pressing constraints could be developed and promoted.

There was little evidence that the dairy production constraints facing poorer farmers in Tanzania had been adequately identified or addressed prior to this project. This project therefore applied participatory appraisal techniques so that farmers could identify and prioritise their constraints and participatory evaluation techniques so that farmers could evaluate experimental technologies for themselves. Finally, farmer-to-farmer learning and evaluation permitted the transfer of potentially beneficial technology from one group of farmers to another. The adoption of a participatory approach to all stages of the technology generation and dissemination cycle is rare in livestock research and this project serves as an example of the benefits which may accrue from this approach.

The technology of manual box-baling of maize stover has shown that real economic benefits can be gained from simple applied technology. Allied with stripping the more digestible portions from maize stover prior to baling, the cost of transported forage reduces from 10 Tanzanian shillings per mega Joule of metabolisable energy to 4 Tanzanian shillings. This same technology can be applied to the roadside grass trade and provide benefits to both sellers and buyers of this forage.

Farmer-to-farmer visit and learning showed promise as a means of technology transfer and may have benefits over either training and visit approaches or local farm open days.

The project has contributed to DFID's development goals by engaging in dialogue with poorer farmers, learning from their experiences and circumstances and allowing them to select and test technologies so that farmers become empowered to improve their own productive opportunities and hence alleviate poverty.

2. BACKGROUND

2.1 JUSTIFICATION

There is a large demand for liquid milk in Tanzania and the current production is not meeting the need (Laurent and Centres, 1990; Komba and Mjingo, 1992; Mdoe, 1993a; Mdoe and Temu, 1994). Milk production from cows and goats on smallholdings gives a regular source of cash income for women (Holden and Coppock, 1992) and improved children nutrition. The ruminant animals which produce the milk contribute towards integrating crop and livestock production through use of crop residues as feed and nutrient cycling via excreta (Thorne, 1995; Tanner *et al.,* 1995). Research findings have shown that inadequate nutrition is the most serious problem which impedes livestock production in Sub-Saharan Africa (Tanzania included), and that, given the introduction of high genetic merit breeds, improved nutrition could substantially raise milk production (McIntire, *et al.* 1992).

2.2 HYPOTHESIS

Economic forage-feed supply, both in quantity and especially in quality, represents a major component to sustainable, profitable milk production on a smallholder dairy farm. It is hypothesized that milk production in the smallholder farms is less than potential, and this is mainly due to lack of farmer-evaluated strategies on how to use forages available on farm, and apply on-station research technologies for improving its utilisation.

2.3 OBJECTIVES

The broad objective of the study was to develop farmer evaluated husbandry strategies for improving and integrating the sustainable utilisation of pasture, crop residues, and tree forages to increase profitable milk production from cows and goats on smallholder crop/livestock farms in Tanzania. The immediate objectives were:

- To review locally available literature on forage feedstuff production and utilisation
- To identify (using the PRA approach), together with farmers, the constraints to, and opportunities for, improved forage utilisation for profitable milk production on smallholder farms.
- To undertake desktop studies based on i) and ii) to develop and compare husbandry strategies for improving and integrating sustainable utilisation of forage for milk production. Developed strategies to be assessed by farmers for acceptability by PRA approaches.
- To undertake on-station or on-farm experiments to provide missing-link information identified in objectives i), ii) and iii) above.
- To devise year-round husbandry strategies (based on objectives i - iv above) for improving and integrating the sustainable utilisation of pasture, crop residues and tree fodder to increase milk production from cows and goats on smallholder, crop/livestock farms and gauge farmer acceptability of the improved strategies.

2.4 RESEARCH APPROACH AND PROCESS

Participatory Rural Appraisal (PRA) was adopted as the research approach to verify the hypothesis and meet the objectives. There is scant information on the participation of farmers in research and especially livestock research (Farrington and Martin, 1988). Conventional research has usually been based on researchers' views of what to research on, and the bulk of this has been basic research with very little applied research. The present study explored an alternative approach and focused on a process of sequential reflection and action, carrying out research with and by the local people rather than on them. Using participatory approaches to identify, prioritise and suggest solutions to the constraints hindering development is suggested as a new way of developing technologies to address local people's problems (Okali *et al.,* 1994; Cornwall and Jewkes, 1995).

The PRA approach made the whole research process farmer-focused and farmer-driven. The process involves research problem identification with farmers, evaluation of possible solutions, carrying out adaptive research with farmers and evaluating the results with farmers. The technical research presented in the present study reflects farmer perceptions of research and is intended to solve pressing problems and constraints.

Due in part to the methodology used in the study, some emphasis has been given to the process, to see if this could be a better approach to forage technology development for smallholder farmers in the future.

As part of this process, constraint identification, technology demand and background literature reviews were internalised in the project. These issues are addressed under the Outputs section of this report.

3. PROJECT PURPOSE

The project was designed to address the DFID RNRRS Livestock Production Programme Purpose of improving the performance of livestock in high potential farming systems.

The project specific purpose was to develop and promote improved strategies for animal husbandry and nutrition in smallholder dairying in crop/livestock systems in high potential areas.

4. RESEARCH ACTIVITIES

4.1 OUTLINE OF HOW THE RESEARCH WORK WAS CARRIED OUT

The research reported was carried out in seven main steps (Figure 1). The steps were linked such that one step gave rise to the next and provided for looking forward and backward to gauge the flow. Three PRA Phases were planned to ensure that farmers had the chance to participate and evaluate various stages of the research.

Figure 1. *Outline of the steps involved in the research carried out*

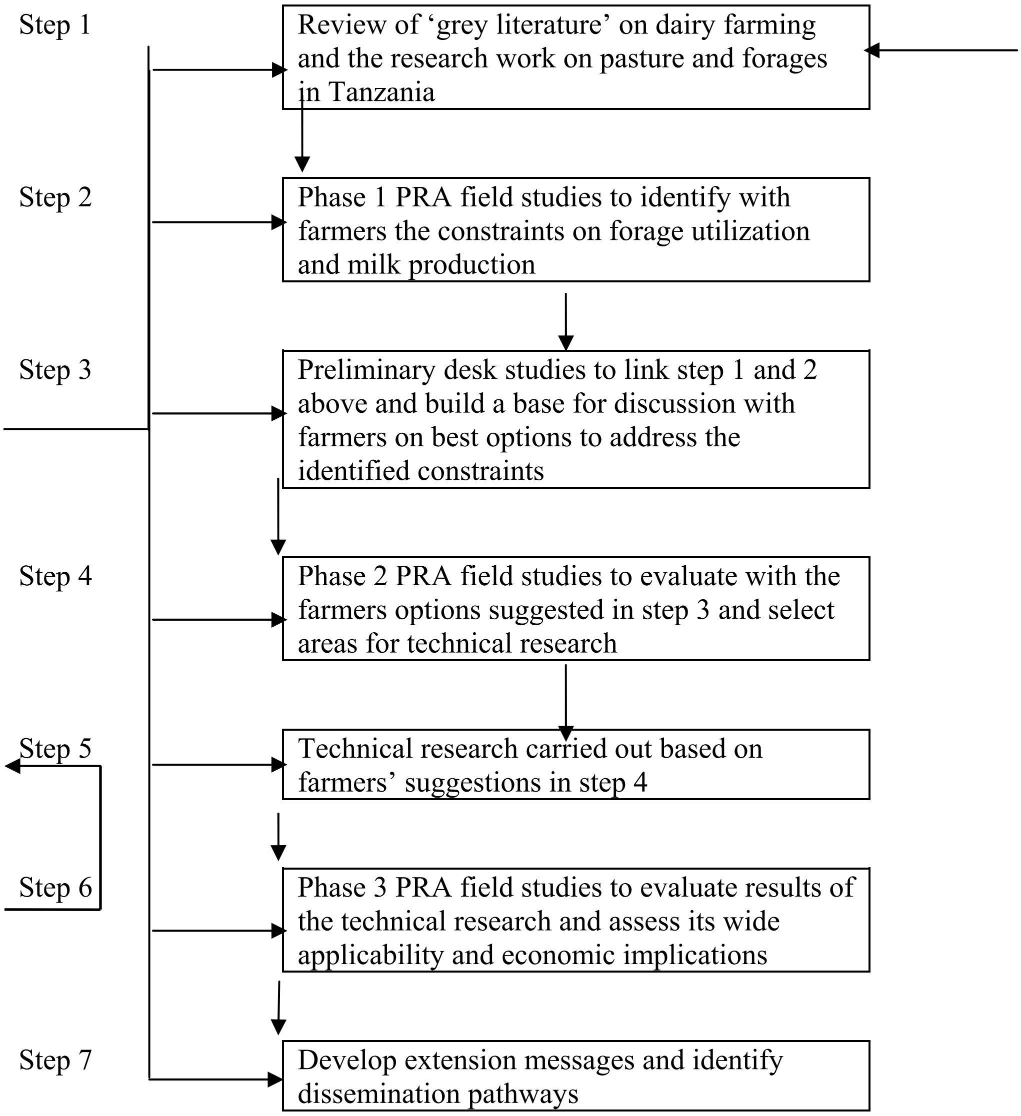


Table 1. *Dates and activities carried out during the study period*

Dates	Activities	Location
May 1996 to Aug 1996	Review of 'grey' literature, selection of the study villages and making contacts with NGOs and extension staff working with smallholder farmers	SUA, LPRI Mpwapwa, ARI Ukiriguru, HPI, SCAPA and CRT Office
Sep 1996 to Dec 1997	Learning some basic computing skills and PRA techniques in preparation for phase 1 PRA studies	The University of Reading
Jan 1997 to April 1997	Conducting Phase 1 of PRA field studies to identify with farmers the constraints in forage production and utilization	Mwanza, Kilimanjaro and Morogoro
May 1997 to Aug 1997	Analyzing Phase 1 PRA studies and desk studies to develop literature-based strategies for discussion with farmers in Phase 2 PRA	The University of Reading
Sep 1997 to Oct 1997	Phase 2 PRA to discuss and evaluate with farmers possible strategies for forage utilization	Kilimanjaro
Nov 1997 to Dec 1997	Commencement of technical research focusing on handling and reducing bulkiness of maize stover	MATI Tengeru
Jan 1998	Phase 2 PRA	Morogoro and Mwanza
Feb 1998 to Mar 1998	Continuation of technical research on leaf stripping and manual box-baling	MATI Tengeru
Apr 1998 to Jul 1998	1. Evaluating with farmers the implications of results of manual box-baling of stover and assess applicability of box-baling of wilted roadside grass	Kilimanjaro
	2. Phase 3 PRA with six case study farmers to develop enterprise budget for assessing economic implications of using improved technologies and different strategies e.g. family labour *vs* hired labour	Kilimanjaro
Aug 1998	Disseminate some of the findings in local scientific conference (TSAP)	Arusha, Tanzania
Sep 1998 to Dec 1998	Analysing data from the six case study farmers and developing the economically tested strategies	The University of Reading
Jan 1999 to May 1999	Writing the thesis	The University of Reading

4.2 THE STUDY LOCATIONS

4.2.1 General

Studies were carried out in three contrasting locations of Tanzania:

- Kilimanjaro. High potential dairying. Improved cows in a coffee/banana/maize farming system.
- Morogoro. Goat milk production in a vegetable/maize farming system.
- Mwanza. A semi-arid area. Milk production from indigenous cows in a cotton/sorghum/maize farming system. This is a priority area in Tanzania for DFID EA.

4.2.2 Kilimanjaro

In Kilimanjaro, the PRA studies were carried out in Samaki Maini and Ng'uni villages. These villages are located in Hai District of Kilimanjaro Region in Northern Tanzania. Selection of the two villages was done in collaboration with the extension staff at district office. Ng'uni village was selected because in the past a technology on urea treatment of maize stover was introduced but was not adopted by farmers. Samaki Maini was selected because it has milk production from both cows and goats.

There are three agro-ecological zones (AEZ) covering this study location. A description of these AEZ is given in Table 2.

Table 2. *Description of the Kilimanjaro study location*

AEZ	Altitude (m.a.s.l.)	Mean Annual Rainfall (mm)	Farming system	Livestock	Population density (persons/km^2)
Highland	1200 - 1550	1600	Coffee/banana with vegetables, maize, beans, yams, sweet potatoes, and sugar cane.	Improved dairy cattle and dairy goats.	650
Midland	900 - 1200	600 - 1200	Maize/beans/vegetables with some coffee and bananas	Local cattle, goats and sheep, with a few dairy cattle	250
Lowland	Below 900	580	Maize/beans/rice with finger millet, sunflower, cassava and sorghum	Local cattle, goats and sheep	50

Source: Derived from ICRA/SARI (1992).

Most farmers in Kilimanjaro location own two plots, one in each of the highland and lowland zones. Human settlements and animals are found in the highland zone, but the bulk of dry season feed resources in the form of crop residues and road side grass, are obtained from the lowland zone. This makes the system dependent on transport between the two zones. The main objectives of livestock keeping are milk and manure. Previous surveys have shown that livestock feed management is the major constraint to milk production in this area (Mlay, 1986; ICRA/SARI, 1992; Mdoe, 1993a).

4.2.3 Morogoro.

In Morogoro, the PRAs were carried out in Mgeta Ward. The villages involved in the study were Nyandira, Tchenzema and Mwarazi. These were the villages where farmers under the SUA managed Dairy Goat Project were located.

Mgeta is located on the foothills of the Uluguru Mountains in Morogoro District, about 250 km west of Dar es Salaam. The area receives an average annual rainfall of 1200 mm. The dominant farming system is vegetable/maize.

Due to the steep slopes of the area, there are very few cattle, the principal livestock kept being local or improved dairy goats. The improved animals are Norwegian goats introduced in Mgeta in 1983 by Sokoine University of Agriculture (SUA) (Mtenga and Kifaro, 1993; Kiango *et al.,* 1994) and their crosses. Goats are either tethered or herded for grazing with there also being some cut-and-carry stall feeding.

4.2.4 Mwanza.

In Mwanza location, the study was carried out in Iteja village. Iteja is in Misungwi District about 55 km south of Mwanza on the Mwanza to Shinyanga road. The village was selected as being representative of the dominant farming system in Sukumalalnd (the area of north-west Tanzania on the south shore of Lake Victoria covering Mwanza and Shinyanga Regions). Iteja village has both 'Luseni/Itogolo' and 'Mbuga' soils which together cover about 57 % of Sukumaland (FSR, 1996).

The area receives about 900 mm annual rainfall although there are considerable variations (Ebong, *et al.;* 1991). Population density increased from 58 per km^2 in 1978 to 70 per km^2 in 1988 (Tamminga and Bunyecha, 1993) however, land is still available. This allows communal grazing to be practised except in peri-urban areas where intensive dairying is now found. The dominant farming system is cotton/sorghum/millet/rice associated with Tanzania Shorthorn Zebu (TSZ) cattle grazed on communal land. In recent years, a World Food Programme funded project (Smallholder Dairy Development and Extension Project - SDDEP) has introduced and distributed dairy cattle to 9 villages located in Misungwi and Kwimba Districts.

4.3 DURATION OF THE STUDY AND ACTIVITIES CARRIED OUT

The study was carried out between May 1996 and August 1998. The study was carried out in steps which were linked. The activities were linked such that one activity gave rise to another and allowed for looking back and for constant contacts with the farmers. The dates and different activities undertaken during the study period are shown in Table 1.

4.3.1 Phases of PRA.

3 Phases of PRA field studies were carried out.

- Phase 1 PRAs (Jan–April '97) involved identification with farmers, of the constraints and problems associated with forage production and forage utilisation.
- Phase 2 PRAs (Sept. '97–Jan. '98) involved farmer evaluation and prioritisation for technical research, the literature-based strategies to address constraints, identified in the Phase 1 PRAs.
- Phase 3 PRAs involved evaluations and testing for economic implications, of strategies prioritised for technical research in the Phase 2 PRAs.

Phase 1 and Phase 2 PRA field studies were carried out in all three study locations, but Phase 3 was carried out only in Kilimanjaro location. The reasons for carrying out Phase 3 PRAs only in Kilimanjaro were lack of identified short term research topics in Mwanza and Morogoro locations that could fit into the time-frame of the study compared to the identification of many constraints in Kilimanjaro location that allowed for short-term research.

4.4 PRA TECHNIQUES USED

PRA techniques used in the present studies included secondary data review of which the main sources were theses, dissertations and BSc. special projects at Sokoine University of Agriculture (SUA). Other sources were annual and programme reports from the documentation centre and FSR department in the Ministry of Agriculture and Co-operatives (MoAC), reports of donor funded and NGO projects (e.g. HPI, SCAPA, FARM Africa, Goat project at SUA and the Lake Zone FSR Project) and extension reports.

Other PRA techniques used were direct observations using observation indicator checklists, group discussions, participatory resource mapping, direct matrix and pairwise ranking, wealth ranking, seasonal calendars, semi structured interviewing (SSI), focus group discussions (using key informants or specialised groups of farmers) and case studies. Problem cause and linkage diagrams were used to identify cause and effect of various constraints and help to analyse possible solutions to the problem. Decision tree diagrams were used in the Phase 2 PRA field studies to establish the most limiting resource in the adoption of improved technologies. The decision tree diagrams were more suitable when discussing with individual farmers, as different farmers had different access to resources.

4.5 THE RESEARCH PROCESS

4.5.1 The PRA team.

Due to the distant location of the study areas it was not possible to have a uniform and common PRA team in all locations. The main investigator in collaboration with extension staff and researchers available in a given location formed a PRA team for that location.

In Mwanza the team was formed by research officers from the Agricultural Research Institute at Ukiriguru (at least two animal scientists and an agronomist were available for each field visit), a village extension officer and a supervisor for a WFP funded project in Mwanza. During Phase 1 PRA in Mwanza location a UK collaborator Mr. Steve Ashley joined the PRA team. Mr. Ashley had previously worked in the area and had a good command of the local language used during the PRAs.

In Kilimanjaro the team for Phase 1 PRA was formed by an extensionist from the district office, the village extension officer, an officer supervising a dairy goat project under HPI and a technician (crops) from Selian Agricultural Research Institute. Mr. Ashley from UK also joined the PRA team in Phase 2 PRAs in Kilimanjaro.

In Morogoro, a dairy goat project extensionist and a field facilitator who had previous PRA experience in the area (Jähnig, 1996) formed the team.

4.5.2 Involvement of NGOs and extension staff.

The involvement of NGOs was maintained in PRAs in all locations. In Kilimanjaro, the NGOs included HPI, Farm Africa and SCAPA (a donor-funded Project operating in collaboration with the MoAC). In Mwanza the NGO involved was a WFP Project working on distribution of improved dairy cows in Sukumaland. In Morogoro, the Department of Animal Science and Production at SUA was the main link.

In all locations, district-level extension staff were contacted at the initial stage of the study and assisted in the selection of target villages. The selection criteria included the availability of milk producers (from cows and/or goats), the diversity of the farming system and how representative the farming system was.

In Morogoro, the target location (Mgeta) was pre-selected due to its involvement in dairy goat production. The dairy goat project is supervised by SUA and so initial contacts were the project supervisors at SUA and then the project extension staff in Mgeta.

4.5.3 PRA Process in the village

When visiting a village, the first contacts were with the administrative staff in the village office. At this stage the objectives of the PRA team were introduced and the expectations of the team from the village explained. The type of information required was kept open and the methods of gathering this information were explained. There followed general group discussions (with emphasis on involvement of as many farmers as possible), focused group discussions and individual interviews. Relevant secondary data (e.g. human and livestock populations, village organisation structure, NGOs working in the village and their areas of assistance, institutions available in the village) were collected from the village office. Besides the secondary data, the village administrative staff also formed the first key informant group which provided the general overview of the village in terms of animals kept, crops grown, feed resources used and channels for marketing products. The village administration also helped in organising general group meetings, focused group meetings and key informant meetings.

4.5.4 Direct investigator observation.

Direct participant observation was the first key tool consistently used when visiting villages. Observation checklists were prepared in advance to ensure that observations were made systematically and that observation from different sites and notable aspects were comparable. Other methods (practised mainly in Phase 2 PRAs) under direct observation included taking measurements using measuring tapes and foot-pace for measuring lengths of planted fodder strips and weighing scales for spot checking of head-loads of forages carried home. Site visits to local markets and homes were made to obtain an insight into the real system. Other indicators such as size and quality of the cattle barn, presence or absence of feed store, type of feeding troughs and feed available in the trough during the visit were used to verify and cross-check information gathered from both groups and individual discussions.

4.5.5 Group meetings.

Group meetings were organised by the village leaders in collaboration with the village extension officer. These were intended to obtain a wide coverage of community level information. The groups also undertook participatory resource mapping, component matrix ranking, pairwise ranking, seasonal calendars and analysis of group discussions. During the meetings, checklists guided the discussions. The procedures for conducting group meetings described by Theis and Grady (1993) were followed. The procedure included moderation of the meetings to see that there was no dominance by any one person or peer group and to ensure minimal interruptions.

4.5.6 Wealth ranking.

Wealth ranking was carried out in Kilimanjaro and Mwanza locations to provide a sample frame of wealth categories of farmers, produce local indicators of wealth and well-being of the community and to enable the selection of farmers for individual interviews with the intention of reaching the 'poorest of the poor' as emphasised by the DFID policy. It was not possible to carry out wealth ranking in Morogoro, as target farmers in this location were pre-determined as those who were involved with the SUA dairy goat project.

The wealth ranking involved the following steps:-

- Collection of a list of all households in the village from the village office.
- From the village list, a systematic selection of names (a name after every 5 names) was done to provide a 20% representation from the village.
- The selected names were written on cards.
- A meeting with key informants who were expected to know many people in the village was planned. During the meeting, the key informants were asked to list criteria used in the village to categorize farmers in different wealth groups.
- Based on the listed criteria, the cards representing 20% of the households in the village were grouped by reading a name and the card placed in appropriate wealth group.

The key informants were then asked to list the characteristics of the people falling in each of the wealth groups. The characteristics were used by the PRA team to select farmers for individual interviews where the focus was to reach the 'poorest of the poor' in the village and have their views included in the PRAs.

4.5.7 Matrix and pairwise ranking.

Direct component matrix rankings were carried out by farmers for items that were first presented as a list and then required to be ranked for, say, importance or priority. Matrix rankings were used in ranking components such as the objectives of keeping livestock, most important feed resources and areas for development research. Farmers were asked to set some criteria to guide the ranking.

Pairwise ranking was carried out by comparing two components at a time. In pairwise ranking the items were written in table form across and longitudinally, as shown in Table 3.3. The components were then compared in pairs and the preferred component was written in the box where the column and row containing the components intersect. Occurrence of each component was counted and its score entered across in the score column. Ranking was then by order of the component scores.

Pairwise ranking was used to rank limiting resources, rank most pressing constraint when the list was less than 8 and rank preferences. Pairwise ranking is not good for a long list as it may end up in confusing the farmers.

4.5.8 Focus group meetings.

The focus group meetings were held with key informants and other specialised groups identified as having a common activity, such as traditional milk processing identified in Mwanza, and farmers who had participated in urea treatment of maize stover in Kilimanjaro. The focus group meetings discussed specific issues important to the groups, and verified some of the information gathered in the group meetings. Key informant meetings also revealed some of the traditional farmer practices that were used to mitigate various livestock feeding crises that arose in their communities.

4.5.9 Individual interviews.

Individual interviews were carried out by visiting individual farmers at their homesteads. The individual interviews were aimed at reaching the most disadvantaged categories in the village who tended to be unable to participate in-group meetings. These included women and resource-poor farmers (RPF). Selection of farmers for individual interviews was done by using the characteristics of farmers falling in the different wealth groups developed during the wealth ranking exercise. The village extension office and two key informants helped to develop a short list of farmers considered to be in the RPF category in the village and the PRA team members picked names from the list for farmers to be visited and interviewed. During the home visits, direct observations were also carried out.

4.6 TECHNICAL RESEARCH

4.6.1 Box-baling General.

Phase 1 PRA in Kilimanjaro location identified transportation costs as a constraint to forage utilisation. It was thought that baled stover would be less bulky than loose stover and hence the transport cost per unit would be reduced. Onim *et al.* (1992) had shown in Kenya that a simple hay baling box formed a practical solution to the problems of transport and storage. This option was among strategies presented to farmers for evaluation during the Phase 2 PRA studies and a demonstration on manual box-baling of maize stover was staged at Samaki Maini village in Kilimanjaro location.

Researchable issues raised by farmers on this technology included:

- What was the optimal size of box?
- How much labour was required?
- What were the benefits?

To answer the farmers concerns on these issues, three experiments were carried out at the Ministry of Agriculture Training Institute (MATI) Tengeru (on the lower slopes of Mount Meru at 2^0 S, 37^0E, and 1400 metres above sea level). Farmers from Samaki Maini participated in the experiment at MATI Tengeru.

Experiment 1 assessed the weights and labour inputs required for three different sizes of bales.

Experiment 2 compared the amounts carried and the costs of carriage (on a pick-up or a truck) of the three sizes of bales against loose stover.

Experiment 3 looked at the labour and cost implications of stripping leaf, sheath and husks (LSH) before manual box-baling.

4.6.2 Labour Force.

Due to financial constraints and farmers' obligations at home it was necessary to minimize the period at MATI Tengeru. Farmers were willing to stay away from their homes for only 8 –10 days and they were able to participate only in one experiment (Experiment 3). Experiments 1 and 2 were carried out using casual labourers and Experiment 3 used casual labourers and farmers. Six farmers (four men and two women) and their village extension worker participated in Experiment 3 at MATI Tengeru. The mean (± s.d) weight of the casual labourers involved was 62.3±2.24 kg. Casual labourers of similar weight were selected to minimise variation between labourer.

4.6.3 Maize stover.

The stover used in the experiments was from the 1997 harvest. The maize was a mixture of varieties, mainly CG 6222 (50 %), Kilima (25 %) and CG4141 (10 %). The stover was stored in the Institute hay barn on a raised platform to deter termites, allow aeration and avoid ground moisture. The Dry Matter content of whole and LSH stover was estimated at 88.2 % and 89.6 % respectively. However due to large variation in the varieties of stover used, a book value of 90 % DM for maize stover was used in the calculations.

4.6.4 Wooden baling boxes.

Three sizes of wooden boxes were used in baling the stover. The boxes were made by a carpenter using a 2.5 cm thick timber as follows:

- Large B1 100 x 50 x 40 cm
- Medium B2 75 x 50 x 40 cm
- Small B3 50 x 50 x 40 cm

The boxes did not have a top or a bottom.

4.6.5 Box-baling Experiment 1.

4.6.5.1 *Objectives*

- To determine the weight of bales made from each of three box sizes
- To determine time required to make a bale using each of three box sizes.

4.6.5.2 *Design*

In this experiment whole stover was baled in a 3 x 3 multiple Latin square design as shown in Table 3. The experiment was carried out over three days with three periods per day. Each period lasted about 45 minutes and all the work was completed before 10.00 hrs (after which stover might be prone to shattering). Each day formed a complete 3 x 3 Latin square repeated on three consecutive days, thus forming a multiple Latin square design. The variable manipulated was "box size" which had three levels: large (B1), medium (B2) and small (B3) as defined above.

Table 3. *Design of Experiment 1*

Day	Period	Labour1	Labour2	Labour3
1	1	B1	B2	B3
	2	B2	B3	B1
	3	B3	B1	B2
2	1	B2	B3	B1
	2	B3	B1	B2
	3	B1	B2	B3
3	1	B3	B1	B2
	2	B1	B2	B3
	3	B2	B3	B1

B1 = Large box. B2 = Medium box B3 = Small box

Each day, each labourer baled three bales using each of the three boxes (large, medium and small).

The process was as follows:

- two pieces of sisal twine each measuring 2.0 m long were laid crosswise inside the box (at about 15 cm from the corners of the box).
- the stover was gathered and chopped to fit the box (to fit Box B1 stover was chopped once, twice for Box B2 or three times for Box B3).
- the stover was then compressed in the box by the labourer trampling on it until the box was full.
- the sisal twines were tightened and tied.
- the bale was then pulled out of the box, or the box laid sideways, and the bale pushed out.

While the experiments were carried out using one labourer, farmers preferred working in pairs which is a common practice in their fields.

4.6.5.3 *Data recorded*

The data recorded were:

- the time in minutes required for baling using each of the three boxes
- the weight in kg of the finished bale.
- Cost per bale. (Calculated as time per bale multiplied by the casual labour pay-rate of Tsh 250 per hour).

Data were analysed by using GLM procedure of SAS (SAS, 1988).

4.6.6 Box-baling Experiment 2.

4.6.6.1 *Objectives*

- To establish the weight of stover carried in a 1.0 tonne pick-up as loose material or as baled stover.
- To establish the cost per kg DM of stover for loose stover or baled as large (B1), medium (B2) or small (B3) bales.
- To assess the amount of stover carried in a 7.0 tonne lorry and compare it with that carried in 1.0 tonne pick-up so as to investigate an economy of scale in maize stover transportation.

4.6.6.2 *Design*

Experiment 2 was divided into two parts:

- **Part One** to establish the weight of maize stover that could be carried in a 1.0 t pick-up.
- **Part Two** to establish the weight of maize stover that could be carried in a 7.0 t lorry.

Part 1 of Experiment 2 used a 4 x 4 Latin square design involving four labourers and four methods of loading maize stover in a 1.0 t pick-up. The methods were:

- Loading and unloading loose maize stover
- Loading and unloading bales made from large size box (B1)
- Loading and unloading bales made from medium size box (B2)
- Loading and unloading bales made from small size box (B3)

The experiment layout is presented in Table 4 Each labourer had to load and unload the 1.0 pick-up four times per day for four days.

Table 4. *Design of Part 1 of Experiment 2*

Day	Period	Labour 1	Labour 2	Labour 3	Labour 4
1	1	Loose - 1	B1 – 8	B2 – 11	B3 – 14
	2	B1 – 5	B2 - 12	B3 – 15	Loose – 2
	3	B2 – 9	B3 - 16	Loose –3	B1 – 6
	4	B3 – 13	Loose – 4	B1 – 7	B2 – 10
2	1	B1 – 8	B2 - 11	B3 – 14	Loose –1
	2	B2 – 12	B3 - 15	Loose –2	B1 – 5
	3	B3 – 16	Loose - 3	B1 – 6	B2 – 9
	4	Loose - 4	B1 – 7	B2 – 10	B3 – 13
3	1	B2 – 11	B3 – 14	Loose – 1	B1 – 8
	2	B3 – 15	Loose – 2	B1 – 5	B2 – 12
	3	Loose - 3	B1 – 6	B2 – 9	B3 – 16
	4	B1 – 7	B2 – 10	B3 – 13	Loose –4
4	1	B3 – 14	Loose - 1	B1 – 8	B2 – 11
	2	Loose - 2	B1 – 5	B2 – 12	B3 – 15
	3	B1 – 6	B2 – 9	B3 – 16	Loose – 3
	4	B2 – 10	B3 - 13	Loose –4	B1 – 7

The sequence followed in allocating the 1.0 t pick-up for the labourers in the four days was as follows:

Day				
1	L1	L4	L3	L2
2	L4	L3	L2	L1
3	L3	L2	L1	L4
4	L2	L1	L4	L3

4.6.6.3 *Experimental procedure*

The make of the 1.0 t pick-up used was a *Datsun* with the following dimensions: length = 2.2 m, height = 1.5 m and width = 1.4 m. These dimensions gave a volume of 4.6 m^3.

4.6.6.4 *Data recorded*

- Time taken to load and unload
- Weight of loaded loose stover
- Number of bales loaded for large, medium and small bales.

4.6.6.5 *Data calculated*

- Weight of baled stover loaded (calculated by multiplying the number of bales loaded by the average weight per bale obtained from Experiment 1).
- Total time (TTIME). This included loading time, unloading time and baling time.
- DM Weight of stover loaded (WEIGHTDM). Calculated by multiplying the stover loaded by the % DM content (90 %).
- Labour cost (LCOST). The labour time used (TTIME) multiplied by labour value (Tsh 250 per hour).
- Total cost (TOCOST). Calculated by adding the cost of hiring a 1.0 t pick-up (Tsh 15,000 per trip) to the labour cost.
- Cost per kg DM (COSTDM). Calculated by dividing TOCOST by WEIGHTDM.

The data were analysed using General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 1988) for the effects of treatment, labour, day and period on dependent variables namely, weight (air dry and DM basis), total time, labour cost, total cost and cost per kg DM.

4.6.6.6 Part 2 of Experiment 2 was designed to investigate the effect of transporting baled or unbaled stover using a 7 tonne lorry. Due to cost constraints the lorry could only be hired for one day so the experimental design used in Part 1 of Experiment 2 could not be replicated for Part 2. In addition, since it is normal practice that loading and unloading are charged for by the transporter as an addition to the hire charge for the lorry, loading and unloading times were not calculated and a flat-rate Tsh 4,000 loading charge added to the Tsh 30,000 per trip cost of lorry hire.

The 7.0 tonne lorry used in the Experiment was an *Isuzu* with a load capacity of 4.8m by 2.3m by 2.1m giving a total volume of 23.6m^3.

Loose stover was loaded and unloaded three times being weighed each time. Bales of each size were similarly loaded and the number of bales recorded.

4.6.6.7 *Data recorded*

- Truck capacity for loose stover (kg)
- Truck capacity for bales (number of bales)

4.6.7 Box-baling Experiment 3.

4.6.7.1 *Objective*

- To determine the labour and cost implications of stripping leaf, sheath and husks (LSH) before manual box-baling.

4.6.7.2 *Design*

This trial was carried out in two stages:

- Stage 1 to quantify the proportion of LSH and stem to whole stover and labour time to strip LSH from the whole stover.

- Stage 2 involved the manual baling of LSH using the three box sizes used in Experiment 1.

4.6.7.3 *Stage 1* of the experiment involved first, a random stripping of stover samples of different weights ranging from 2 – 8 kg so as to develop a standard sample weight. The sample that had minimum variation both in weight and time was 5.0 kg and was therefore adopted as standard sample. Three casual labourers and three farmers were involved (not on the same day) in stripping 5.0 kg of whole stover in triplicate (n = 9 for each group).

One farmer commented that the time for stripping erect stover in the field might be shorter than the time for stripping cut forage. This was an important note, but since it was not possible to have erect stover in the field verification was not done.

4.6.7.4 *Stage 2* of Experiment 3 was conducted in a replicated Latin square design as shown in Table 5. The experiment was carried out in two days using six casual labourers (L1 – L6) and replicated using six farmers during another two days. The process was carried out in the morning (8.00 – 11.00 am) to reduce leaf shattering.

4.6.7.5 *Data recorded*

- weight (kg),
- time (minutes)
- volume (m^3) of the bales made. Volume was taken by measuring, using a tailor's tape measure, the length, width and height of the bales.

Table 5. *Layout of Experiment 3*

Day	Period	L1	L2	L3	L4	L5	L6
1	1	B1	B2	B3	B1	B2	B3
	2	B2	B3	B1	B2	B3	B1
	3	B3	B1	B2	B3	B1	B2
2	1	B3	B1	B2	B3	B1	B2
	2	B1	B3	B3	B1	B3	B3
	3	B2	B2	B1	B2	B2	B1

4.7 FARMER EVALUATION ACTIVITIES.

4.7.1 General.

The long list of literature-based strategies that were developed as a base for discussion with farmers in Phase 2 PRA field studies in Kilimanjaro, contained technologies that required either to be tested on farm or presented as extension messages that could be considered by farmers. The literature-based strategies were evaluated by farmers in the Phase 2 PRAs.

The strategy of manual box-baling of maize stover which was prioritised high by farmers in Kilimanjaro location for technical research, was tested as explained earlier. Other strategies that were prioritised high by farmers in Phase 2 PRAs, included contour bunds planted with fodder grass and MPTs, and inter-crop maize with pigeon pea in the lowlands of Kilimanjaro. The strategy of contour bunds was addressing two constraints identified by farmers in Kilimanjaro location: land degradation and decline in soil fertility; and shortage of dry-season forage.

The 'grey literature' showed that there was sufficient information on strategies to conserve the soil and plant forage on sloping land (Kinsey, 1993; SCAPA, 1993; Inades-Formation

Tanzania, 1993a and b; Per Assmo and Eriksson, 1994). Furthermore, the review showed that farmers on the slopes of Mount Meru in Arumeru District had adopted the technology of contour bunds planted with fodder and MPTs. In view of this, the idea of conducting technical research with farmers in Kilimanjaro location on how to construct contour bunds and planting forage was not considered as promising as taking farmers to the area where the technology had been adopted and letting the farmers learn from their fellow farmers by seeing, asking and where appropriate copying the technology. The approach of *farmer to farmer visit and learning* was demonstrated and found to be successful in the Philippines (Fujisaka, 1988). Also the approach has been advocated by Bevan *et al.* (1993) as one of the routes to enhance rapid adoption of technologies.

4.7.2 Objectives.

- To evaluate with farmers the wooden boxes used in Experiments 1-3 for size preference.
- To investigate the possibility of using the manual box-baling technique in baling wilted roadside grass.
- To introduce the approach of *farmer to farmer visit and learning* as a technique to promote technology adoption.

4.7.3 Farmer Evaluation of size preference.

This study involved two groups of farmers and two PRA tools.

Group One was composed of 19 farmers at a farmers training course at MATI Tengeru. These farmers had seen one of the manual box-baling experiments described above which used casual labourers. The farmers requested and were given a briefing session on the technology. Another session the next day introduced the farmers to the practice of baling stover using the three boxes. Although the group of 19 farmers did not have sufficient time to practise stripping of stover, they were able to bale some LSH (stripped earlier by casual labourers) and using their experience from home they were able to evaluate the possibility of combining stover stripping and box-baling LSH. The 19 farmers then evaluated the three boxes using a one-page questionnaire. The questionnaire enabled the farmers to comment individually on which size of box they preferred and why.

The second group composed of 25 farmers who performed an evaluation of the baling boxes by first setting out criteria for a good box baler and then voting on how each of the boxes satisfied the criteria.

4.7.4 Box-baling for wilted roadside pasture.

Roadside grass is mainly sold in the lowlands of Kilimanjaro along the main road running from Himo to Moshi (22 km) and Moshi to Bomang'ombe (25 km). The trade is dominated by women and children. Recently, roadside grass has been introduced in the local markets and is sold by women and children.

This study was carried out with farmers who sell roadside grass both along the Himo - Moshi road and also in a bi-weekly local market at Kwasadala in Hai District in Kilimanjaro.

The Himo – Moshi road was chosen because it has many long-established kiosks and it serves a wide hinterland due to the number of roads leading of the main road into the highlands.

The study was conducted in four stages:

- A rapid appraisal (RA)
- Individual interviews involving sellers and buyers of roadside grass
- Group meetings with sellers of roadside grass
- Demonstrations of manual box-baling of wilted grass

4.7.5 Rapid Appraisal.

The RA established the number of forage kiosks present, the variation between kiosks (number of sellers or buyers), gender of sellers and the peak hours and peak days for selling forage.

4.7.6 Individual Interview.

The RA enabled selection of suitable kiosks and target groups for the individual interview portion of the study. This investigated the socio-economic constraints and problems associated with the trade and suggested avenues for improvement, including the introduction of manual box-baling of wilted grass.

4.7.7 Group Meeting.

From the previous results, the grass-selling kiosk at Uchira village was selected for a detailed PRA. This kiosk had more that 20 permanent sellers and attracted more buyers than most of the other 32 kiosks studied.

The data collected and the PRA tools used to collect the data are presented in Table 6.

Table 6. *Data collected and PRA tools used*

Information/data	PRA tool used
Background of the trade	Key informant interview and time trend diagrams
Trend of the trade	Time trend diagrams
Source of forage	Semi structured interviews (SSI)
Common species sold	Direct observation
Seasonal availability of grass	Seasonal calendars
Problems associated with the trade[1]	Group discussion and pairwise ranking and linkage diagrams
Price and pricing mechanism	Key informant and direct observation
Weight of bundles/head-loads	Spot weighing
Stage of maturity of the grass[2]	Direct observation
Potential buyers	Semi structured interviews (SSI)
Preferences of buyers	Semi structured interviews (SSI)
Income generated and expenditure[3]	Pie charts

[1] Problems associated with the trade as perceived by the buyers, were collected through interviews with individual buyers who were buying roadside grass

[2] The stage of maturity assessed was only applicable for the particular season when the PRA was undertaken (May/June 1997)

[3] Sellers were not willing to reveal the real income obtained from selling of roadside grass as they were suspicious that the investigation may be associated with imposing tax on the trade

4.7.8 Demonstration.

Two demonstrations of manual box-baling were carried out at the kiosk in Uchira village. The medium size box was used following the evaluation carried out with farmers at MATI Tengeru and the results of Experiment 2.

The first demonstration was to sensitise the sellers and obtain their views on the box-baling technology. In the second demonstration data were collected to determine the cost per bale.

Data collected included: weight (kg) and price (Tsh) of each wilted grass bundle contained in a bale, time taken to bale and weight of bale.

Sellers were asked to set the price of bales after considering the amount and price of grass used, time taken and sisal twine used.

4.7.9 Farmer to farmer visit and learning.

Previous studies of farmer participatory research (FPR) and technology transfer such as those by Fujisaka (1988) on upland soil conservation in the Philippines and Bevan *et al.* (1993) on farmer imitation suggested that farmer to farmer visit and learning might prove to be a suitable method for encouraging technology transfer and uptake.

According to Fujisaka (1988), six farmers and two local researchers from a district with sloping land visited a neighbouring district where a technology of contour cultivation and hedgerow planting was practised. The visiting farmers had not used previously used this technology although it was thought that it might form a solution to the land degradation and fodder shortages experienced. On return to their home area, the farmers experimented with the technology, adapting it to local conditions and working as a co-operative group to plant fodder and tree legumes.

Land degradation and low production of forage and food crops was identified as a constraint during the PRA field studies in Kilimanjaro. Similar constraints had been identified in Arumeru District in northern Tanzania in the 1980s. However, from 1989, the Soil Conservation and Agroforesry Project in Arusha (SCAPA) had introduced the technology of contour bunds and bench terraces planted with fodder grass and trees in an attempt to reduce the problem (SCAPA, 1993; Per Assmo and Erikson, 1994). The technology was introduced to registered farmers and according to the Project reports (SCAPA, 1993) participant farmers have benefited through increased fodder and milk production. The success of this Project has led to more farmers applying to SCAPA for inclusion in the programme (SCAPA, 1993).

It was thought that farmer to farmer visit and learning might therefore be a suitable technique to allow transfer of the contour bund technology from Arumeru to Kilimanjaro.

4.7.10 Implementing the approach of ‘farmer to farmer visit and learning’.

The visit to the SCAPA Project area in Arumeru District involved six farmers accompanied by their village extension officer from Samaki Maini in Kilimanjaro.

5. OUTPUTS

5.1 OUTPUT 1 REVIEW OF LITERATURE.

5.1.1 General overview.

A large proportion of the literature (except for the PRA methodology) presented here is from locally (Tanzania) published and unpublished research in the fields of pasture and forage production and utilisation, smallholder dairying and dissemination of agricultural research findings. The main reason for concentrating on local literature was that the present study was planned to investigate with farmers the constraints to adoption and use of improved technologies, and also to develop strategies for better use of improved technologies on pasture and forage utilisation. It follows therefore that the starting point should be the available local research to allow an assessment of whether technologies suitable for the local conditions have been developed and assess what are the missing links that need further research. The review is presented in four main sections that include:

i) The traditional smallholder sector in Tanzania. The categorisation of the smallholdings, milk production from the sector, constraints to increased milk production and the policy and institutional issues related to the dairying system.

ii) Past research on pasture and forage production and utilisation in Tanzania. This section is in two parts: a) before 1982 and b) after 1982. The reason for this split was that in 1982 Tanzania Government changed its policy on focus to research. Before 1982 the focus of research on pastures and forages was towards large scale farms (state farms and ranches), but in 1982 the emphasis and focus of research on pastures and forages was diverted to smallholder farms. A total of 114 locally published and unpublished studies were reviewed.

iii) The extension-farmer interface in Tanzania including the state of agricultural research in general, the dissemination of agricultural research findings and the existing linkages between research, extension, farmer and other stakeholders working for rural development.

iv) Participatory Rural Appraisal (PRA) methodology.

The review is concluded by salient findings from the “grey” literature as related to the objectives of the present study.

5.1.2 The traditional smallholder sector in Tanzania

5.1.2.1 *Smallholder household characteristics in Tanzania*

The National Sample Census of Agriculture conducted in Tanzania (URT, 1994) showed that the country had about 3.7 million agricultural households, of which 82.4% were male headed and 17.6% were female headed. The census also revealed that 77.4% of the total country population lived in agricultural households in the rural areas where they formed the traditional smallholder sector. In 1994 about 37% of the agricultural households kept livestock on small land holdings of less than 2.0 ha (World Bank, 1994). The number of animals kept per household averaged 2 - 4 cattle and/or less than 10 small ruminants. However, the number depended on the farming systems of the area. It was estimated that more than 95% of ruminant animals were kept by smallholders in the traditional livestock sub-sector and contributed about 27% of the entire gross value of agricultural output (URT, 1994). Despite this contribution and the importance attached to the smallholder sector, smallholder farmers have not managed to increase production through the use of developed ‘improved’ technologies. Reasons for the lack of adoption of ‘improved’ technologies are subjects of investigation in this study. However, it is hypothesised that low adoption is partly due to lack of farmer evaluation of the technologies and strategies developed.

Socio-economic considerations in the development of strategies may help enhance farmer acceptability and adoption.

5.1.2.2 *Categories of smallholder farmers*

According to Kayongo (1991), smallholder farmers can be grouped into two broad categories. Category One includes farmers producing milk from pure or improved cattle (for home use and partly for commercial) and Category Two those who keep local zebu cattle for meat and draught power but which also provide milk for home consumption. In Tanzania, category one dominates in the dairy potential areas of Kilimanjaro, Arusha, Tanga, Southern Highlands and in the newly-growing peri-urban dairy sector in most towns. As a sub-category to this, dairy goat projects in areas of Mgeta in Morogoro, Samaki Maini and Magadini (under HPI) in Kilimanjaro and Dareda in Arusha have been initiated to meet family and neighbour milk needs. Category two dominates in the cotton/sorghum/maize belt of Sukumaland where about 27% of the cattle population in the country are kept (URT, 1994) and draught power is a higher priority than milk (Ngendello, 1994a, and b). PRA field-studies in the present project involved farmers of Category One in Kilimanjaro and Morogoro locations and farmers of Category Two in Mwanza location.

5.1.2.3 *Milk production from the smallholder sector*

A wide range of milk yields per cow per day has been reported in Tanzania (Table 7). The variation exists within and between breeds. The data presented in the Table were mainly based on studies carried out on smallholder farms, therefore it may be assumed that different farmers could have different management strategies which could contribute to the variation within and between locations. Variation has also been observed in milk related traits, namely lactation length, calving interval and age at first calving. Although it is known (Kinsey, 1993) that poor management and poor feeding have a tremendous effect on milk yield and related traits, there is no clear evidence why farmers still operate under poor management practices, despite the large number of technologies to improve livestock management systems. A cover statement indicating that low milk production is caused by inadequate nutrition or simply “poor feeding” has been a caption in most articles addressing milk production in Tanzania (∅rskov, 1987; Kimambo *et al.*, 1992; Shem, 1993; Mbwile, 1994) and elsewhere in developing countries. There is a need now to substantiate such statements by giving reasons for the inadequate nutrition or poor feeding practices. The present study investigated with farmers the constraints to forage production and utilisation and the reasons for low use of improved technologies. Furthermore the study tried to develop with farmers feasible strategies to fit the farming system, with emphasis on economic feasibility and improvement in production.

Research elsewhere in the tropics, has also reported a wide range in lactation yields. In Kenya, Reynolds *et al.* (1993) reported a production of 2648 l over 12 months in a good (wet) year and 1754 in a bad (dry) year indicating an average of 7.2 and 4.8 l/cow/day for wet and dry years respectively. Reynolds *et al.* (1993) further reported that when natural pastures are the main feed source, milk yields are proportionately 0.46 lower when rains fail, but when Napier replaces natural pastures or when cassava (0.4 ha) and leucaena (0.2 ha) are included in the system, milk yield is only 0.35 lower. Matching lactation performance and feeding in studies carried out in the Kenya Highlands, Anindo and Potter (1986) showed that Friesian cows fed on Napier fodder *ad libitum* gave more milk when they were given concentrates. The cows fed only the forage gave 10.4 kg milk daily, while those given 8.0 kg concentrate, along with the forage, yielded 15.0 kg. Total feed intake per cow was 3.16 and 4.29 kg DM per 100 kg body weight respectively. Missing in the Anindo and Potter (1986) study was the cost and benefit comparison for the 8.0 kg concentrate fed, compared to the value of additional 4.6 l milk. Working on Jersey cows in the coastal semi-humid zone of Kenya, Muinga *et al.* (1993) reported a milk yield of 6.4 and 4.2 kg/day for cows fed on Napier alone at eight and sixteen weeks of lactation respectively. The addition of 300 g CP from fish meal increased milk yield to 7.6 kg/d, while addition of some CP from copra cake increased the yield to 8.0 kg/d for cows during the first eight weeks of lactation. Similarly, supplementing with an additional 300 g CP from 5.0 kg fresh Leucaena or a mixture of 1,050 g copra cake and 350 g maize bran increased milk yield from 4.2 to 5.2 kg per day for cows in their sixteenth week of lactation. As in the study by Anindo and Potter (1986), the study by Muinga *et al.* (1993) did not make an economic evaluation.

5.1.3 Trend of milk production in Tanzania.

5.1.3.1 *Milk production from cattle*

The trend in cattle milk production in Tanzania over the period 1981 to 1996 showed a relatively low growth (Figure 2). These production levels were below domestic demand for over two decades and the country was until recently, importing dairy products to partially bridge the gap (MoAC/SUA/ILRI, 1998). The reasons for this low growth rate were mainly attributed to the traditional management and husbandry strategies employed in rearing of these animals. With development and use of improved husbandry strategies, especially on nutrition, and the provision of socio economic requirements such as agricultural credit and marketing channels for both inputs and products it is anticipated that the present milk production can be increased (MoAC/SUA/ILRI, 1998).

Figure 2. *Trend in milk production in Tanzania: 1981-1996 (Source: Mdoe and Temu (1994) and MoAC/SUA/ILRI (1998))*

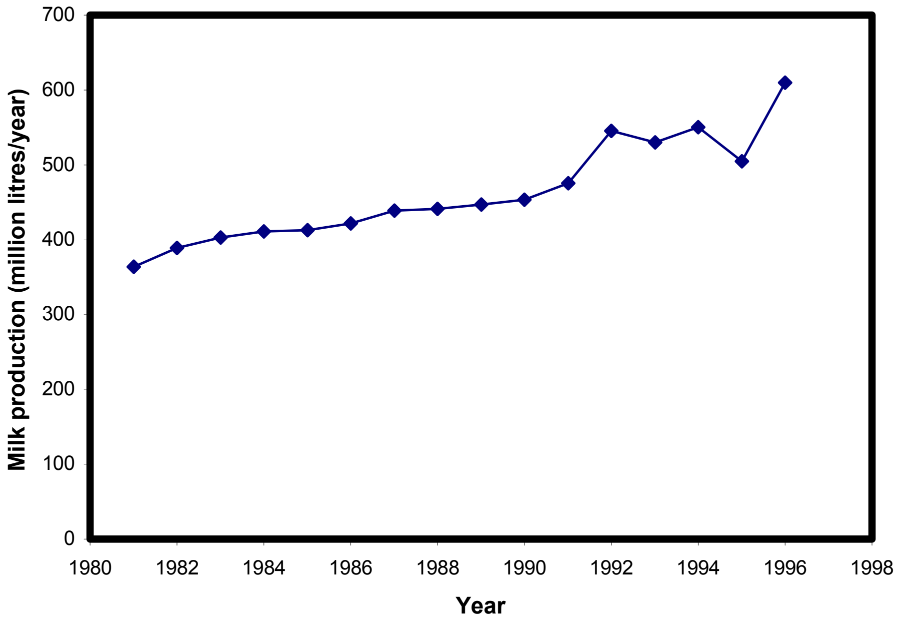


Table 7. *Milk production and related traits in Tanzania*[1]

Breed	Location	Milk yield (l/cow/day)	Lactation length (days)	Calving interval (months)	Age at 1st Calving (months)	Reference
Zebu	Sukumaland	0.75 (dry season) 2.0 (rainy season)	240	24 – 36	48 - 60	Ngendello, 1994a, b
	Kilimanjaro	2.3	279	21.2	45.9	Mdoe, 1993b
	Northern Tanzania	1.4	309	26.3	43.2	Ngategize, 1989
	Kilimanjaro	1.7	-	25	47	Zalla, 1982
Crossbreeds	Morogoro	6.2	312	14.1	35.7	Shekimweri, 1982
	Kilimanjaro	5.4	333	17.5	34	Mdoe, 1993b
	Kilimanjaro	6.9	-	22	34	Zalla, 1982
Pure *Bos taurus* breed	Mbeya	8.4	344	14.4	-	Mchau, 1991
	Morogoro	6.0	248	13.3	35.5	Shekimweri, 1982
	Kilimanjaro	6.4	327	16	31.9	Mdoe, 1993b

[1] Except for the study by Shekimweri (1982) which was carried out on parastatal farms, all other studies were carried out on smallholder farms.

5.1.3.2 *Milk production from goats*

There is a steadily growing population of dairy goats in Tanzania and a recent estimate of pure exotic breeds and their crosses is 1500 (Mtenga and Kifaro 1993). These goats are concentrated in Arusha, Kilimanjaro and Morogoro regions. The main breeds are Toggenburg, Aglo-Nubian, Alpine, Saanen, Norwegian and their crosses. The first four breeds and their crosses are promoted by HPI, Farm Africa and various church groups, while Norwegians and their crosses are promoted by Dairy Goat Project at SUA. Dairy goat production is seen as a suitable low cost and low risk alternative to cattle, especially for resource poor farmers (RPF) in areas of intensive land use with limited feed resources. Milk yield from dairy goats has been reported with a large variation by various authors. Mtenga and Kifaro (1993) reported a mean daily yield of 1.1 litres, Kiango (1996) 0.87 litres and recently Jähnig (1996) 1.5 litres. There is no data on milk production from local goats.

5.1.4 Policy and institutional issues regarding the dairy sector in Tanzania.

5.1.4.1 *The effect of liberalisation on the dairy sector*

Until the late 1980s, dairying in Tanzania was taken as a task for specialised dairy farms and a few rich farmers. The running of the whole agricultural sector was governed by the socialist ideology put forward through the Arusha Declaration of 1967. During this period it was not possible to make a profit even in dairying, as prices of both inputs and products (including milk) were set by the government and not by market forces. As a result of this, the development of the dairy sub-sector was very slow. In the late 1980s, the government embarked on a liberalisation policy that was imposed by the Structural Adjustment Programme (SAP). Liberalisation aimed to promote private sector participation in organising and directing the national economy through market signals. Following liberalisation, private sectors, farmer organisations and co-operatives emerged and formed the informal sector in milk marketing as opposed to the public sector which was under Tanzania Dairies Limited (TDL). The informal sector proved to be more efficient than the public sector, which had previously been handling and controlling milk prices. As part of the informal sector, some small businessmen started to go around the villages using bicycles buying milk which they sold in towns at high prices. High prices and the reliability of this form of milk marketing made more farmers aware that dairying was attractive and could give quick cash income. This awareness was followed by a marked increase in dairy cattle keeping both in the rural and peri-urban areas (Mlozi, 1995; 1996).

However liberalisation also had some negative effects in the dairy sector. In parallel with liberalisation, the private sector did not take control over all aspects contributing to the smooth running of dairying. Extension services remained the task of government. Veterinary and AI services were being privatised at a very slow pace, and both veterinary and AI services became scarce or only available at a very high cost (MoAC/SUA/ILRI, 1998). According to the farmers interviewed during the PRA field studies, the private individuals who engaged in supply of feed inputs, especially concentrates, were not trust-worthy and sold substandard feed. Unfortunately, policy makers did not establish a quality control system to check and enforce standards for inputs supplied by the private sector.

5.1.4.2 *Farmer organisations and the growth of the smallholder dairy sector*

Liberalisation and milk marketing problems in dairy areas, especially in the North, triggered the formation of farmer dairy groups. Two farmer groups in Northern Tanzania, Nronga and Ng'uni Women's Dairy Co-operative Societies, were established in 1987. These farmer groups facilitated collection of milk (from members) and its transportation to towns where higher prices prevailed. The groups were mainly "women's dairy groups". Women formed the groups since milk was considered to be the property of women, and women retained the cash obtained from milk sales. The groups created awareness among rural farmers that dairying could give rapid and reliable household cash income. Formation of farmer dairy groups promotes growth of the dairy sub-sector in the rural areas.

Rapid growth in dairying was also observed in the urban and peri-urban areas in 1990 to 1996 (Figure 2). Urban agriculture, and especially the keeping of dairy cows, is now undertaken by people of all socio economic classes (Mosha, 1991; URT, 1991a; Sawio, 1993; Mlozi, 1995; 1996). This demonstrates the importance of milk production, and suggests that the business is profitable in urban and peri-urban areas. Studies on the economics of dairying in rural areas have been limited to milk marketing (Mdoe, 1993b) with little attention to the economics of milk production *per se.*

5.1.5 Constraints to increased milk production from the smallholder sector.

There is a large amount of literature indicating that the main constraint to increased livestock production, and particularly milk production, in the tropics is inadequate nutrition (Preston and Leng 1987; ILCA, 1990; 1991; 1994; Abate *et al.,* 1992; McIntire *et al.*, 1992; Osuji *et al.,* 1993; ILCA, 1994; Preston, 1995; ILRI, 1996; 1997). In the tropics, both native and introduced pastures are the principal feed resources for ruminant animals, and are complemented by crop residues and by-products. With the exception of improved pastures used by farmers practising zero grazing, native pasture and crop residues are seasonal and tend to be of low quality. The biosciences research program of ILRI has addressed improved feeding strategies leading to increased livestock production in the tropics and much has been done towards the development of fodder banks (ILRI, 1997; Elbasha *et al.,* 1999). Despite these efforts to address improved feeding strategies, there appears to have been little uptake and use of the improved technologies by farmers (Kidunda *et al.*, 1990; Ehui and Shapiro, 1995).

In Tanzania, forage is the main feed resource for ruminant animals in the traditional smallholder farms. Many studies (Kitalyi, 1982; Mbwile and Wiktorsson, 1982; Lwoga, 1985; Urio and Mlay, 1985; Mero and Uden, 1990; Kimambo *et al.,* 1990; Kitalyi, 1993; Mbile, 1991; 1994; Komwihangilo *et al.,* 1993; Shem, 1993; Mwilawa *et al.,* 1993; Mlay, 1994; Sarwatt, 1995, Urio *et al.,* 1995) have investigated ways of improving forages for increased livestock productivity. Many BSc special projects, MSc dissertations and PhD theses addressing forage production and utilisation are available at Sokoine University of Agriculture (SUA) in Morogoro. However, Kidunda *et al,* (1990) reported that few new technologies have been adopted by farmers. It therefore follows that constraints to increased milk production on smallholder farms remain unsolved. Apart from inadequate nutrition, Kinsey (1993) noted that there are other dairy husbandry factors that may constrain increased milk production such as poor housing, poor hygiene, poor disease control and poor breeding management.

5.1.6 Research on forage production and forage utilisation in Tanzania.

5.1.6.1 *Forage research before 1982.*

Research in Tanzania to increase ruminant productivity through the use of improved forages started in the early 1930s (French, 1941; Kusekwa, 1990; 1994; Mbwile, 1994). A review of research highlights in this subject by Kusekwa *et al.,* (1993) showed that until 1982 work concentrated on grasslands and large scale farms. This was mainly because during the pre-independence (pre-1961) and post independence periods (1962 –1982) the main aim of agricultural research was to enhance the production of export-oriented products and there was little or no attention given to subsistence food and livestock products. During this time, pasture and forage research provided information on vegetation communities, classification, adaptation, productivity, nutritive value and determination of grazing systems on range-lands and sown pastures. Much of the research was therefore not suitable for adoption by smallholder farmers.

5.1.6.2 *Pasture and forage research policy after 1982*

The year 1982 was a turning point in the research programme for pasture and forages in Tanzania. In this year, the Government changed its policy and decided to shift emphasis from addressing problems of the large-scale farming industry to small-scale livestock production because it represented the majority of ruminant animals in the country (MALD, 1983; Kusekwa *et al.,* 1993). Under the new policy, research institutions were required to conduct research that would incorporate indigenous technical knowledge (ITK) into research and solve smallholder farmer production constraints. Researchers were urged to shift the emphasis from basic research to adaptive research and from on-station to on-farm in order to increase adoption.

5.1.6.3 *Problems in the implementation of the 1982 research focus to smallholder farms*

Although the idea of changing research emphasis from addressing problems of large-scale farms to smallholder farmers was sensible, and was expected to impact positively on the smallholder livestock sector, implementation was faced with a number of problems and was affected by other policies formulated on socialistic ideology that was designed to transform the rural agricultural sector (ESRF, 1997). These policies carried strong political slogans such as *"Siasa ni Kilimo"* (Agriculture needs a political thrust), *"Kilimo cha Kufa na Kupona"* (Agriculture is a matter of death and survival) and *"Mvua za kwanza ni za kupandia"* (the first rains are for planting). These slogans did not contain specific technical messages for either farmers or extensionists. However, extensionists (as government employees) were supposed to serve the interests of the employer and ensure that farmers implemented the slogans.

Implementation of the change of emphasis (after 1982) was also affected by the fragmentation of agricultural research, frequent changes of organisational structure and frequent transfer of research staff between research institutions (Shao, 1992).

A major organisation change in 1982, with implications for development and use of pasture and fodder research, was the formation of two parastatal bodies, the Tanzania Agricultural Research Organisation (TARO) and the Tanzania Livestock Research Organisation (TALIRO). TARO engaged in crop research and TALIRO in livestock research. Between 1982 and 1986 the two bodies were also operating under different ministries (TARO under the Ministry of Agriculture and TALIRO under the Ministry of Livestock Development) making the whole idea of crop-livestock integration difficult. The two bodies did not make any significant impact on research development (Shao, 1992) especially on smallholder farms, and were therefore dissolved in 1987. All research activities, previously conducted by TARO and TALIRO were transferred for co-ordination by the Department of Research and Training (DRT) under MoAC. Very recently another major re-organisation took place and the DRT was transformed to the Department of Research and Development (DRD). From the former DRT, the training section was removed to form an independent department under MoAC. In the same re-organisation, the agricultural extensionists were removed from the Department of Agriculture and Livestock Development in the Ministry of Agriculture and placed under Local Governments, with a very weak linkage with the agricultural research system. This re-organisation was partly enforced by the World Bank, which is currently financing the agricultural research and extension systems in Tanzania under TARP II and NAEP II respectively.

These frequent changes have had deleterious effects on technology development and transfer. In reviewing agricultural research and training in Tanzania, Shao (1992) and Bevan *et al* (1993) characterised the research as oversized, uncoordinated and lacking defined research priorities. Bevan *et al.* (1993) further commented on ineffective management and supervision, low staff morale due to poor training and low pay, and the lack of a system for providing feedback from farmers to researchers and policy makers.

5.1.6.4 *Lessons from the review on the research policy implementation*

It may be concluded that lack of adoption of improved technologies by smallholder farmers is not a fault of the farmers, but a fault of the system of research development and dissemination. Policy makers seem to override and influence the research and extension systems with little consideration of farmers views. The complexity of the system is compounded by lack of funding and the need to comply with donor interests, some of which appear to have little interest in helping the real farming situation (Shao, 1992). In reviewing approaches to research, Kurwijila (1993) stated that the process of problem identification should constitute part of the research spectrum and categorise constraints into technical, institutional and policy before embarking on research.

Because of the contractual agreement with the sponsor, DFID, the scope of the present study is limited to the technical part of technology development and adoption in the field of forage production and forage utilisation.

5.1.6.5 *Review of technical research on forage production and utilisation*

The first step of the present study was to review 'grey literature' on forage production and forage utilisation in Tanzania. This included published and unpublished research. The objective was to establish a base of available technical resources before investigating with farmers what they are practising on their farms. The review revealed a large amount of published and unpublished local research on pasture and forage. The literature was categorised for period when undertaken, whether carried out on-station or on-farm, what type of farmers were targeted (large or small), forage type, feeding system addressed (grazing, tethered grazing or stall feeding), type of animals used, and whether linking forage, milk production and economics.

A total of 114 research and 11 survey works (Table 8) carried out between 1941 and 1996 were reviewed. Out of the total number, only 6 were reported before 1980, 39 were in the 1980s and 69 in the 1990s.

Table 8. *Summary of reviewed local research on forage production and forage utilisation carried out in Tanzania between 1941 and 1996*

Type of study	Number reviewed	Number considering smallholder	Number considering economics	Linking forage, milk & economics	
				Production	Socio-economics
On-station	103	39	11	7	9
On-farm	11				
Survey[1]	11		6		
Total	125	39	17	7	9

[1] Survey based studies are presented in Table 9

The sources included annual and progress reports from research stations under the Department of Research and Training (DRT) in the Ministry of Agriculture and Co-operatives (MoAC), BSc. (Animal Science and Production and Rural Economy) special project reports, MSc. dissertations and Ph.D. theses published at Sokoine University of Agriculture (SUA) and papers presented in conferences.

Of the 103 on-station studies shown in Table 8, 56 originated from SUA, 26 from Livestock Production Research Institute (LPRI) Mpwapwa, 11 from UDSM (before the Faculty of Agriculture, Forestry and Veterinary Science became the present SUA in 1984), 5 Livestock Research Centre (LRC) Tanga, 2 from Ministry of Agriculture Research and Training Institute (MARTI) Uyole, 2 from MARTI Tengeru and one from MARTI Ukiriguru in Sukumaland (Mwanza).

The studies involving forages were categorised into grasses, legumes, crop residues, whole crop and multipurpose trees, and totalled 108 studies. Of these 108 studies, 64 involved grass of which 2 involved grazing, 4 grazing with cut and carry, 3 tethered grazing, 16 cut-and-carry, 11 hay/standing hay (one grazing standing on hay), 2 silage, 3 silage and hay while 23 were not specific. Twenty-seven studies were reported to have involved leguminous forage of which, 2 involved grazing, one grazing with cut-and-carry, 6 cut-and-carry, 3 hay, 2 silage and 13 were not specific. Thirty-three of the publications involved crop residues; of these 10 involved maize stover, 6 bean straw, 2 rice straw, 2 on maize stover and sorghum stover, 2 on sorghum stover and bean straw, 2 on maize stover, rice straw and wheat straw and 9 were on mixed crop residues (banana leaves, sugar cane tops and wheat straw). Six studies reported whole crop silage, 2 involved maize alone, 3 maize and sorghum, and one on sorghum and pearl-millet. Multipurpose tree forage was reported in 23 studies of which 11 involved *Leucaena spp*, 5 involved *Leucaena spp* and other trees, one *Sesbania spp* alone and 6 studies were on local trees and shrubs.

The local literature showed that 90% of publications (103 out of 114) involved on-station studies; only 4 involved both on-farm and on-station studies. The on-station studies were mainly 'basic' research aimed at generating knowledge on chemical composition and nutritive value (51), digestibility and degradability (47), intake, selectivity and supplementation (34), forage DM yield and agronomic measures (36). Twelve publications considered the influence of feed on the animal product (5 on milk production and 7 on meat production - growth). Also, twelve studies considered chemical treatment of low quality forage such as crop residues. Physical treatments such as chopping or pelleting were not investigated in any of the publications.

Forty-four publications specified the farm size aimed at; 39 specified small-scale farming and 5 large-scale. Seventy of the publications did not indicate scale.

Out of 54 publications which involved the use of animals in forage evaluation or utilisation, 20 involved cattle, 12 goats, 13 sheep, 6 sheep and goats and 2 goats and cattle and 1 cattle and sheep. Two publications used rabbits.

Twenty-six of the publications considered the animal product of which 16 were on milk (nine of them were on socio-economics and marketing) and 10 on meat. Manure or animal power was not mentioned in any of the publications, indicating the low priority given by researchers to these animal products despite their importance in crop-livestock interaction.

Economics was only mentioned in 11 (about 10%) of the 114 publications reviewed. The economic aspects emphasized costs (such as feed) and marketing of the product. Nine publications that considered milk, were on socio-economics and marketing. No publication evaluated forage production costs in relation to milk output and returns and hence there was no evidence of economic evaluation of milk production.

5.1.7 Survey-based studies.

The survey-based studies reviewed were only those carried out in the three study areas of the present project (Kilimanjaro, Morogoro and Mwanza). Table 9 shows a list of 11 surveys carried out in the target study areas. This information was generated by studies at SUA and the NFSRP under the DRT. The surveys presented in Table 9 identified researchable issues on forage utilisation and milk production. All but one of the surveys was undertaken between 1986 and 1996. Of the 11 publications, 9 suggested forage improvement as a researchable issue; one suggested milk marketing and one linkage. It is notable that all the investigations were of a diagnostic nature. Only one of the studies (Jähnig, 1996) involved a PRA approach.

Table 9. *Survey-based studies carried out in Kilimanjaro, Morogoro and Mwanza study areas*

Author, year & sponsor	Location	Approach		Title	Researchable issues identified in the report
		Diagnostic	PRA		
Brandstrom, 1976 **	Mwanza (Sukumaland)	Xx		Livestock development in Mwanza Region	Marketing of surplus milk in rural areas
Mlay, 1986 **	Hai (Arusha / Kilimanjaro)	Xx		Use of diagnostic surveys in directing on-farm research: The experience of the smallholder dairy feeding systems project	Investigate cost implications of baling crop residues and large scale transportation of bales to utilisation areas. Improving nutritive values of crop residues
Urio, 1986 **	Hai (Arusha / Kilimanjaro)	Xx		On-farm research on utilisation of crop residues by smallholder dairy farmers in Hai District, Tanzania	Exploit all feed resources available on farm, and incorporate them in on-farm feeding trials
Moulton 1988,**	Mgeta (Morogoro)	Xx		The potential for dual purpose goats in the village of Nyandira, Tanzania.	Testing of developed hypothetical models for sustainable dairy goat production
Sendalo *et al.,* 1993 NRI/ODA	Mgeta (Morogoro)	Xx		Tethering of small ruminants in Tanzania: The case of Morogoro District	Effect on intake and production of differing time goats are allowed to graze during tethering
Mdoe, 1993a**	Hai (Arusha / Kilimanjaro)	Xx		Smallholder dairy production and marketing of milk in Hai District, Tanzania	Improving nutritive value and reduce transportation costs of crop residues
ICRA-SARI, 1992 ICRA	Hai (Arusha / Kilimanjaro)	Xx		Coming down the mountain: A study on the agriculture on the slopes of Mount Kilimanjaro	Feed quantity and quality for dairy cattle
Ngendello, 1994a & b TNFSRP,1994	Kwimba (Sukumaland)	Xx		Informal Livestock Survey in Kwimba District	Use of crop residues as supplements to oxen and milking cows of farm
Budelman, 1996 TNFSRP, 1994	Kwimba (Sukumaland)	Xx		In search of sustainability	Development of information centre for farmers
Jähnig, 1996 The University of Reading[1]	Mgeta (Morogoro)		Xx	Production of East African Goats, and Norwegian Crosses in the Uluguru Mountains in Tanzania: A farmers' perspective on Feed Resources and Feeding System	Planting fodder of high nutrient density is recommended and appears to be compatible with the farming system. However more studies and solution to farmers' reluctance to planting fodder are needed.
Kiango, 1996 NORAD	Mgeta (Morogoro)	Xx		Studies on factors affecting performance of dairy goats and socio-economic aspects of dairy goat production in Tchenzema and Dareda wards in Tanzania	Establishment of grass/legume forage to save as supplementary feed and reduce dependence on high cost concentrate feeds

Key: ** = Sponsor not indicated

[1] This study was in collaboration with the present project

5.1.8 Research-extension-farmer interface in Tanzania

5.1.8.1 *The state of agricultural research in Tanzania.*

As in many other developing countries, agricultural research in Tanzania is vested in the National Agricultural Research System (NARS). The NARS is comprised of the Department of Research and Development (DRD) of the Ministry of Agriculture and Co-operatives (MoAC), the Tropical Pesticides Research Institute (TPRI), the Sokoine University of Agriculture (SUA), the University of Dar-es-Salaam (UDSM) and a few private cash-crop estates (Kirway, 1995). Within MoAC, the research is carried out in various research institutes located in 7 zones. Pasture and forage research has been mainly the responsibility of Central Zone at LPRI Mpwapwa and PRC Kongwa. These two stations, both located in the semi-arid areas, were required to develop improved forage production and utilisation technologies for the whole country.

5.1.8.2 *Dissemination of agricultural research findings.*

Ehui and Shapiro (1995) pointed out that although research may provide good technologies to help achieve productivity increases, technology needs to be transferred to farmers to ensure impact. Communicating research findings to farmers has to be done through the agricultural extension services. According to Chaudhry (1978), there are four types of extension services operating in the world. These are:-

i) Public sector extension services
ii) University extension services
iii) Co-operative extension services and
iv) Voluntary extension services

Tanzania mainly has public sector extension services. The government, through the Ministry of Agriculture and Co-operatives (MoAC), finances these services. Under the MoAC, the extension department operates independently of the research department. This institutional set-up may have an implication for research technology development and transfer to farmers.

In analysing the agricultural and policy environment in Tanzania, Bevan *et al.* (1993) stated that the agricultural extension service suffered from deficiencies of low funding, poor scheme of service, ineffective management, low research inputs, poor marketing, poor input supply and lack of credit. The authors concluded that agricultural research and extension in Tanzania was weak and poorly organised.

Muhamed (1983) analysed the agricultural extension set-up in developing countries and concluded that most systems need major changes in their institutional set-up for them to be effective in disseminating knowledge to the farming community. In suggesting strategies for transfer of improved technology to farmers of different size and tenure categories, Naseem (1978) suggested three options which might be involved: institutional reforms; structural change and transformation of attitudes. The institutional reforms should strengthen the agricultural extension services and institutionalise the credit supply system. The credit delivery system in Tanzania is complex. Most farmers lack working capital. Institutional reform enabling the availability of credit to smallholder farmers might result in much more uptake of improved technologies.

5.1.8.3 *Existing linkages between research, extension, farmers and various NGOs.*

The need for strong linkages between research and technology transfer agencies, and especially extension, has always been acknowledged by the Government of Tanzania (URT, 1983, URT, 1991b). Donor-funded projects (*e.g.* National Agricultural and Livestock Research Project (NALRP); National Agricultural and Livestock Extension Rehabilitation Project (NALERP)) also stressed the importance of such linkages (World Bank, 1988, 1989). The Project documents of both NALRP and NALERP stated that linkage would be based on four main areas:

i) Common decision by the research and extension services on the types of farmer problems to be solved by research.

ii) Methods of communicating research to extension workers.
iii) Extension workers feeding back to research on any additional field problems reported by farmers.
iv) Research scientists trying to solve farmer problems by addressing feed back from extensionists.

However, missing in the above was the involvement, and roles of NGOs and farmer representatives in the research technology development and transfer process. Ehui and Shapiro (1995) emphasised the need to include international organisations and NGOs in the process of research technology development and transfer. Weak linkages may result in duplication of work, and misuse of resources. Kirway (1995) pointed to the weak linkages among the various actors in the research/extension farmer interface in Tanzania. Kirway (1995) attributed the weak linkages to inadequate funds to support and sustain linkages (i.e. funding workshops and conferences), insufficient time to communicate with other linkage partners, and to some extent, linkage partners trying to protect their "territories" by fulfilling just their project objectives and therefore avoiding outsider interference.

5.1.9 Participatory Rural Appraisal (PRA)

5.1.9.1 *Definition of PRA.*

Theis and Grady (1991) defined PRA as an intensive systematic, but semi-structured learning experience carried out in a community by a multidisciplinary team, which includes community members. Chambers (1992) added that the predominant mode in PRA is facilitatory and participatory in nature, with outcomes focused on the empowerment of the local people. In analysing the definition of PRA, Webber and Ison (1995) pointed out that it is usually unclear what is meant by community, participation and learning experience. These three key words, focus attention on how, in the process design of a PRA, interpretation of data is managed, the purpose of such analysis and who is involved. According to Ison (1993), community simply mean "a state of being held in common" and in the context of local people, sharing a social and physical environment and similar interests. The more debatable term is participation. Burkey (1993) called it a 'catchword' within the field of development theory and policy. Burkey (1993) further pointed out that the first step in achieving genuine participation is a process in which rural people themselves become more aware of their own situation, i.e. the socio-economic reality around them, their real problems, the cause of these problems and what measures they themselves can take to begin changing their situation. Chambers (1992) noted that PRA is intended to enable local people to conduct their own analysis and often to plan and take action. As from 1995, the term PRA has been used interchangeably with participatory learning and action (PLA) and both Institute of Development Studies (IDS) and IIED (International Institute for Environment and Development) are now updating most of the PRA and RRA notes and manuals to PLA notes and manuals (Chambers and Guijt, 1995).

5.1.9.2 *Evolution of PRA.*

According to Chambers (1994) PRA has many sources, but the most direct is rapid rural appraisal (RRA) from which it has evolved. RRA itself began as a response in the late 1970s and early 1980s to the biased perception derived from the brief rural visits by the urban based professionals (Chambers referred to this as rural development tourism) and the many defects and high costs of large scale questionnaire surveys. As PRA has evolved from RRA it has much in common with RRA, but differs basically in the ownership of information and the nature of the process. In RRA, information is more extracted by the researcher as part of the process of data gathering, but in PRA, the information is generated, analysed, owned and shared by local people as part of a process of their empowerment (Chambers, 1994).

5.1.9.3 *Tools and techniques of PRA.*

PRA makes use of a wide range of tools and techniques. Theis and Grady (1991) listed 36 different tools and techniques which can be used in conducting a good PRA study. However, the authors pointed out that any given PRA will not necessarily use all of the techniques listed.

Chambers (1994) noted that the more developed and tested methods of PRA include participatory mapping and modelling, transect walks, matrix scoring, well-being grouping and ranking, seasonal calendars, institutional diagramming, trend and change analysis, flow and causal diagram and analytical diagramming. Some PRA tools are suitable for data collection (e.g. direct observation, secondary data review, semi- structured interviews and photographs) while others are better for data analysis (e.g. analysis group discussions, innovation assessment, livelihood analysis). Other tools are suitable for both (e.g. social mapping, ranking, construction of diagrams). It is important to note that the best PRA tools are those that should allow full involvement of the local people. It is therefore a duty of the PRA team to select the most appropriate and useful set of techniques each time a PRA is done.

5.1.9.4 *Principles, attitudes and behaviour in using PRA.*

In order to have truly participatory work, a set of PRA principles, attitudes and behaviour were developed for adoption by outsiders to a community. IDS (1996) compiled a pack aimed at giving a reader an overall appreciation of PRA. In this pack, principles, attitudes and behaviour were discussed; and all were considered to be important throughout any PRA process. The main principles of PRA are summarised in Table 10. The key elements include openness, sharing, flexibility and cross-verification of information.

Table 10. *Main principles of PRA*

Principle	Key elements of the principle
1. The right attitude	• Openness • Curiosity • Acceptance • Sensitivity
2. The right behaviour	• Sharing • Being friendly • Showing respect • Listening carefully • Avoid lecturing • Embracing errors • Being neutral • Encouraging
3. Flexibility and innovation	• Not making the method rigid
4. Triangulation	• Cross verification of information • Diversity of analysis
5. Optimal ignorance	• Avoid collecting unnecessary data
6. Appropriate impression	• Accept a degree of inaccuracy

Source: IDS (1996)

From Table 10 it would seem that “curiosity” and “avoid collecting unnecessary data” are contradictory. It may be difficult for the investigator to judge how much information would be needed to be curious. Curiosity may result in finding out more than the required information.

Ways of dealing with such contradiction would be for the PRA team to use its own best judgement and strike for a balance.

5.1.9.5 *The limitations of PRA.*

Chambers (1992) wrote, "*PRA has much potential, but is not an answer to all rural development and community problems. The methodology has limitations, which must be recognised and addressed if unrealistic expectations and early disappointments are to be avoided.*" Chambers (1992) further described some of the more common limitations as:-

i) "Initial investment of time and resource in training the practitioners. This may cause impatience among donors, politicians and villagers when there is a delay in tangible benefits. PRA needs patience.
ii) PRA could be discredited by over-rapid adoption and misuse, hence calling every development intervention with local people as "PRA" while in actual fact there is no active involvement of local people in decision making and planning.
iii) Rushing and lack of commitment to follow-up may lead to compounding of errors and miss the participation of the poorest as they are neither seen, listened to, nor learnt from. PRA needs true commitment.
iv) Unlike formal surveys where there is a standardised format often for a required statistical analysis and quality, PRA needs to allow a wide flexibility and informal learning from the local people.
v) Dominance from the practitioners or local elite may destroy the quality of the PRA. If there is no empowerment and real handing over of the stick, then PRA remains just a label."
vi) Despite the above limitations, institutions ranging from small NGOs to UN agencies have become interested in participatory methodologies for research and extension (Cornwall and Jewkes, 1995).

5.1.9.6 *PRA versus other research methods.*

Theis and Grady, (1991) wrote, "*PRA techniques compliment, and in many cases substitute for other research methods, but do not make redundant more formal and detailed surveys and analyses.*" The choice of methods for research depends on the kind of information required and on the availability of resources. When accurate quantitative data are required, coupled with sophisticated statistical analysis, PRA is not as good as formal survey techniques. However, when the objective is to learn from community members, their attitudes and opinions, PRA is the best method. Shanley *et al.* (1997) reported that the utility of PRA is high when used in conjunction with other more quantitative methods.

It is interesting to note that the rapid interest in PRA methodology among donor agencies, has influenced recipient governments and research organisations to adopt PRA. PRA is therefore spreading fast and becoming more mainstream. The fast spread of PRA is reducing the use of the conventional research methods i.e. questionnaires and surveys. Chambers and Blackburn (1996) warned that because of the rapid uptake of PRA, there were dangers of scaling up its use too quickly, and in the process there were risks of PRA being discredited.

5.1.9.7 *PRA in livestock related research.*

While there is a large number of references indicating a wide use of PRA techniques in the fields of anthropology, community development, health, agroforestry, environmental conservation and gender analysis, in agricultural studies use of PRA has largely been in farming systems with emphasis on crops. Farrington and Martin (1988) noted little use of PRA methodology in livestock research. Recently, Bennison *et al* .(1997) reported use of PRA in the Gambia to investigate feeding strategies of ruminant-livestock owners and implications for policy makers. Loc *et al.* (1997) reported a PRA survey of pig production and farm feeding trials with protein supplementation of traditional diets in Vietnam. These recent publications of Bennison *et al.* (1997) and Loc *et al.* (1997) indicate that PRA methodology is beginning to be used in livestock research.

5.1.10 Summary of major issues from the literature review

- Milk production in the smallholder sector in Tanzania is below the potential that could be achieved through the use of forage alone as demonstrated in Kenya.

- The main constraint to increased livestock production and in particular milk production, is adequate nutrition. However, there is no research that has attempted to investigate why this constraint persists in the tropics.

- There is a large volume of local unpublished research on pasture and forage utilisation, but the information is of restricted access (e.g. dissertations and theses at the SUA, and filed reports in the NARS institutions). Furthermore the information is presented in technical language difficult to grasp by farmers and extensionists. Also, there is a lack of economic evaluation which would be needed by extensionists.

- During the past 15 years the agricultural research system in Tanzania has been unstable with frequent changes in organisation structure. This has interrupted progress in research programmes, including that of pasture and forage production.

- There are weak linkages between researchers, extensionists, farmers and other stakeholders working for the development of farmers.

- The agricultural extension system, which is the major organisation for disseminating research findings to farmers in Tanzania has suffered deficiencies of low funding, poor scheme of service for staff, ineffective management, low research inputs, inadequate marketing, low input supply and lack of credit. The system has therefore failed to solve farmers' production constraints.

- In Tanzania, there have been a number of 'political slogans' that were associated with the socialistic ideology and were passed to farmers in the rural areas for implementation. These slogans did not contain clear technical messages. Furthermore they interfered with the dissemination of technical messages because extensionists were pre-occupied with advocating the political slogans instead of extending technical messages.

- The PRA methodology is a good tool for understanding the community but it needs to be backed up with other research methodologies in order to obtain statistically quantifiable data.

- PRA as a research methodology is spreading rapidly and there are dangers of its overuse as it is sometimes difficult to fulfil the requirements in terms of triangulation and multidisciplinary team formation.

5.2 OUTPUT 2 FORAGE-FEEDSTUFF RESOURCES AND ECONOMIC CONSTRAINTS ON SMALLHOLDINGS IDENTIFIED.

5.2.1 Objectives of keeping livestock.

The production objectives of those keeping livestock in the three locations are shown in Table 11.

Table 11. *Ranking of the objectives of keeping livestock in the three study locations*

Objective	Location		
	Mwanza (n=26)	Kilimanjaro (n=21)	Morogoro (n=25)
Milk	3	1	1
Meat	Not mentioned	3	4
Manure	2	2	3
Draught power	1	Not mentioned	Not mentioned
Cash income	4	4	2

1 = high 4 = low
n = number of farmers involved in the ranking

The present study considered milk as the target and measurable output for efficient and economic utilisation of forage available on farm. However, the results of the Phase 1 PRA field studies showed multiple objectives of keeping livestock. Milk ranked differently in the three study locations indicating that strategies for using the available feed resources on farm are likely to differ. In principle the farmer would normally offer the best feed to the class of animals which he/she considers is giving the most valued and desired product. In Mwanza, where the objective was draught power, improved feeding strategies have focused on supplementing work-oxen with cotton seed cake (CSC) so as to have good body condition prior to the ploughing season (Ngendello, 1994b). In Kilimanjaro and Morogoro, donor-funded projects have concentrated on improving forage utilisation for increased milk production (Urio and Mlay, 1985; Laurent and Centres, 1990; Kinsey, 1993; Mtenga and Kifaro, 1993).

However, it was observed that some farmers in Mwanza were changing their objective from draught power to milk production. This observation may imply that milk production will become more useful as a measurable indicator for better utilisation of forage in Mwanza location and that suitable feed-utilisation strategies will need to be developed.

5.2.2 Livestock feeding systems and major feed resources.

As indicated previously, the three locations were distinct, had different livestock feeding systems, and different feed resources (Table 12). Accessibility to these feed resources also varied between locations, and between farmers within a location because of the land tenure system and wealth group of the farmers. In Mwanza, where the land was communally owned, communal grazing land was accessible to every farmer. In Kilimanjaro and Morogoro, land was individually owned and individual farmers owned both natural and planted forages on the land in their possession. Use of concentrates depended on cash (working capital) availability. Concentrate was given only to productive animals e.g. in Kilimanjaro concentrate was offered only to dairy cows at milking. In Mwanza concentrate was offered to working oxen.

5.2.2.1 *Extensive grazing on communal land*

The type of livestock feeding systems practised in any location may have an influence on the uptake and use of improved technologies. This suggests that under extensive feeding systems, where the grazing land is accessible to every member of the community, forage utilisation improvements should focus on the grazing land. To be successful, interventions need to be introduced, received and accepted by the community. Steel (1995) commented that communal adoption of technologies is difficult and in most cases has not worked.

Interventions applied to the communal grazing system may lead to a complete change of the livestock feeding system, and may have social implications. Experiences with interventions on communal grazing land to overcome overgrazing and soil erosion in the semi-arid area of Kondoa, in Central Tanzania (Östberg, 1985; Larsson, 1993; Ulotu, 1993), showed that eviction of animals from the area was a necessity. The eviction required government interventions through imposing laws. The result of this a was change in the feeding system, from grazing to stall-feeding. Although changes in feeding system had a positive impact on the environment and on productivity per animal and per land area, the change had a negative impact on the social aspects of the farmers.

Potential technologies for improving pastures in a communal grazing system, might include over-sowing of pasture legumes into natural pastures (Rukanda and Lwoga, 1981; Kusekwa *et al.,* 1993), systematic control of pasture utilisation by grazing animals through deferred-rotational grazing (Rushalaza *et al.,* 1993) and manipulation of stocking rate to match available feed resources (Preston and Leng, 1987). These technologies may be applicable on institutional farms and ranches, but may need major modification before being introduced into smallholder farmers practising grazing on communal land. Preston and Leng (1987) noted that the major problem in helping smallholder farmers practising a grazing system, is how to apply management strategies on communally owned land. Steel (1995) also reported this difficulty.

5.2.2.2 *Stall-feeding system*

Under stall-feeding systems (practised in Kilimanjaro and Morogoro locations) individual farmers are responsible for gathering feed for the animals. Stall-feeding is normally practised in areas with land shortage and where the land tenure is based on individual ownership, as in Kilimanjaro and Morogoro locations. Under a stall-feeding system, interventions for improved forage production and forage utilisation might be focused on an individual farmer or a group of interested farmers. In Kilimanjaro and Arusha regions, where dairying is prevalent and land is scarce, efforts have been made by HPI (Kinsey, 1993) and SCAPA (SCAPA, 1993; Per Assmo and Erickson, 1994) to introduce technologies for increased fodder production on smallholder farms. However, these technologies were introduced only to project farmers in Arusha, Arumeru and Hai Districts. Reports from SCAPA (SCAPA, 1993) showed that there has been a positive impact on Project farmers under the programme. Due to lack of funding and low morale there has been little effort by the extension staff to disseminate similar technologies to other, non-project farmers (Kisaka and Uliky, 1997). In a meeting held with extensionists in Kilimanjaro location it was revealed that the extension messages produced by HPI were not extended to other farmers because the manual was sold and the government did not provide funds to buy such training material. Furthermore, it was revealed that progressive farmers, who were ready to pay were assisted by the extensionists to purchase the extension messages. The system here therefore discriminated against poorer farmers.

5.2.3 Seasonal supply of different feed resources.

In all three-study locations, some feeds were categorised as seasonal and some were non-seasonal though the amount available differed with season. Seasonal and non-seasonal feeds supplies were more evident in Kilimanjaro than Morogoro or Mwanza. This was mainly due to the fact that in Kilimanjaro animals were totally stall-fed and farmers gathered the feed as opposed to Mwanza where the animals were grazed or Morogoro where goats were sometimes tether grazed (Table 12). Farmers in Kilimanjaro were therefore able to categorise more easily between months of forage abundance and months of forage scarcity. Seasonal and non-seasonal forage feeds for Kilimanjaro are presented in Table 13. A detailed investigation of feed supply in Kilimanjaro was carried out with six case study farmers as presented in Phase 3 PRA.

In Phase 1 PRA field studies investigation of seasonal availability of different feed types was carried out by asking farmers to allocate between 0 and 5 bean seeds for each type of feed against the months from January to December. The results from the three study locations are presented in Table 14.

Seasonal feed availability was considered an important parameter in the present study because it influences the development of feeding strategies. Some seasonal feeds such as crop residues could be stored for use in the dry season, provided storage costs were reasonable. Remarkably, during the PRAs in Kilimanjaro location, weeds and roadside grasses were not mentioned as important feed resources. However, a review of past research in the area showed that weeds and roadside grasses represented about 45% of the annual feed used on smallholder farms in Kilimanjaro (Laurent and Centres, 1990). This was confirmed in the detailed case studies carried out later. Weeds are available during the long wet season from (March to June) and are intensively used by farmers. The intensive use of weeds during the weeding period, apart from maximising use of feed resources, also maximises use of labour as the feed is collected by labour used in weeding the banana/coffee on the smallholding.

There are two main problems associated with the use of weeds. Firstly, the use of weeds as feed fluctuates. Weeds are offered whenever weeding is carried out. Since there is no planned sequence for weeding, there is also no planned sequence of offering this type of feed to animals. Secondly, farmers mentioned that feeding of weeds may be constrained by spraying pesticides on coffee. After spraying, weeds obtained from the field within 14 days may be discarded as farmers fear poisoning their animals. On the question of fluctuations in the type of feed offered, recent studies in Kenya (Sanda *et al.,* 1999) reported poor performance of animals when forage type was changed every five days.

5.2.4 Assessment of resource availability in the three study locations.

During Phase 1 PRA field studies the resources available on farm were assessed with farmers (Table 15). In the context of the present study, technology was identified as an important resource in the utilisation of forages to increase milk production. Therefore the resources assessed were land, labour, capital and technology. The PRA team contributed technical knowledge (based on research findings) and the farmers shared their indigenous technical knowledge (ITK) on forage production and forage utilisation e.g. the idea of setting aside a reserved area of land *'ngitili'* to be grazed during the peak dry season in Mwanza.

5.2.5 Identification of constraints to forage production and forage utilisation.

Although the main purpose of the Phase 1 PRA studies was to identify with farmers the constraints to forage production and forage utilisation, the PRA methodology also identified non-forage constraints that had an influence on the use of improved technologies to increase milk production. Linkages between forage and non-forage constraints were identified by use of problem linkage diagrams. These are presented in Figure 3 for Kilimanjaro location. The non-forage constraints were common in all three-study locations.

The identification of non-forage constraints posed some difficulties in trying to confine the investigation to forage related constraints which was the purpose of the Project. The non-forage constraints included lack of credit facilities, shortage of land, high prices of inputs, low prices of agricultural products and poor infrastructures such as roads. These observations gave a clear indication of how complex the smallholder system is and suggested that profitable milk production might not only be a function of better forage utilisation, but also a function of the other non-forage factors acting on the smallholding system.

Table 12. *Major feeding systems, feed resources and human population density in the three study locations*

Parameter	Location		
	Mwanza	Kilimanjaro	Morogoro
Feeding system	Extensive grazing	Stall-feeding	Stall and tether grazing
Pastures	Natural pastures	Improved pastures and natural pastures cut along roadside and valley bottoms	Natural and improved pastures
Crop residues	Maize, beans, sorghum and chick pea	Maize, beans, sunflower and banana based residues	Maize, beans and vegetable based residues
Multipurpose trees	Browsed only during grazing	Both local and improved MPTs cut and stall-fed	Local and some improved MPTs cut and stall-fed to goats
Concentrates	Offered to work oxen	Offered only at milking	Used, but supply limited
Land tenure system	Communal ownership	Individually owned under clanship	Individually owned under clanship
Human population density (person/km^2)	50[a]	650[b]	225[c]

[a] FSR, 1996
[b] ICRA/SARI, 1992
[c] Bhatia and Ringia, 1996; Kiango, 1996

The identified constraints in all three locations, were then brought together in order to see which constraints were common to all or only to some of the study locations (Table 18).

The problem linkage diagram presented in Figure 3 shows that smallholder farmers are operating under a relatively complex and diverse system. Milk production in the smallholdings is not only limited by forage production and utilisation but also by non-forage constraints such as: inadequate extension services; inadequate rural infrastructure; low output prices; high input prices; lack of credit facilities and poor marketing. Most of the non-forage constraints are related to policies and institutions. Furthermore, farmers also mentioned shortage of land and bad weather as constraints. However, these two constraints are beyond the intervention capacity of researchers or policy makers.

The observed complexity of the system in which smallholders are operating may imply that efforts to solve the constraints need to be addressed in a holistic manner by different key actors working for the development of smallholder farmers. Identification of appropriate technology relevant to a farming system is only part of many tasks to be carried out to address the complex problems of the farmers. There is therefore a ‘task environment’ that has to be looked at when considering technologies for adoption by smallholder farmers. Kast and Rasenzweig (1985), as cited by Eponou (1993), defined a “task environment” as the specific forces that influence the decision-making process and the transformation of organisations within a particular system. In an agricultural technology system, the key elements of the task environment that affect the linkages between research, extension and farmer are policy, structure of the farming system, and donor involvement (Eponou, 1993). In this context, it is worth noting that in developing countries, donor involvement has dominated the ‘task environment’ and influenced the decisions of the policy makers. Unless donors adopt a farmer-focused approach to constraint identification and a long-term approach to implementation, farmers are unlikely to benefit.

Table 13. *Categorisation of forage feeds to seasonal and non-seasonal in Kilimanjaro*

Feed type	Seasonal	Non-seasonal
Planted fodder		
Napier grass *(Pennisetum purpureum)*		✓
Setaria *(Setaria splendida)*		✓
Guatemala *(Tripsacum laxum)*		✓
Native fodder		✓
Banana leaves		✓
Banana pseudostems		✓
Maize stover	✓	
Bean straw	✓	
Local MPTs used for feeding animals		
Mkuyu *(Ficus spp)*		✓
Avocado *(Persea americana)*		✓
Mfurufuru *(Croton macrostachuys)*		✓
Marie *(Bridelia micrantha)*	✓	
"Mfifina" *(Commiphora zimmermanni)*	✓	
"Mandandava" (Botanical name was not available)	✓	
Msanje *(Albizia spp)*		✓
Kawilia *(Grevillea robusta)*	✓	
Masale *(Dracaena alfromontana)*		✓
Mshamana *(Maraganitania discoides)*		✓
Makemgera *(Commelina beghalenses)*	✓	

5.2.5.1 *Constraints identified in **Mwanza** location*

Forage and forage related constraints identified in Mwanza location are presented in Table 16. The constraints were mainly related to the communal grazing system and the number of animals kept. Farmers in Mwanza location perceived losses of forage (both native pastures and crop residues) due to trampling to be a major constraint to forage utilisation.

In the Phase 1 PRA field studies, some villages that were visited prior to the selection of the target village (Iteja) were found to keep improved dairy cows. These cows were distributed by a World Food Programme (WFP) Project which is trying to boost milk production in Sukumaland through the use of improved breeds. Farmers under the WFP project were civil servants or retired officers and hence fairly rich compared to the rest of the community. These farmers were not considered in the present study.

5.2.5.2 *Constraints identified in **Kilimanjaro** location*

In Kilimanjaro location the identification of constraints was carried out by using a problem linkage diagram. Farmers were asked to list constraints to profitable milk production in their location. Farmers then listed both forage and non-forage constraints related to profitable milk production. Each of the listed constraints was written on a piece of paper and the papers were placed on the ground. Low milk production and low household income were written by using a red marker pen to indicate that the constraints were leading to them. Farmers were then asked to link the constraints by using sticks and show how they were related to low milk yield and low household income. A problem linkage diagram was then produced as shown in Figure 3. The use of problem linkage diagrams helped to analyse the problem, cause and effects. Some of the problems, such as shortage of land and bad weather, were beyond the capacity for intervention by either researchers or policy makers.

Table 14. *Scoring of seasonal forage feed availability in the three study locations[1]*

Forage type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mwanza (n=17)												
Grazed grasses[2]	3	3	5	5	4	3	1	1	0	0	1	2
Rice straw	0	0	0	0	0	0	3	4	0	0	0	0
Maize stover	0	0	0	0	0	0	1	2	5	0	0	0
Chick pea residues	0	0	0	0	0	0	0	3	5	0	0	0
Sorghum stover	0	0	0	0	0	0	1	2	5	0	0	0
Kilimanjaro (n=21)												
Maize stover	0	1	0	0	0	0	0	3	5	2	0	0
Bean straw	2	3	0	0	0	2	5	3	1	0	0	0
Napier grass	1	2	2	3	5	3	3	2	2	2	3	2
Guatemala	1	2	2	3	5	3	3	2	2	1	1	2
Setaria	1	1	2	3	4	3	3	2	2	1	2	2
Marie	0	0	0	5	5	5	5	5	3	1	0	0
Mfifina	0	0	0	4	5	5	4	3	3	1	0	0
Mandandava	0	0	0	5	5	5	5	3	3	1	0	0
Makengera	0	0	3	5	5	4	3	0	0	0	0	0
Morogoro[3]												

[1] The scores assigned 0 for none and 5 for abundant.

[2] In Mwanza location farmers indicated that the grazing land was almost empty in September and October and animals were moved away to areas around Lake Victoria. Working oxen and a few lactating cows were left behind to graze on reserved areas (*ngitilis*).

[3] Farmers in Morogoro did not show a marked seasonal feed availability, but they pointed out a problem of diarrhoea associated with lush pastures during the rainy season. Feed shortages were caused by land occupied by crops. This meant a limit on the area for tethering and restricted access to grazing via crop-growing field.

The high cost of inputs was one constraint, this included both veterinary drugs and concentrates. It was suggested that the problem with concentrates was compounded by unregistered businessmen adding filler material e.g. ground maize cobs. There were no registered companies which could reliably supply genuine inputs to farmers, and at a reasonable prices.

Table 15. *Relative resource availability in the three study locations*

Location	System of keeping livestock	Resource			
		Land	Labour	Capital[1]	Technology
Mwanza	Extensive grazing	Medium	High	Tied up in livestock	Low
Kilimanjaro	Stall-feeding	Low	Medium	Low	Medium
Morogoro	Stall-feeding to tether grazing	Low	Medium	Low	Medium

[1] Farmers' understanding of capital was based mainly on availability of hard cash (working capital). Farmers did not view farm asserts like animals as capital. The confinement of capital to hard cash may therefore contribute to the ranking of this resource as low in all study locations.

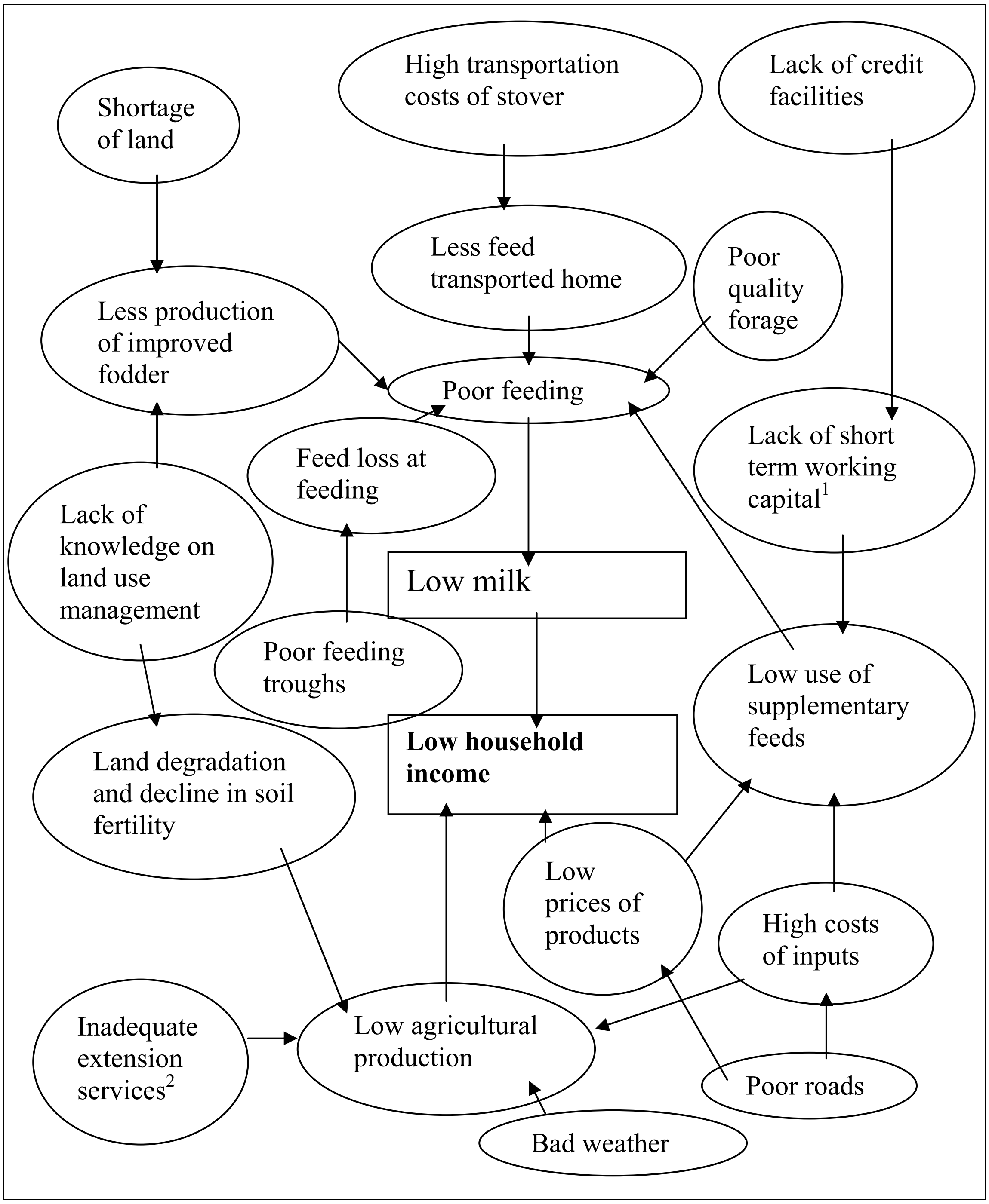
Table 16. *List of specific constraints identified in Phase 1 PRA field studies in Mwanza location*

1. Multiple objectives of livestock keeping. Milk not first priority, so farmers reluctant to invest too much time, effort or money on milk production. Draught power was the first priority, followed by milk and manure.
2. Large herds perceived to discourage storage of feeds for dry season feeding. Farmers claimed that stored feed would last only for a day or two. Also large herds difficult to manage if feeding stored feed during peak of forage scarcity in dry season.
3. Crop residues were grazed *in situ,* resulting in large losses due to trampling; however uneaten residues were returned to soil.
4. Large losses of forage in communal grazing land due to trampling, because no proper grazing plan.
5. Cotton seed cake (CSC) was not readily available for purchase for use as a supplement.
6. Animals were kept together in a common kraal, so not possible to practise selective feeding.

5.2.5.3 *Constraints identified in **Morogoro** location*

In Morogoro location, farmers grouped the constraints into three main groups. Group one involved management constraints consisting of diseases, lack of extension and veterinary services and lack of knowledge. Group two involved feeding constraints composed of limited land for tethering and or grazing (this constraint was related to land occupied by crops and so limiting tethering areas), expensive concentrates, low quality forage and lush pastures causing diarrhoea during the wet season. Group three involved constraints related to resources and services available such as lack of capital, lack of technical advice, land scarcity and lack of transport. These constraints were ranked individually by 25 farmers to yield a mean rank (multiple response). Some farmers ranked only three most important constraints, while others ranked up to five, with one being most pressing. The mean ranks are presented in Table 17.

Figure 3. *Problem linkage diagram for smallholdings in Kilimanjaro*



[1] Working capital included cash required for renting land, paying casual labourers and buying drugs especially acaricides and dewormers.

[2] Inadequate extension services were generalised as the main cause of low agricultural production, which included both crops and livestock.

Table 17. *Mean rank of the constraints identified in Morogoro location*

Constraint	Mean rank[1]
1 Goat management constraints	
a) Disease	1.1
b) Lack of technical knowledge on goat management	1.7
c) Lack of extension and veterinary services	1.9
2. Feeding constraints	
a) Feed availability (limited to land occupied by crops in all seasons of the year)	1.7
b) Lush grasses causing diarrhoea during wet season	1.8
c) Low quality forages	1.8
d) Expensive concentrates	1.9
e) Limited land for tethering and grazing	1.9
3. Constraints related to resources and services[2]	
a) Capital	1.3
b) Lack of technical advices	1.9
c) Land scarcity	2.4
d) Transport	2.8

[1] Multiple response at a scale of 1–5 (1 most pressing, 5 least pressing), number of respondents = 25.
[2] Labour was not perceived as a constraint in Morogoro.

Table 18. *Summary of forage and forage related constraints and problems identified in all locations*

	Constraint/problem	Mwanza	Kilimanjaro	Morogoro
1.	Shortage of dry-season forage[1]	✓✓✓	✓✓✓	✓✓✓
2.	Low quality forage	✓✓✓	✓✓✓	✓✓✓
3.	Lack of improved forage feeding strategies	✓✓	✓✓✓	✓✓✓
4.	Lack of knowledge on forage conservation		✓✓	✓
5.	High transport costs of crop residues and loss of leaves		✓✓✓	
6.	Land degradation and decline in soil fertility		✓✓✓	✓✓
7.	Fluctuations in type of feed offered		✓✓	
8.	High cost of concentrates		✓✓✓	✓✓
9.	Problems of milk marketing	✓	✓✓	✓
10.	Poor feeding troughs leading to feed loss		✓✓	✓

✓ low severity ✓✓ medium severity ✓✓✓ high severity
[1] In Morogoro forage shortage was mainly associated with land occupied by crops and hence limit tethering and grazing land

5.2.6 Prioritisation of constraints common to all or two of the locations.

Shortage of dry season forage, low quality of forages and lack of improved forage feeding strategies were common constraints identified in all three locations (Table 18). Farmers in Kilimanjaro location identified more constraints compared to Mwanza and Morogoro.

5.3 OUTPUT 3 MISSING-LINK TECHNICOLOGIES FOR PRODUCING FORAGE-FEEDSTUFFS WITH INCREASED NUTRITIVE VALUE AND IMPROVING SUSTAINABLE UTILISATION OF FORAGES.

5.3.1 Results of Box-baling Experiment 1.

LSMeans of Weight and Time for manual baling of stover are presented in Table 19. Weight decreased (P<0.05) as the box size decreased. In contrast, Time increased (P<0.05) when decreasing the size of box from large (B1) to medium (B2), but there was no difference (P>0.05) between medium (B2) and small (B3). The greater time required to make medium and small bales was attributed to the process of chopping stover to fit the smaller boxes. Since baling time determined labour costs, the costs of baling also increased with decreasing box size. Experiment 1 established mean weight and time for baling using each of the three boxes and hence data for calculating the cost of making a bale (one labour hour was Tsh 250).

The effects of Labour, Day, Period and LabourXPeriod interaction were not significant (P>0.05) for the variable Weight. However, there was a significant difference (P<0.05) between Labour for the variable Time. In other words, although the labourers made bales of similar weight, there was a variation in time taken between labourers. This indicates that efficiency of baling may vary between operators but the product is not affected.

Table 19. *Experiment 1: LSMeans of weight, time and bale cost of manual baling of maize stover*

Treatment	Weight (kg)	Time (minutes)	Bale cost[1] (Tsh)
B1 large	15.1[a]	13.9[a]	58.3[b]
B2 medium	12.2[b]	16.7[b]	70.0[a]
B3 small	9.4[c]	17.7[b]	74.2[a]
s.e. of LSMean	0.40	0.90	3.82

[a,b,c] Means with different letters within column are significantly different (P<0.05).
[1] Since the stover was not purchased, the labour cost required to bale was considered as bale cost.

5.3.2 Results of Box-baling Experiment 2.

5.3.2.1 *Stover handled in 1.0 t pick-up.*

LSMeans for the weight and costs associated with handling (baling, loading and unloading) of stover in 1.0 t pick-up are shown in Table 20. Weight of stover handled differed (P<0.05) between loose and baled stover. Labour costs and total costs of handling stover varied significantly (P<0.05) with treatment where loose stover had lowest and small box bales (B3) had highest costs. However, the calculated cost per kg DM showed that loose handling had the highest cost per kg DM and bales from medium box (B2) recorded the lowest cost per kg DM.

Day and period had no significant effect on the dependent variables considered in the experiment.

Table 20. *Experiment 2: LSMeans for weight and costs involved in maize stover handling in 1.0 t pick-up*

Treatment	Weight of stover loaded		Labour cost for baling, loading & unloading (Tsh)	Total cost of labour & vehicle hiring (Tsh)	Cost per kg DM (Tsh)
	Air dry (kg)	DM (kg)			
Loose	160[a]	144[a]	236[a]	15236[a]	106[a]
B1 large	226[b]	203[b]	941[b]	15941[b]	79[b]
B2 medium	262[c]	236[c]	1607[c]	16607[c]	71[c]
B3 small	261[c]	235[c]	2268[d]	17268[d]	73[c]
s.e. of LSMeans	3.4	3.0	17.0	17.0	1.4

[a,b,c,d] Means with different letters within the same column are significantly different (P<0.05).

5.3.2.2 *Stover handled in 7.0 t lorry*

The triplicate measurements and the mean weights of stover that could be transported in a 7.0 tonne lorry are presented in Table 21.

Table 21. *Weight (± s.d) of maize stover loaded in 7.0 t lorry as loose or bales from B1, B2 and B3*

Measurement	Weight of stover loaded (kg)			
	Loose	B1	B2	B3
1	758	1575 (105)	1716 (143)	1800 (200)
2	743	1605 (107)	1692 (141)	1827 (203)
3	762	1560 (104)	1656 (138)	1791 (199)
Mean	754	1580 (105)	1688 (140)	1809 (201)
s.d.	10	23 (2)	30 (3)	18 (2)

Number in brackets represents the number of bales loaded.

5.3.2.3 *The implication of economy of scale in maize stover transportation.*

An objective of Experiment 2 was to assess the amount of stover carried in a 7.0 t lorry and compare it with that carried in a 1.0 t pick-up so as to investigate the economy of scale in maize stover transportation. The amount of stover transported in a 1.0 t pick-up is presented in Table 20 and the amount of stover in 7.0 t lorry is presented in Table 21. After considering the hiring costs for a 1.0 t pick-up (Tsh 15,000) and 7.0 t lorry (Tsh 34,000), cost comparisons for using 1.0 t pick-up and 7.0 t lorry are presented in Table 22.

Table 22. *Cost comparison between 1.0 t pick-up and 7.0 t lorry in stover transportation*

	Hiring the truck (Tsh/trip)	Mean weight of air dry stover loaded (kg)			
		Loose	B1	B2	B3
1.0 t pick-up[1]	15,000	160	225 (15)	264 (22)	261 (29)
7.0 t lorry[2]	34,000[3]	754	1575 (105)	1680 (140)	1809 (201)
Ratio of Lorry:pickup	1:2	1:5	1:7	1:6	1:7
Hiring cost saved[4] (Tsh)		41,000	71,000	56,000	71,000

[1] Table 20
[2] Table 21
[3] Cost of hiring a 7.0 t lorry was Tsh 30,000 and cost of loading stover and unloading was Tsh 4,000
[4] Calculated by assuming that the stover transported in 7.0 t lorry would have been transported in 1.0 t pick-up e.g. the 105 B1 bales transported in 7.0 t lorry would have been transported in 7 trips of 1.0 t pick-up costing a total of Tsh 105,000, but same weight was transported in 7.0 t at Tshs 34,000 only.
Figures in brackets are number of bales loaded in the truck

5.3.3 Results of Experiment 3.

5.3.3.1 *Proportion of LSH and stem to whole stover and time for stripping*

The results obtained from stripping samples of 5 kg maize stover are presented in Table 23.

Table 23. *Experiment 3: Mean (± s.d). weight of LSH and stem, and time to strip 5 kg sample of stover by casual labourers and farmers*

	Labourer	Farmer	Proportion of stover to whole (%)
LSH (kg)	2.6±0.07	2.6±0.07	52
Stem (kg)	2.3±0.06	2.3±0.07	46
Time[1] (min)	4.2±0.41	3.6±0.37	

[1] A farmer commented that stripping of erect stover in the field could be easier and may take less time than recorded in this experiment
Number of samples stripped was 9 for each group (casual labourers and farmers)

5.3.3.2 *Weight, volume and time taken to bale LSH*

The weight, volume and time taken to bale stripped LSH are presented in Table 24.

Table 24. *Experiment 3: LSMeans ± s.e of LSMean. of weight, volume and time for LSH bales made by casual labourers and farmers[1]*

Labour type	Casual labourers			Farmers		
Box size[2]	B1	B2	B3	B1	B2	B3
Weight (kg)	19.7[a]	16.0[b]	10.2[c]	20.2[a]	16.6[b]	10.8[c]
s.e. of LSMean.		0.22			0.19	
Volume (m^3)	0.27[a]	0.20[b]	0.14[c]	0.26[a]	0.20[b]	0.15[c]
Expected volume (m^3)	0.20	0.15	0.10	0.20	0.15	0.10
s.e. of LSMean.		0.002			0.002	
Time (minutes)	20.0[a]	16.2[b]	11.0[c]	17.2[a]	14.4[b]	9.4[c]
s.e. of LSMean.		0.31			0.33	

[1] The analysis were carried out separately and hence the mean comparisons are within the labour type i.e. casual labourers or farmers
[2] B1 = large (100 x 50 x 40 cm) B2 = medium (75 x 50 x 40 cm) B3 = small (50 x 50 x 40 cm)
[a,b,c,] Means with different letters within row and within labour type are significantly different (P<0.05)

5.3.3.3 *Weight of baled LSH stover transported in 1.0 t pick-up.*

Experiment 2 (Table 22) established the weight of stover that could be loaded in a 1.0 t pick-up either as loose stover or as a whole number of bales using the B1, B2 and B3 bale sizes. In Experiment 3, the number of bales and hence weight of LSH in 1.0 t pick-up are presented (Table 25). Bales made from the medium size box (B2) allowed more stover in the 1.0 t pick-up for both whole baled stover as well as baled LSH stover.

Table 25. *Number of bales and weights of stover loaded in a 1.0 t pick-up as LSH and whole stover*

	Number of LSH bales loaded	Weight of LSH[1] (kg)	Number of whole stover bales loaded[2]	Weight of baled whole stover loaded[2] (kg)
B1 large	19	380	15	225
B2 medium	24	384	22	264
B3 small	34	374	29	261

[1] Air dry weight of LSH in 1.0 t pick-up when transported as loose stover is 83 kg.
[2] Data from Table 22 (this is incorporated here for making comparison between baled LSH and whole stover).

Noting the dimensions and volume (4.6 m^3) of the 1.0 t pick-up used, it was expected that it could carry 23, 30 and 46 bales of large, medium and small bales respectively. The observed deviation from expected to actual may have been caused by the increase in volume of bales due to expansion after being removed from the box.

5.3.4 Summary of costs associated with handling of maize stover.

The three baling experiments have established costs associated with handling maize stover as loose and as baled material. When handled as loose stover, the costs involved are hiring of the 1.0 t pick-up and the labour costs for loading and unloading. When stover is baled whole, the costs involved are hiring the pick-up and the labour cost for baling. When stover is handled as bales of LSH, the costs involved are hiring the pick-up, the labour cost for stripping and the labour cost for baling. Flow charts of these costs are presented in Figure 4 and Figure 5 for stover handled in 1.0 pick-up and 7.0 t lorry respectively.

5.3.5 Conclusions from box-baling experiments.

5.3.5.1 *Manual box-baling*

The bottlenecks of the traditional farmer practice of transporting loose stover in a 1.0 t pick-up or using tractor-trailers in Kilimanjaro were identified more than ten years ago in surveys carried out by Mlay (1986) and Urio (1986). A smallholder dairy development project funded by FAO and IDRC introduced stover baling technology using a conventional tractor driven John Deere hay-baler. This technology, though reducing the bulkiness of the stover, was found inappropriate by resource-limited smallholder farmers due to the high costs of hiring the baler.

The experiment on manual box-baling carried out in the present study showed that manual box-baling was more economical than the conventional practice of transporting maize stover as loose material. The most economical box size was the medium size (75 x 50 x 40 cm). This box recorded the highest load in 1.0 t pick-up for stover handled as baled whole and baled LSH. The medium box is slightly smaller than the simple hay-baling box (85 x 55 x 45 cm) that was proposed for baling dried hay and stover in Kenya (Onim *et al.,* 1992).

The inverse relationship between baling time and size of box was attributed to the time required to reduce the length of the stover (by chopping) to fit the smaller boxes. While stover would need to be chopped once to fit a large box (B1), it would need to be chopped twice or thrice to fit in the medium box (B2) and would require even further chopping to fit a small box (B3).

Associated advantages of the box-baling technology include space saving in the storage shed and easy budgeting of the available forage. Space saving in the storage shed could be estimated based on the volume of the 1.0 t pick-up used. If the volume of the 1.0 t pickup used was 4.6 m^3 and could carry 160 kg loose stover or 260 kg baled whole stover then the stover volume was 35 kg/m^3 and 57 kg/m^3 for loose and baled stover respectively. The increase in stover stored per volume was 63% when baling was used to replace traditional loose handling of stover.

If truck owners could accept the idea of transporting baled stover and charge per bale (instead of hiring), as practised with bags of grain, then resource-poor farmers (RPF) could also afford to pay for and transport a few bales in a communal truck.

5.3.5.2 *Conclusion from Experiments 1 and 2*

Manual box-baling of stover reduced bulkiness of the material and reduced transportation cost by up to 33%. The medium size box (B2 = 75 x 50 x 40 cm) gave the largest cost reduction in handling of maize stover. The medium box is therefore recommended for baling stover by smallholder farmers in Kilimanjaro. The practice will increase the amount of stover transported from the lowlands to the highlands and increase the amount of forage available at home. Although not measured in the present study, the practice is expected to reduce leaf shattering during transportation, and will improve the storage of stover and feed budgeting at home.

Following the demonstration staged at Samaki Maini village in November 1997, a farmers group was formed in the village in early 1998. The group is composed of 10 founder members and is aiming at joint efforts in manual baling and transportation of stover for their own use and where possible selling the excess to other farmers. This development is likely to promote the adoption of the technology by more farmers.

5.3.5.3 *Conclusion from Experiment 3*

Although the results of Experiment 3 were not statistically compared between farmers and casual labourers, results from the two groups showed that farmers used less time both in stripping and baling compared to casual labourers. This may indicate commitment to the work showed by farmers, and may suggest that casual labourers may need close supervision when doing the work or be employed on a contract basis.

The medium box (B2 = 75 x 50 x 40 cm) gave the highest weight per load and is therefore recommended for adoption. This box was also ranked high by farmers during the evaluation of the three boxes used in manual baling of maize stover.

Although the extent of leaf shattering was not measured in the present experiment, it is expected that leaf shattering would have been reduced as baled LSH was more secured than loose stover. Farmers who participated in the experiment were enthusiastic about stripping and baling LSH. This indicated that the experiment exposed some advantages which they did not know before.

A further benefit of stripping for LSH is that the stems remain in field to be incorporated in the soil to increase organic matter. A study on decomposition of maize stover when incorporated in the soil (Lekasi *et al* 1992) showed higher yields of maize in the subsequent cropping season where maize stover was incorporated in the soil. The benefits of easier storage and feed budgeting are obvious with baled compared to loose stover. Children left at home could be told how many bales to offer and the farmers could easily estimate how long the stored feed would last.

Figure 4. *Flow chart of costs associated with handling maize stover in 1.0 t pick-up as loose, baled whole or baled stripped for leaf, sheath and husk (LSH)*

Maize stover

A	Cost of hiring the pick-up per trip (Tsh)		15,000	
B	Method of handling the stover	Loose	Baled whole in B2	Baled LSH in B2
C	Weight of stover loaded (kg DM)	144	235	342
D	Cost of processing and loading[1] (Tsh)	236	1,607	7,560
E	Total cost (Tsh) = [A+D]	15,236	16,607	22,560
F	Weight of LSH[2] (kg DM)	75	122	342
G	Cost per kg DM of LSH (Tsh) = [E]/[F]	203	136	66
H	Energy content of LSH transported[3] (MJ ME)	645	1,049	2941
I	Cost per MJ ME (Tsh) [E]/[H]	24	16	8
J	Potential milk yield from the stover transported[4] (l)	108	175	490

[1] Processing included baling for whole stover and stripping and baling for LSH.
[2] Proportion of LSH in whole stover is 52%.
[3] ME value of LSH is estimated at 8.6 MJ/kg DM (FAO, 1981, 1991).
[4.] The ME required to produce a litre of milk is assumed to be 6.0 MJ.

Figure 5. *Flow chart of costs associated with handling maize stover in 7.0 t lorry as loose, baled whole or baled stripped for leaf, sheath and husk (LSH)*

Maize stover

A	Cost of hiring the 7.0 t lorry per trip (Tsh)		30,000	
B	Method of handling the stover	Loose	Baled whole in B2	Baled LSH in B2
C	Weight of stover loaded (kg DM)	754	1512	2240
D	Cost of processing and handling[1] (Tsh)	4,000	9,800	44,100
E	Total cost (Tsh) = [A+D]	34,000	39,800	74,100
F	Weight of LSH[2] (kg DM)	392	786	2240
G	Cost per kg DM of LSH (Tsh) = [E]/[F]	87	51	33
H	Energy content of LSH transported[3] (MJ ME)	3371	6760	19264
I	Cost per MJ ME (Tsh) [E]/[H]	10	6	4
J	Potential milk yield from the stover transported[4] (l)	562	1127	3211

[1] Processing included baling for whole stover, stripping and baling for LSH, and hauling the stover to a storage place from where the stover is unloaded

[2] Proportion of LSH in whole stover is 52 %

[3] ME value of LSH is estimated at 8.6 MJ/kg DM (FAO, 1981, 1991)

[4] The ME required to produce a litre of milk is assumed to be 6.0 MJ

5.4 OUTPUT 4: FARMER-EVALUATED & SUSTAINABLE HUSBANDRY STRATEGIES FOR IMPROVING UTILISATION OF FORAGES & PROFITABLE MILK PRODUCTION.

5.4.1 Evaluation of the wooden baling boxes used in Experiments 1 – 3.

Evaluation of the wooden baling-boxes was carried out by two groups of farmers, each using a different PRA technique. The results of the evaluations are presented in Table 26 for the individual farmer evaluations and in Table 27 for the group evaluation by voting based on criteria set.

Table 26. *Individual farmer evaluation of the three wooden boxes for size preference*

Box size preference	Farmers preferred (n = 19)	Percentage
Large	1	5
Medium	7	37
Small	7	37
Medium and Small	4	21

Assessment by individual questionnaire.

Table 27. *Evaluation of the three wooden boxes by farmers through voting*

Criteria	Large (B1)	Medium (B2)	Small (B3)
1 Easy to bale	15	8	2
2 Easy to be lifted by children	0	7	18
3 Carry more load in truck	3	16	6
4 Easy to put in store	5	10	10
Total score	23	41	36
Rank of the box	3	1	2

The results show that farmers generally preferred the medium and small boxes to the large box. In Kilimanjaro location when children are left at home, they are instructed to feed the animals at particular times (especially when the trough is completely empty). These farmers will therefore prefer bales that can be easily handled by children and this is reflected in the overall ranking. Also, bulk feed is not always put in the trough at one time as farmers would not like to have much refused feed and this may also count against the larger sized bales.

5.4.2 Results from the survey and demonstration on use of wooden boxes to bale wilted roadside grass.

5.4.2.1 *Trends in the roadside grass trade*

Information on changes in the numbers of sellers and kiosks involved in the roadside grass trade along the Himo - Moshi highway between the 1960s and the 1990s was collected through key informant meetings and the results are shown in Table 28. The trade has grown steadily since the 60s, an indication that the trade is profitable, attracting more sellers to join. The high demand for grass is driven by the increase in number of dairy animals kept in the highlands and the growing urban and peri-urban dairy sectors (Mlozi, 1995).

Table 28. *Trends in the roadside grass trade on the Himo - Moshi highway from the 1960s to the 1990s*

Years	Number of kiosks	Number of sellers
1960s	3	< 10
1970s	5 – 8	15 – 20
1980s	12 – 15	30 – 40
1990s	26	> 60

Source: Phase 3 PRA field studies conducted with sellers of roadside grass in lowlands of Kilimanjaro

5.4.2.2 *Characterisation of the roadside grass trade*

Characterisation of the roadside grass trade in the wet and dry seasons is presented in Table 29. The PRA survey showed that there is a marked difference in trade between the wet and dry seasons.

Table 29. *Characterization of the roadside grass trade in wet and dry seasons*

Component	Wet season	Dry season
Sellers	Mainly children and a few women	Mainly women and a few children (children cannot afford fetching grass from distant sources)
Source of grass	Near (3 – 5 km)	Distant (10 - 20 km)
Selling prices	Low (300 –500 Tsh per load weighing 35-40 kg)	High (1000 –1500 Tsh per load weighing 40-45 kg)
Buyers (market)	Few and selective	Many and competitive
Type of forage sold	Local grass (mainly Star grass)	Very mature local grass, crop residues (maize stover and bean straw) and weeds (mainly *Commelina beghalenses*)
Labour demand for other activities	High (casual labour work in weeding pays more)	Low (there is no other alternative use of the available labour)
Extent of losses	High (due to spoilage by rain and/or sun drying)	Low (buyers are always available and demand is high)
Number of kiosks	Many	Few (few women can afford fetching grass from distant sources)
Constraints	Spoilage, lack of market and low prices	Fatigue due to walking, poor quality forage and lack of credit facilities to expand the trade.

5.4.2.3 *The role of roadside grass trade in smallholder dairy sector in Kilimanjaro*

Both sellers (16) and buyers (11) considered that the roadside grass trade has been a good source of forage for animals kept in the highlands, since the 1960s. The trade developed as a result of the introduction of improved dairy animals into the highlands where land for cultivating improved forage is scarce. The trade has grown steadily, but sellers pointed out that in recent years there was a notable increase in the volume of the trade. This increase in volume may be attributed to two main reasons:

- The increase in the dairy cattle population in the region. Kilimanjaro alone is keeping 46% of Tanzania's dairy cattle (MoAC/SUA/ILRI, 1998). These animals are confined under a stall-feeding system. Forage feed obtained from the highland plots is not sufficient.

- The recent development of urban agriculture whereby dairy cows are kept in the backyards of flats and government quarters and therefore depend on brought-in forage (Sawio, 1993; Mlozi, 1995). According to buyers of roadside grass from the peri-urban and urban sectors, the roadside grass trade contributes significantly to the forage feed supply in their sectors.

Despite the importance of roadside grass in supplying forage to the smallholder dairy sector in Kilimanjaro, there has been no specific research planned to improve the trade. Research has been carried out (Kimambo *et al.,* 1990) to document the nutritive value of roadside grass but nothing has been done to investigate the problems associated with the trade.

Given the fact that the roadside grass trade is growing steadily and that in recent years there has been an introduction of local grass as a commodity in local markets there is a need to have more study of this forage source. Since its inception, the main source of the grass has been native grass from the side of the roads, fallow lands and valley bottoms. These sources are likely to diminish as cultivation for food crops is intensified. It may therefore be promising to advocate planting improved pastures as relay cropping in the lowlands of Kilimanjaro and sell these pastures in the same way that the roadside grass is sold. This could form a long-term plan to replace the roadside grass as the native pasture sources become exhausted.

5.4.2.4 *Forages sold: species, maturity and selling season*

The botanical composition of the forage sold in the local markets and along the roadside varied considerably with season and selling station (Table 30). Crop residues (maize stover, bean straw and groundnut straw) were sold only during the harvesting period for these crops (June - August). Weeds, especially Commelina, from fallow lands and from coffee estates (found in Kwasadala local market) were available in early to mid dry season (July to end of August).

Table 30. *Dominant forage species, stage of maturity and season sold*

Forage species	Stage of maturity and season	Selling station[1]
Star grass (*Cynodon spp.*)	• Flowering – wet season • Mature to senescent - dry season	All stations visited
Couch grass (*Digitaria scalarum*)	• Pre-flowering to flowering – early dry season	Kwasadala and Yam-Makaa
Brachiaria spp.	• Flowering – wet season • Mature to senescent - dry season	Mabungo, Uchira & Yam-Makaa
Panicum spp.	• Flowering – wet season • Mature to senescent - dry season	All stations visited
Heteropogon contortus	• Late vegetative - end of wet season • Very mature – dry season	All stations visited
Commelina beghalensis	• Late vegetative - end of wet season • Very mature – dry season	Kwasadala and Yam-Makaa
Gycine wightii	• Flowering – early dry season	Kwasadala and Yam-Makaa
Maize (*Zea mays*)	• Stover – early to mid long dry season	Mabungo, Yam-Makaa & Kwasadala
Common bean (*Phaseolus vulgaris*)	• Straw – early to mid dry season	Mabungo, Yam-Makaa & Kwasadala
Groundnut (*Arachis hypogaea*)	• Straw – early to mid dry season	Uchira

[1] Selling station refers to the forage kiosks that were visited during the RA.

5.4.2.5 *Problems associated with the roadside grass trade*

The problems associated with the roadside grass trade as perceived by both buyers and sellers were investigated by using a pair-wise ranking technique. This technique enabled identification of the most limiting problems (Tables 31 and 32).

Table 31. *Pairwise ranking of problems associated with roadside grass, as perceived by buyers*

	Ticks	Poor quality	Poor packing	Worms	Score	Rank
Ticks		Poor quality	Poor packing	Ticks	1	3
Poor quality			Poor quality	Poor quality	3	1
Poor packing				Poor packing	2	2
Worms					0	4

The existing linkages between the problems identified by buyers and sellers may give hints of possible solutions. The manual box-baling technology if adopted could solve the problem of poor packing identified by buyers. The problem of packing was under the control of the sellers. Poor packing (i.e. loose tying of the bundles) appeared to be a deliberate ploy by the sellers to make the bundles seem large. However, sometimes buyers felt cheated and were reluctant to buy.

Manual box-baling of wilted grass could impress buyers through the improved packing. This may increase the number of buyers and so improve marketing and reduce spoilage of grass. Lack of market and spoilage were ranked high by sellers as constraints to the trade.

Sellers had little control over quality as they had no specific land where they could produce grass under improved management.

The comments given by sellers about manual box-baling of roadside grass may imply that adoption of the technology requires further investigation, and especially the response of the buyers.

It is suggested that if manual baling of wilted grass is complemented with the formation of roadside grass seller groups, and co-operative construction of simple hay sheds, the current losses of grass would be reduced, and marketing improved.

Table 32. *Pairwise ranking of problems associated with roadside grass, as perceived by sellers*

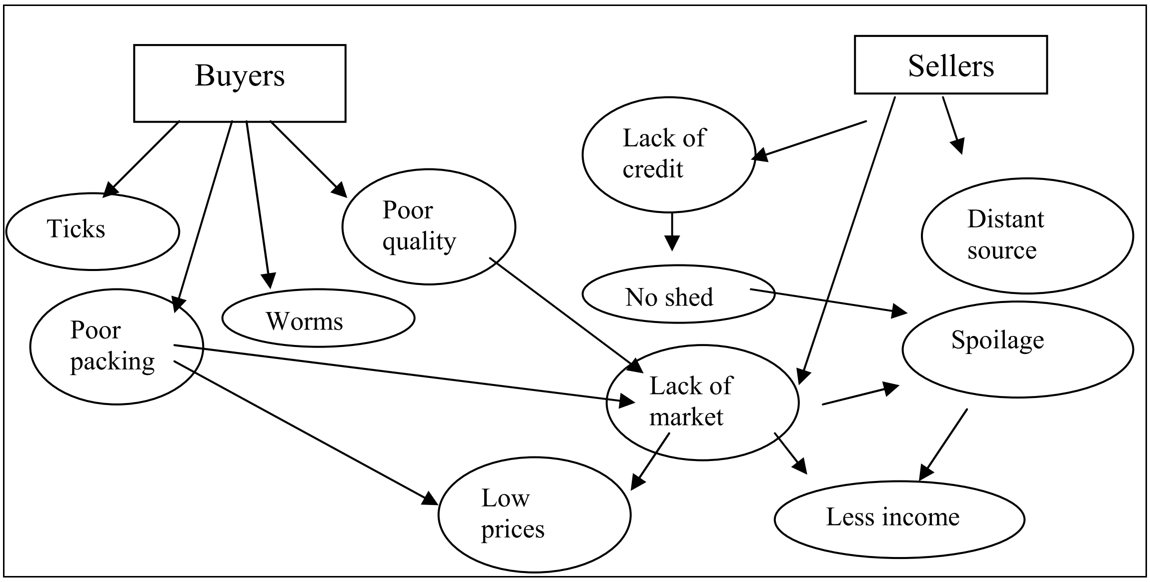
	Distant source	Low prices	Spoilage	Market problems	Lack of credit	Score	Rank
Distant source		Low prices	Spoilage	Market problems	Lack of credit	0	5
Low prices			Spoilage	Market problems	Low prices	2	3
Spoilage				Spoilage	Lack of credit	3	1
Market problems					Market problems	3	1
Lack of credit						2	3

Forages from valley bottoms and fallow lands were preferred to the forage cut from the roadside (five buyers interviewed said that they did not buy grass cut along the roadside as this could contain ticks). Buyers considered poor packing of the grass a problem. Poor packing was done purposely by sellers so as to make the bundle look large. This observation may suggest that sellers are less likely to be interested in the baling technology as the technology would involve securing the bales tight, unless more buyers would go for baled grass and be willing to pay more.

5.4.2.6 *Linkages between the problems identified by buyers and sellers in roadside grass trade.*

There were close linkages between the problems identified by buyers and sellers of roadside grass (Figure 6). Poor quality and poor packing were perceived by buyers as the major problems (Table 31) while lack of market and spoilage were perceived by sellers as main problems (Table 32). Lack of market identified by sellers was associated with poor quality and poor packing identified by buyers. Improvement in the quality of the roadside grass is a long-term issue, but the improvement in packing is short-term and does not demand much working capital. Manual box-baling could be one intervention to improve packing of the wilted forage and reduce spoilage

Figure 6. *Linkage diagram for the problems identified by the buyers and sellers of roadside grass*



5.4.2.7 *Results from the demonstrations of manual box-baling of wilted grass*

Table 33 presents results from the second demonstration on manual box-baling of wilted roadside grass. The demonstration was not planned as a typical scientific experiment and hence the data were handled only with a hand calculator rather than a computer statistical programme. Baling was done by women sellers and interested men who were attracted by the technique and participated in the demonstration.

Table 33. *Results of a manual box-baling of wilted roadside grass at Uchira village in Kilimanjaro*

Bale No.	Time taken to bale[1] (minute)	Weight of the bale (kg)	Value of grass baled[2] (Tsh)
1	18	16.0	370
2	15	13.0	340
3	17	17.0	380
4	13	15.0	360
5	17	18.0	380
6	14	16.5	360
7	15	13.0	340
8	12	14.0	350
9	18	16.5	360
10	15	14.0	350
11	12	16.5	360
12	14	17.0	380
13	15	17.5	360
14	17	16.5	370
15	12	16.0	370
16	13	15.0	360
17	18	16.0	370
18	17	17.5	400
Total	269	285	6560
Mean	14.94	15.8	364
S.D.	2.13	1.50	15.03
C.V.	14.25	9.49	4.13

[1] Baling was done by using the medium box (75 x 50 x 40 cm).
[2] Price of the bundle which weigh on average 30 kg was Tsh 500. However, sellers could portion out the bundle and sell the portions at low prices.

On average each bale contained grass worth Tsh 350 - 400 (364), based on sellers conventional packing. The bales were displayed for sale, and buyers were able to choose between fresh cut green grass, wilted loose packed and wilted baled grass. Sellers set the price at Tsh 600 per bale, but buyers were only willing to pay Tsh 500 per bale. Looking at the cost of baling the sellers did not consider baling time as a cost because there was no other better alternative use of that time (they have to stay idle otherwise waiting for the buyers to come). The sisal twine is used in bundles as well so it is not an added cost. The only concern was on the cost of the wooden box which was considered as a fixed cost that has to be incurred once and does not vary with the baling operation. The discussion of sellers comments on the manual box-baling demonstration is presented later.

5.4.2.8 *Evaluation of the demonstration on manual box-baling on roadside grass*

Wilted grass for baling was bought from the sellers. Before baling, each bundle of grass was weighed and the weight recorded against its price. Each bale was also weighed (Table 33). Sellers were then asked to estimate and assign a price per bale.

Sixteen sellers at Uchira village (where the demonstration was staged) were asked to comment on the applicability of manual baling technology to wilted grass. The sellers gave different views. Nine of the sellers interviewed (56%) considered the technology good and likely to improve the trade, four sellers (25%) considered that more grass went into the box and that this would reduce their profit margin. The other three sellers (19%) reserved their comments on the basis that buyers should be asked first for preference before embarking on and recommending the baling of wilted grass.

During the demonstration when the 18 bales were made of roadside grass, (Table 33) buyers with closed vans commented that they could buy a small number of bales and fit them properly in vehicles. This was an indication that the technology could improve marketing of roadside grass.

5.4.3 Farmer-to-farmer visit and learning

The *farmer to farmer visit and learning* was carried out by taking six farmers and their village extension officer from Kilimanjaro to Arumeru District so that they could learn by seeing and hearing from their fellow farmers about the technology of contour bunds planted with fodder. The objective of the visit was to introduce the approach of *farmer to farmer visit and learning* as a technique to promote technology adoption.

Farmers commented that the visit was more interesting than seeing demonstration plots on-station on farmers' day or seeing plots demonstrated during agricultural shows. Visiting farmers were very enthusiastic to learn from their counterparts about other benefits that accrued from adopting the contour bund technology, besides the 50% increase in fodder production. An added advantage was that visiting farmers were able to make comparison of the crop stand between the SCAPA project farmer's field with an adjacent farm belonging to a non-project farmer who had not adopted the technology of contour bunds.

The contour bund technology is only suitable to farmers with sloping land. The visiting farmers were not pre-visited to assess whether they had sloping land. The probability of visiting farmers practising the technology back on their own land, so that other farmers in Kilimanjaro could copy from them was therefore questionable.

5.4.4 Economic evaluation

5.4.4.1 *Resource profiles for the six case-study farmers*

The resource profiles for the six case study farmers are presented in Table 34. Capital resource was difficult to investigate as farmers were reluctant to reveal their actual physical assets including cash available. However farmers claimed to have very little or no operating cash and capital was mainly tied up in livestock and other physical assets. As in the PRA field studies, the case study farmers perceived capital as hard cash. They did not consider farm assets such as unproductive animals as a means of generating working capital.

All six farmers had plots of land in both the highlands and in the lowlands. The land plot in the lowland was used for maize production while that in the highland was used for coffee/banana, planted fodder and scattered local MPTs. Urio and Mlay (1985) and Mdoe (1993a) reported similar findings from this study area. Due to the small sample size, the data collected did not show a clear pattern between wealth groups for size of highland plot, but the size appeared to decrease with wealth group for the lowland plots. The two female farmers among the case-study farmers indicated that they had rented the lowland plot. The female farmers also pointed out that there was gender discrimination against land ownership in the study area where women are traditionally not allowed to own land. ICRA/SARI (1992) made a similar observation. The land tenure system in the study area is based on traditional customs and is controlled through a clan system. Men as the heads of households, make decisions on how to use that land.

The family size ranged from 4 to 7, but the potential working labour was 2 to 3. The working labour was composed mainly of the husband and wife. Children under 18 years were in school while those above 18 had migrated to towns in search of work or to do business. Not evident in Table 34 is the fact that a major cash income was obtained from the sale of coffee. This source of income was seasonal and was mainly controlled by men. The PRA findings showed that cash income from coffee was used for major development activities such as building a new house and paying for school fees. Regular cash income for paying for day-to-day household needs was obtained from sale of milk, bananas and vegetables. In most cases women controlled this cash.

Table 34. *Resource profiles for 1997 for the six case study farmers in Kilimanjaro*

Wealth group	High		Medium		Low	
Farmer	A	B	C[1]	D	E[1]	F
Resource						
Family size	4	6	5	7	4	4
Potential working labour	2	3	2	3	2	2
Livestock kept (TLU[2])	4.3	7.2	3.8	6.0	1.9	3.7
Highland plot size (ha)	1.6	1.6	1.2	1.6	1.6	0.8
Area under fodder (ha)	0.24	0.32	0.16	0.20	0.10	0.12
Lowland plot size (ha)	1.6	1.2	0.8	0.8	0.4	0.6
Number of dairy cows lactating	1	1	1	2	1	1
Proportion of TLU lactating[3]	0.4	0.2	0.4	0.5	0.8	0.4

[1] Female farmer (female-headed household).
[2] TLU presented is the mean of farm TLU at the opening and closing of the year (TLU is calculated by adding average weights of all animals on the farm and dividing by 250 kg which is the base for 1 TLU).
[3] Calculated by dividing the weight of cows lactating (i.e. 400 kg x number lactating) by total weight of animals kept on farm (i.e. multiplying the TLU kept by 250).

Farmer E had 1.9 TLU on farm (equivalent to a total of 475 kg) and had one cow lactating (equivalent to 400 kg). Proportionally, 80% of the animals were productive in 1997 for this farmer. As shown later in Table 37 farmer E also had high enterprise budget per 400 kg cow compared to the other farmers with one cow lactating.

5.4.4.2 *Cost of inputs*

The farm dairy enterprise budget (margin) involved quantifying all inputs and outputs from a dairy enterprise. The input that accounted for a large proportion of the variable costs was feed. Costs of inputs for each of the six case study farmers in Kilimanjaro are presented in Table 35. Variable costs other than feed, which were directly related to the dairy enterprise, were veterinary costs (bus fares to report disease cases, purchase of acaricide and treatment charges) and consumable items (repair of shed, ropes, sickles and bush knives). Other services were haulage of manure and marketing costs. The estimated costs for these activities were based on labour hours involved in performing the activity. It is worth noting here that the enterprise budget (margin) calculated, valued all labour (family and casual) involved in the dairy enterprise at a labour value of Tsh 250 per h. The use of family labour alone, or using some hired and family labour were then considered as strategies for increasing the profitability in milk production. Total variable costs (TVC) and the percentage contribution of feed to TVC, for each case study farmer, were also calculated and presented in Table 35.

Table 35. *Total variable costs (TVC) associated with the dairy enterprise and the % contribution of feed and other costs in the variable annual costs for each of the case study farmers in 1997*

Wealth group	High		Medium		Low	
Farmer	A	B	C	D	E	F
Veterinary costs (Tsh)						
Acaricide	39000	65000	39000	65000	0	0
Bus fare to report cases	8000	12000	8000	6000	6000	8000
Treatment charges	16000	25000	22000	26000	26000	17000
Consumables (Tsh)						
Repair of shed	12000	20000	10000	15000	10000	14000
Ropes	5000	8000	4000	5000	2000	2000
Sickles and bush knives	5000	5000	5000	5000	5000	4000
Other services (Tsh)						
Haulage of manure	26000	22500	26000	26000	26000	19500
Marketing of milk	30000	30000	0	15000	0	30000
Total non-feed costs (Tsh)	141000	187500	114000	163000	75000	94500
Feed costs[1] (from Table 43) (Tsh)	343500	481500	190200	314500	140000	236500
Total variable costs (TVC) (Tsh)	484500	669000	304200	477500	215000	331000
Feed costs as % of TVC[2] (%)	71	72	63	66	65	71

[1]Feed cost for each of the six case study farmers is presented in Table 43
[2] Mean of the six case study farmers is 68±3.8

5.4.4.3 *Benefits from the dairy enterprise*

Farmers quantified the tangible benefits obtained from the dairy enterprise, which were milk and sale of live animals. Milk sold and milk consumed at home were valued, based on the local market price of milk. In 1997, milk price in the study area was Tsh 200 per litre and did not show variation with season. A milk marketing survey (MoAC/SUA/ILRI, 1998) conducted in Kilimanjaro in the same base year found a similar price at village level, but prices were higher (between Tsh 250 – 300 per litre) in Moshi town (about 40 km away from the village).

The prices received for animals sold were as stated by the case study farmers. Manure obtained as a result of refused feed mixed with the animal bedding was difficult to estimate and was therefore not included. Livestock purchases were not included in the variable costs, but were included as negative items in the benefits. The change in herd value, calculated as the difference between opening and closing herd value, was added to the benefits. The benefits obtained from the dairy enterprise for each of the six case study farmers are presented in Table 36.

Table 36. *Benefits obtained from the dairy enterprise*

Wealth group	High		Medium		Low	
Farmer	A	B	C	D[1]	E	F
Milk yield						
Lactation length (days)	330	360	330	330	300	300
Lactation yield[2] (l)	1950	2250	1800	1650	1350	1500
Average yield per cow/day (l)	6.0	6.0	6.0	5.0	5.0	5.0
Value of milk [3](Tsh)	390000	450000	360000	660000	270000	300000
Value of manure (Tsh)	65280	107712	55488	88128	28397	55162
Sale of animals (Tsh)	180000	190000	395000	40000	75000	0
Total revenue (TR) (a) (Tsh)	635280	747712	810488	788128	373397	355162
Contribution of milk to TR[4] (%)	61	60	44	84	72	84
Animal purchased (b) (Tsh)	0	330000	22000	115000	180000	0
Opening herd value (Tsh)	590000	795000	705000	580000	295000	390000
Closing herd value (Tsh)	535000	1220000	252000	880000	445000	520000
Change in herd value (c) (Tsh)	-55000	425000	-453000	300000	150000	130000
Total benefits (a – b) + c (Tsh)	580280	842712	335488	973128	343397	485162

[1] Farmer D had two lactating cows and hence had higher saleable milk compared to others.
[2] Lactation yield excluded the milk fed to calves as calves were allowed direct suckling before and after milking.
[3] Value of milk included milk sold and milk consumed at home.
[4] Mean of the six case study farmers is 67.5±122.

5.4.4.4 *Case-study Dairy Enterprise Budgets*

The dairy enterprise budgets (margins) for the six case-study farmers are presented in Table 37. The budgets were calculated by subtracting the total variable costs (Table 34) from the total benefits (Table 35).

Table 37. *Dairy enterprise budgets (margins) for 1997 for the six case-study farmers*

Wealth group	High		Medium		Low	
Farmer	A	B	C	D	E	F
Total benefits (Table 36)	580280	842712	335488	973128	343397	485162
Total variable costs (Table 35)	484500	669000	304200	477500	215000	331000
Enterprise budget (margin)	95780	173712	31288	495628	128397	154162
TLU kept (based on 250 kg)	4.3	7.2	3.8	6.0	1.9	3.7
TLU based on 400 kg cow[1]	2.7	4.5	2.4	3.8	1.2	2.3
Cows lactating	1	1	1	2	1	1
Proportion of TLU lactating[2]	0.4	0.2	0.4	0.5	0.8	0.4
Enterprise budget (margin) per 400 kg cow[3]	35474	38603	13036	130428	106997	67027

[1] TLU based on 400 kg cow equivalent was calculated by multiplying the TLU kept by farmers shown in Table 34 by 250 (unit for 1 TLU - Table 39) and then dividing by 400.
[2] Calculated by dividing the weight (400 kg x number lactating) of cows lactating by total weight of animals kept(i.e. TLU x 250).
[3] The enterprise budget (margin) was divided by the TLU based on a 400 kg dairy cow equivalent.

5.4.4.5 *Comments on the dairy enterprise budget (margin)*

The dairy enterprise budget (margin) calculated in Table 37 showed that based on 1997 input and product prices, smallholder farmers in Kilimanjaro were operating at positive margins. The trend in margins based on the data from the six case-study farmers showed that farmers in the low income groups had higher margins per cow compared to farmers in high wealth groups. This trend may have been caused by low TLU (based on 400 kg cow) which is the dividing factor for the enterprise budget (margin). Also the higher enterprise margin (budget) observed with farmers in the low wealth category may have been contributed by the fact that poorer farmers spent less on variable costs (for example by not buying concentrates) and sometimes they took risks by not implementing routine prophylactic measures (such as using acaricides).

Other factors contributing to variation in margins included whether the farmer sold or purchased animals during the year and the number of cows that were lactating during the year. Of the six case-study farmers only one (farmer D) had two cows in lactation during the year and so had more marketable milk compared to other farmers. As shown in Table 37, farmer E had few TLU on the farm and had one cow lactating. The one cow represented a high proportion of the TLU kept (80%). Farmers D and E had the highest enterprise budget per 400 kg cow equivalent compared to the other farmers. The observation from the two farmers may suggest that the dairy enterprise budget (margin) could be improved by keeping most of the animals kept on farm in production (i.e. having high a proportion of the herd lactating).

5.4.4.6 *Farmers' units of measure for forage feeds*

Farmers' units of measure for forage feed types were converted to standard units and are shown in Table 38. Other values used while working with the feed data from the case study farmers were based on book values obtained from the literature and other sources, as cited in Table 39.

Table 38. *Mean, standard deviation and coefficient of variation (C.V.) of the various head loads of forage units used by farmers in Kilimanjaro*[1]

Parameter	Banana leaves	Banana pseudostems	Planted fodder	Roadside grass	Weeds
Samples weighed[2] (n)	8	9	12	12	11
Mean weight (kg)	40	30	40	30	30
S.D.	2.7	2.3	3.1	3.0	4.0
C.V. (%)	7.0	7.6	7.7	10.0	13.0

[1] Measurements were taken using a 100 kg x 500 g Hanson scale

[2] Measurements were taken at random and the number of observations depended on farmers found doing the activity during the visit or farmers met carrying a head load of forage and agreed to have the load weighed by the investigator.

5.4.4.7 *Feed types used by the six case study farmers in 1997*

Different feeds utilised from January 1997 to December 1997, by each of the six case-study farmers in Kilimanjaro, are presented in Table 40. Each farmer was asked to indicate how much of each feed was used in each month so as to build a seasonal distribution of the feed offered during the year.

5.4.4.8 *Seasonal distribution of the feed offered during the year 1997 for the six case-study farmers*

The annual feed offered, shown in Table 40 gave no information on the distribution of each feed type across the seasons of the year. To establish the seasonal distribution, each farmer was asked to indicate how much of each of the feeds was used in the year 1997. The farmer was then asked to indicate how each feed was distributed in the short dry season (Jan - Feb), long wet season (Mar - Jun), long dry season (Jul - Oct) and short wet season (Nov - Dec). The data from each of the six farmers were then entered in a spread-sheet. The six spreadsheets (one for each of the six case study farmers) were linked to produce a master spreadsheet representing averages for the six case study farmers. The master spreadsheet was then used to test the strategies for increasing profitable milk production.

The seasonal distribution of the feed offered during 1997 by the six case-study farmers in Kilimanjaro is shown in Table 41.

The seasonal feed availability information developed during the Phase 1 PRA field studies in Kilimanajaro did not show the obvious contribution of weeds and roadside grass as seasonal feeds. In Table 13 only ‘Makengera’ *(Commelina beghalensis)* which is a weed, was mentioned as a seasonal feed. Secondary data from the same location showed that weeds and roadside grass were important feed resources representing around 45% of the annual feed DM used on farms (Laurent and Centres, 1990). As shown in Table 41, data from the six case-study farmers showed that weeds and roadside grass contributed up to 23% of the annual feed DM offered (i.e. weed 12% and roadside grass 11%).

Table 39. *Values used in converting farm data to standard units in preparing dairy enterprise budget*

Variable	Average value		References[1]
DM value of feeds used (g/kg)			
Planted forage			
In wet season	170		Kimambo *et al.,* 1990
In dry season	250		
Roadside grass	350		Kimambo *et al.,* 1990
Banana leaves	210		Kimambo *et al.,* 1990
Banana pseudostem	90		Kimambo *et al.,* 1990
MPTs	350		Kimambo *et al.,* 1992
Maize stover	900		Shirima, 1994
Units used by farmers to measure forage (kg)			
Head load of planted fodder	40		This study
Head load of banana leaves	40		This study
Head load of banana pseudostem	30		This study
Head load of weeds	30		This study
Load of road side grass	30		This study
Maize stover in 1.0 t pick up	160		This study
Feed ME and CP values	ME (MJ ME/kg DM)	CP (g/kg DM)	
Planted fodder	10.0	103	Kimambo *et al.,* 1990; Abate, *et al.,* 1992,
Maize stover	8.6	40	FAO, 1981, 1991
Roadside grass	9.3	107	Kimambo *et al.,* 1990
Sunflower seed cake	11.9	267	FAO, 1981, 1991
Wheat feed	11.7	169	FAO, 1981, 1991
Banana leaves	7.6	127	Kimambo *et al.,* 1990
Banana pseudostems	10.3	39	Kimambo *et al.,* 1990
Weeds	9.3	114	Assumed to be as for roadside grass
Multipurpose trees (MPTs)	8.8	165	Kimambo *et al.,* 1992
Bean straw	8.7	66	Kimambo *et al.,* 1990
Manure parameters			
Daily manure output (kg per 100 kg LW)	5.0		Taiganides, 1987; Murwira, *et al.,* 1995
N content of manure (kg/t)	6.0		Taiganides, 1987
Cost of N in fertilizer (Tsh/kg)	544		This study
Tropical livestock unit (TLU) (kg live weight)	250		McIntire *et al.*, 1992
Labour cost[2]			
Based on 8 h working day at Tsh 2,000 per day (Tsh/h)	250		This study

[1] Labour (family and hired) accounted for and charged at Tsh 250 per hour.

Table 40. *Feeds utilised in the year Jan. 1997 - Dec. 1997 by the six case study farmers in Kilimanjaro*

Wealth group	High		Medium		Low	
Farmer	A	B	C	D	E	F
a) Feed utilised in kg DM						
Planted fodder	2278	2714	1664	2101	1050	1277
Maize stover	432	648	144	675	144	144
Roadside grass	525	2100	525	1365	158	840
Sunflower seed cake	360	675	90	360	90	225
Wheat feed	450	450	180	270	0	135
Banana leaves	1747	1747	1092	1092	1092	1529
Banana pseudostems	562	562	351	351	351	491
Weeds	1080	864	756	1296	756	1080
MPTs	1750	2800	1400	1225	1225	1575
Bean straw	-	-	248	180	144	0
b) Feed utilised in kg/TLU						
Planted fodder	530	377	438	350	553	345
Maize stover	100	90	38	113	76	39
Roadside grass	122	292	138	228	83	227
Sunflower seed cake	84	94	24	60	47	61
Wheat feed	105	63	47	45	0	36
Banana leaves	406	243	287	182	575	413
Banana pseudostems	131	78	92	59	185	133
Weeds	251	120	199	216	398	292
MPTs	407	389	368	204	645	426
Bean straw	0	0	65	30	76	0
c) Relating feed utilised and animals kept on farm						
Average TLU kept[1]	4.3	7.2	3.8	6.0	1.9	3.7
TLU based on 400 kg cow[2]	2.7	4.5	2.4	3.7	1.2	2.3
Annual feed offered[3] (kg DM)	9184	12560	6450	8915	5010	7296
Feed offered per day[4] (kg DM)	25.2	34.4	17.8	24.4	13.7	20.0
Feed kg DM/TLU/day[5]	5.9	4.8	4.7	4.1	7.2	5.4
Feed kg DM/400 kg cow/day[6]	9.3	7.6	7.4	6.6	11.4	8.7
Feed as % of 400 kg LW cow[7]	2.3	1.9	1.9	1.6	2.9	2.2

1 From Table 34
2. Calculated by multiplying the TLU kept by farmers as shown in Table 34 by 250 kg and dividing by 400 kg to give a TLU based on 400 kg cow equivalent.
3 Calculated by adding the annual contribution of different feed types
4 Calculated by dividing the annual feed offered by 365
5 Calculated by dividing the daily feed offered by the average TLU kept on farm
6 Calculated by dividing the daily feed offered by TLU based on 400 kg cow equivalent
7 Calculated on the assumption that available feed was distributed equally throughout the year.

Table 41. *Seasonal distribution of the feeds used in 1997 by the case study farmers in Kilimanjaro (kg DM)*[1]

Season	Short Dry		Long Wet				Long Dry				Short Wet			Feed type as %
Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	of total
Planted fodder	150	150	159	159	159	159	142	142	142	142	168	168	1840	23
Multipurpose trees[3]	139	139	139	139	139	139	139	139	139	139	139	139	1668	20
Banana leaves	145	145	89	89	89	89	137	137	137	137	95	95	1384	17
Weeds	0	0	243	243	243	243	0	0	0	0	0	0	972	12
Roadside grass	150	150	0	0	0	0	141	141	159	159	18	0	919	11
Banana pseudostems	47	47	29	29	29	29	44	44	44	44	30	30	446	5
Sunflower seed cake[4]	25	25	25	25	25	25	25	25	25	25	25	25	300	4
Maize stover	24	24	0	0	0	0	0	30	23	49	68	69	287	4
Wheat feed[4]	21	21	21	21	21	21	21	21	21	21	21	21	252	3
Bean straw	8	0	0	0	0	0	0	9	9	0	7	15	47	1
Total kg DM offered/month	709	701	705	705	705	705	649	679	690	716	571	562	8103	100
Average TLU kept	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5		
TLU based on 400 kg cow[5]	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8		
DM offered per day (kg)	23.6	23.4	23.5	23.5	23.5	23.5	21.6	22.6	23.0	23.9	19.0	18.7		
DM/400 kg cow/d[6]	8.4	8.3	8.4	8.4	8.4	8.4	7.7	8.1	8.2	8.5	6.8	6.7		
DM offered as % of 400 kg LW	2.1	2.1	2.1	2.1	2.1	2.1	1.9	2.0	2.1	2.1	1.7	1.7		

[1] The figures presented are the average of the six case study farmers in Kilimanjaro
[3] Farmers estimated an average daily use of between 10 - 15 kg of fresh MPTs per day in all seasons
[4] Concentrate feeds (sunflower seed cake and wheat feed) were offered only to lactating cows during milking and did not vary with season
[5] Calculated by multiplying the average TLU kept by 250 and then dividing by 400
[6] Calculated by dividing the DM offered per day by TLU based on 400 kg cow

Table 41 shows that maize stover, roadside grass, weeds and bean straw were seasonal feeds. It is interesting to note that in the Phase 1 PRA field studies, weeds were not mentioned as an important feed resource, but the case study farmers mentioned this feed resource and indicated its importance to the annual feed offered on farm. The reason for this may be the fact that during PRA field studies farmers were concentrating only on feeds available during the dry season when they found it difficult to feed their animals. The case studies revealed that weeds contributed largely during the long wet season (March - June) where they contributed up to 34% of the total DM offered. However, the overall annual contribution of weeds was only 12%, ranking fourth after planted fodder (23%), MPTs (20%) and banana leaves (17%).

Of the ten different feed types used on farm, planted fodder, MPTs and banana leaves were the most important, accounting for about 60% of the annual feed supply on the farm. Weeds, roadside grass, maize stover and bean straw were seasonal feeds, with roadside grass and weeds being the most important, contributing up to 11% and 12% of the annual feed supply respectively. Bean straw and maize stover contributed only 1% and 4% of the annual feed supply respectively. Despite the low contribution of maize stover to the annual feed supply, farmers during the PRA field studies ranked stover as the most important dry season feed that should receive research interventions. Strategies for increasing planted fodder production were also ranked high for research intervention.

5.4.4.9 *Banana-based feeds*

Banana-based feeds (banana leaves and banana pseudostems) were among the abundant feeds reported to be available throughout the year in Kilimanjaro and were contributing up to 22% of the annual feed used on-farm. With the exception of banana fruit peelings (which forms almost a negligible portion of the ruminant feed in Kilimanjaro), banana vegetative parts are characterised by low nutritive value (Kimambo and Muya, 1989; Kimambo *et al.,* 1990). The PRA field studies explained how farmers feed the banana-based feeds, but did not show farmer practice on how they conserve banana-based feed resources to be used in the dry season.

It was expected that banana-based feeds would have been used more during the wet season when they are abundant. However farmers claimed that animals do not eat much of this feed during the wet season and so only a limited amount is offered. In the wet season much of the available excess banana leaves were pruned to act as a mulch in the coffee/banana field. Apart from the banana leaves, farmers also indicated that during the wet season many suckers come up. Farmers had a strategic way of removing these suckers to allow for both fruit and feed. Normally three suckers per plant were allowed to grow to fruiting stage. In the strategic de-suckering, an extra sucker was allowed which was removed later for feeding the animals. The number and sequence of leaving these suckers depended on the number of animals kept, the canopy cover, species/variety of banana and the amount of manure applied. The extra suckers left on the plant were normally conserved fodder which could be used for a few days at the beginning of the dry season. This information did not emerge from the PRA field studies.

Research on forage production and utilisation of banana-based feed resources has not reported the "leaving of suckers" approach to fodder conservation. Babatunde (1991) stated that much research on banana as animal feed had concentrated on the fruit for feeding monogastric animals. However, Sheikh (1989) attempted to ensile banana vegetative parts, but the results were not promising.

Other traditional ways of using the banana-based feed resources explained by the case-study farmers included strategic pruning of the banana leaves for feeding animals during the dry season. During the dry season, the main considerations observed while pruning banana leaves for animal feeding included the variety, number of leaves present and stage of growth. Tushimereirwe (1996) showed that farmers in Uganda left more than eight leaves on pre-flowered plants. After flowering and when the fruit was maturing, severe pruning (mainly to reduce the weight and avoid toppling of the plant in case of heavy weight) to leave up to two leaves did not affect the quality of the fruit, however four leaves are recommended. This suggests that research on the use of banana based feeds for animal feeding should therefore include the farmer, banana agronomist and animal scientist.

5.4.4.10 *Multipurpose trees (MPTs)*

The PRA findings showed that farmers in Kilimanjaro used several local MPTs to feed their animals. The seasonal and annual contribution of different feed types showed that there was a relatively high inclusion of MPTs in the feed offered. MPTs contributed up to 20% of the annual DM offered and its use was apparently evenly distributed throughout the year.

The quantities of MPTs given in Table 41 were based on farmers estimating that, on average, they used 10 – 15 kg per day of fresh feed from MPTs. This estimate was found plausible, but it still holds that during the wet season the use of this feed resource was higher than in the dry season. This reasoning is based on the fact that farmers mentioned rationing of feed from MPTs by strategic pruning of twigs and mixing different tree species when feeding during the dry season.

5.4.4.11 *Maize stover and roadside grass*

Maize stover and roadside grass were the main dry season forage feeds mentioned by farmers. The contribution of bean straw was only 1% and considered negligible. Roadside grass contributed up to 11% of the annual feed DM supply, while maize stover was low at only 4% of annual feed DM supply for the six case-study farmers in Kilimanjaro location. On the other hand, cost analysis showed that maize stover had the highest cost per MJ of ME (Tsh 11) when compared to the other feed sources. The PRA field studies revealed that farmers were aware of this problem since they pointed to high transportation costs as a constraint to the use of maize stover and scored high the strategy of manual box-baling as a promising research intervention for reducing the bulkiness of stover.

The seasonal distribution of different feeds showed that maize stover was used from August (when it is harvested) to February. Farmers indicated that during the short wet season (November and December) the use of maize stover increased compared to its use during the peak dry season. The reason given by farmers was that more stover was used to mix with succulent banana pseudostems, as less roadside grass was purchased. Further investigation of this observation revealed that farmers were reluctant to use cash to purchase roadside grass while they had maize stover at home that could substitute for roadside grass. The use of roadside grass dropped from about 22% in July to October, to about 3% in November while the use of stover rose form 5% in August to October, to 12% in November to December.

The substitution of roadside grass with maize stover from November to December would seem to farmers to be a good strategy as less ‘cash’ was used during this period. However, farmers were seemingly unaware that the cost per MJ ME derived from roadside grass was less (Tsh 6) than that derived from maize stover (Tsh 11).

Farmers gave two main reasons for the high value attached to maize stover. Firstly, maize stover was reliable because even during severe drought the stalks that had failed to produce grain ended up as stover, and the stover could be transported home to feed animals. Secondly, some farmers preferred not to buy roadside grass cut during the wet season, as they claimed that it could be associated with carrying home worms. However, there is no research to support this claim.

Past research (Urio and Mlay, 1985; Laurent and Centres, 1990; Kimambo *et al.,* 1990; Shirima, 1994) and the PRA findings of the present study showed the dependence on maize stover as a dry season feed in Kilimanjaro. This dependence is expected to increase due to the increasing fragmentation of land in the highlands because of population growth and inheritance leading to less land being available for growing Napier. Therefore one research task on maize stover is to develop strategies that will reduce its transportation costs and hence reduce stover cost per MJ of ME at the user site. Reducing the cost of transport would also contribute towards adoption of other improved technologies on maize stover utilisation in the study area and hence have an impact on milk production.

Manual box-baling was investigated as one option and its impact on the changes in ME (MJ) cost was presented in Figures 4 and 5.

5.4.4.12 *Use of weeds and its limitations*

As shown in Table 41, weeds contributed up to 34% of the feed DM supply during the long wet season and about 12% of the annual feed DM supply. The case-study farmers pointed to one main limitation of weeds as feed: the possibility of poisoning animals following feeding weeds from recently sprayed coffee fields. Coffee trees are normally sprayed seasonally with pesticides that are indicated poisonous to human beings and animals. Manufacturers do indicate a period of between 10 – 14 days when vegetables and animal feeds obtained from sprayed fields should be discarded, but sometimes farmers overlook this instruction. Weeds removed within this period are not used as feed but are used as mulch. Farmers' coping mechanisms for ensuring efficient use of both labour (labour used in weeding also produces feed for animals) and feed resources include spraying the fields after weeding.

Another limitation to the use of weeds is the acute fluctuation in type of forage feed offered. During the peak weeding period, animals are constantly fed weeds but this feed discontinues immediately weeding ends. Farmers may not be aware of the effect of such fluctuations, but a recent study in Kenya (Sanda *et al.*, 1999) reported poor performance of animals when the type of forage offered was changed every five days. Further research to investigate the effects of fluctuations on type of feed offered and develop ways of mitigating it is recommended.

5.4.4.13 *Limitations of feed resources available on farm*

Except for concentrates and to some extent planted fodder, most of the forage feeds listed in Table 42 are low quality forages (i.e. low in ME concentration). The factor limiting supply of ME from these feeds is animal intake. The calculated ME available per 400 kg cow varied between farmers. A higher ME was available per 400 kg cow for farmers in the low income group since these farmers kept relatively few animals (low TLU on the farm). Although estimated to be available, this would not all be consumed because of the low ME concentration of the feed. To make use of the available ME of 103.3 MJ ME calculated for farmer E (in the low-income group), the intake would need to be 2.75% to 3.0% of LW. Such intakes would be considered too high and not achievable with low quality forage (the estimated average ME concentration of the feed was 9.2 MJ/kg DM). The calculated milk yield of 9.4 l/day for this farmer was therefore not realistic. Supplementation with more concentrated feed would be essential to achieve 9.4 l/day.

When calculating the dairy enterprise budget, it was found that feed was the most expensive item (accounting for 68% of the TVC) and that milk was the main income (accounting also 68% of the total revenue). Therefore, strategies that would lead to better use of feeds at lower cost would likely improve farm profits. Profitability would be improved further if such strategies were associated with an increase in milk price.

5.4.4.14 *Handling and feeding of forage feeds at homesteads in the highlands*

There were three main sources of forage feeds used on farm, namely the highland plot, the lowland plot and grass from the roadside or from the bi-weekly local market at Kwasadala. The sale of local grass in the markets is now becoming a common practice and is likely to open up the sale of planted fodder by farmers who do not keep cattle. Forages from the highland plot included planted fodder, banana based feeds, MPTs and weeds. Handling of these feeds involved use of family labour or casual labour in cutting and carrying feed for the animals. Forage from the lowland plot included crop residues and particularly maize stover. Handling of this feed involved transporting as loose material in 1.0 t pickups to the user site in the highlands (about 20 km away). Grass from the roadside and the local market was purchased. Handling of the roadside grass involved purchase and transport to the highland site. Roadside grasses were transported in pickups and sometimes in car boots and on roof racks (carriers) of cars.

PRA field-studies and the observations made during the farm visits showed that stover was stacked around the animal house or stored in partly completed sheds (without roof). Lack of proper forage storage was associated with lack of capital to build the sheds.

Feeding of the forage at the homesteads depended on several factors. When labour was limiting, as during the peak coffee-picking period, animals were fed with feeds requiring minimum time to collect. These included un-chopped banana leaves (normally banana leaves and banana pseudostems are chopped before feeding) and sometimes stored feed (stover or roadside grass), regardless of whether it was the dry season or not. During the weeding period in the coffee/banana field, animals were fed weeds obtained from the field.

Maize stover was chopped before being fed and in most cases chopped stover was mixed with chopped banana leaves and pseudostems. Sprinkling with salted water or *"magadi"* was mentioned as a common procedure used by farmers in the study area. Farmers claimed that this increased the appetite of the animals, but there is no research evidence that has evaluated this farmer practice. Further research on this farmer practice is suggested.

5.4.4.15 *Feed nutritional values and costs.*

Presenting the annual feed utilised on farm (Tables 40 and 41) on a kg DM basis, provides little information on nutrient availability to the animals as there is a large variation in nutrient concentration between feeds, even at the same DM content. Feed ME was therefore used to evaluate the different feeds used by the case study farmers. Energy is the major nutrient required by dairy cows and is second only to DM intake in terms of its importance in ration formulation (Chamberlain and Wilkinson, 1996).

The ME value of the feeds used by each of the six case study farmers was calculated by multiplying the amount offered in Table 40 by the respective ME value in Table 39. The ME supplied by each feed and its contribution (%) to the annual ME supplied are presented in Table 42. In addition, Table 42 shows the expected utilisation of the offered ME for maintenance and milk production. The calculations of ME requirement for both maintenance and milk production were based on equations given by AFRC (1993). The ME for maintenance for 400 kg cow was calculated to be 47 MJ and this was deducted from the daily ME supplied. The balance ME was assumed to be used for milk production. Calculations of ME requirement for milk production were based on Equations 55 and 56 in AFRC (1993), the results of which showed that about six MJ of ME is required to produce one litre of milk.

The ME requirement for pregnancy was not considered because farmers reported a calving interval of 18 - 22 months indicating extension of the feed budget beyond the budgetary year under the calculation. Furthermore, the inaccuracy introduced by ignoring the requirement for pregnancy was considered unimportant bearing in mind that the purpose of the budgeting was to provide a platform to compare the economic implication of different strategies.

The potential milk yield shown in Table 42 was calculated assuming that all the feed ME on offer was consumed by the animals. There may be some error here in that some of the feed offered was refused and hence did not contribute to the ME under calculation. However, observations made during the farm visits showed that farmers had their way of maximising the use of feed available by offering it 'piece meal' to maximise intake and reduce refusals. When only a small amount of feed was put in the trough the animal had less room for selection and therefore consumed most of it (Aboud *et al.,* 1993). In this situation the amount of feed offered would be the intake.

Table 42. *ME supply by different feed, their % contribution to the annual total ME and potential milk yield for the six case study farmers in Kilimanjaro in 1997*

Wealth group	High income		Medium income		Low income	
Farmer	A	B	C	D	E	F
Planted fodder (MJ ME)	22780 [25]	27140 [23]	16640 [27]	21010 [24]	10510 [22]	12770 [18]
Multipurpose trees (MPTs) (MJ ME)	15400 [18]	24640 [20]	12320 [20]	10780 [12]	10780 [22]	13860 [20]
Banana leaves (MJ ME)	13277 [15]	13277 [11]	8299 [13]	8299 [10]	8299 [17]	11620 [17]
Weeds (MJ ME)	10044 [15]	8035 [9]	7030 [15]	12053 [18]	7031 [20]	10044 [19]
Roadside grass (MJ ME)	4883 [5]	19530 [16]	4883 [8]	12695 [14]	1469 [3]	7812 [11]
Banana pseudostems (MJ ME)	5789 [5]	5789 [5]	3615 [6]	3615 [4]	3615 [8]	5057 [7]
Sunflower seed cake (MJ ME)	4284 [5]	8032 [7]	1071 [2]	4284 [5]	1071 [2]	2678 [4]
Maize stover (MJ ME)	3715 [4]	5573 [5]	1238 [2]	5805 [7]	1238 [3]	1238 [2]
Wheat feed (MJ ME)	5265 [6]	5265 [4]	2106 [3]	3159 [4]	0	1580 [2]
Bean straw (MJ ME)	0	0	2158 [4]	1566 [2]	1253 [3]	0
Annual available ME (MJ)	85436 [100]	117281 [100]	59360 [100]	83265 [100]	45257 [100]	66659 [100]
Available ME/day[1] (MJ)	234	321	163	228	124	183
TLU based on 400 kg cow[2]	2.7	4.5	2.4	3.7	1.2	2.3
ME available per 400 kg cow (MJ/day)	86.7	71.4	67.7	61.6	103.3	79.4
ME for maintenance (400 kg cow) MJ/day	47	47	47	47	47	47
ME available for milk (MJ/day)	39.7	24.4	20.7	14.6	56.3	32.4
Potential milk production (l/day)[3]	6.6	4.0	3.4	2.4	9.4	5.4

[1] Calculated on assumption that the total available ME was equally distributed in the year.

[2] Calculated as shown in footnote in Table 37.

[3] Calculated requirement for producing one litre of milk was 6 MJ ME.

Numbers in brackets represent percent contribution to the annual total ME used on farm.

Table 43. *Individual feed costs and their % contribution to the total annual feed costs of the six case study farmers in Kilimanjaro in 1997 (Tsh)*

Wealth group	High income		Medium income		Low income	
Farmer	A	B	C	D	E	F
Planted fodder	71,500 [20]	84,500 [18]	52,000 [27]	65,000 [21]	32,500 [23]	39,000 [17]
Multipurpose trees (MPTs)	65,000 [19]	30,000 [6]	32,500 [17]	39,000 [12]	39,000 [28]	52,000 [22]
Banana leaves	27,000 [8]	30,000 [6]	16,500 [9]	16,500 [5]	16,500 [12]	23,500 [10]
Weeds[1]	0	0	0	0	0	0
Roadside grass	30,000 [9]	120,000 [25]	30,000 [16]	78,000 [25]	9,000 [7]	48,000 [20]
Banana pseudostems	25,000 [7]	30,000 [6]	16,000 [8]	16,000 [5]	16,000 [11]	22,000 [9]
Sunflower seed cake	40,000 [12]	75,000 [16]	10,000 [5]	40,000 [13]	10,000 *[7]*	25,000 [11]
Maize stover	45,000 [13]	72,000 [15]	15,000 [8]	34,000 [11]	15,000 [11]	15,000 [6]
Wheat feed	40,000 [12]	40,000 [8]	16,000 [9]	24,000 [7]	0	12,000 [5]
Bean straw	0	0	2,200 [1]	2,000 [1]	2,000 [1]	0
Total feed costs	343,500 [100]	481,500 [100]	190,200 [100]	314,500 [100]	140,000 [100]	236,500 [100]

[1] Cost of weeding was attributed to coffee/banana enterprise and not to livestock enterprise.

Numbers in brackets represent percent contribution to the total feed costs.

The metabolizable protein (MP) system (AFRC, 1993) has replaced the traditional crude protein (CP) system as a standard for the protein requirement for ruminants. The MP system is beginning to be used in developing countries. However, due to lack of assessment of feeds for MP, the CP system is still the most commonly used system in developing countries. Chamberlain and Wilkinson (1996) stated that protein ranked third as a limiting factor in dairy cow nutrition, after voluntary dry matter intake and energy. In this study the primary forage utilisation constraint facing the smallholder farmers in the study area was the quantity available. Therefore consideration of the quality component was confined to energy, since the levels of milk production (summarised in Table 7) were below the 10.5 kg per day that could be sustained by feeding forage alone (Anindo and Potter, 1986; Muinga *et al.,* 1993).

The CP contents for the feeds offered are presented in Table 39. The average dietary protein content of the feeds offered by the case study farmers was calculated to be 124 g/kg DM. This calculated CP level is within the range 120 – 130 g CP per kg DM considered sufficient for both maintenance and milk production for cattle in the tropics consuming sufficient levels of DM (Sloan and Rowlison, 1988). Satter (1985) also showed that the most profitable level of CP supplementation is to increase the dietary CP to about 120 g/kg DM.

An interesting perception of protein supplementation was raised by a farmer during the Phase 2 PRA field studies in Kilimanjaro while discussing the need for concentrate supplementation to supply both energy and protein to the animal. The farmer said "*you are telling us to buy concentrate to supplement our cattle, but who is supplementing the zebras and the buffaloes in the national parks? These zebras and buffaloes are always healthy and breed very well"*. This comment shows that farmers believe forage is a complete diet for ruminant animals, and the concern is how to have more forage for the animals rather than supplementation by using concentrate. It may be argued therefore that strategies for protein supplementation to animals in smallholdings may be feasible if addressed through incorporation of leguminous forages and MPTs such as *Leucaena* spp.*, Sesbania spp, Gliricidia* spp. and *Calliandra* spp. into the planted fodder. Studies at the University of Reading have demonstrated the benefits of alley cropping of *Leucaena* with food crops (Mureithi, 1992) and Calliandra/Napier grass intercropping technology (Nyaata, 1998) on smallholder dairy farms in Central Kenya. Study by Nyaata (1998) has confidently predicted the adoption of this technology by farmers. Paterson *et al.* (1996) demonstrated that 3 kg/day of fresh Calliandra leaf gives the same milk production as 1 kg of commercial concentrate.

5.4.4.16 *Feed costs*

Sources of forage feeds used on farm were presented earlier. The costs associated with handling of forage feed obtained from the highland plot included labour hours used in gathering and feeding. Farmers were asked to indicate the labour time used in handling one unit (see Tables 38 and 39 for farmer units of measure), and the costs were obtained by multiplying the labour hours used by Tsh 250 which was the calculated labour charge per hour. Maize stover was valued as the cost of hiring a 1.0 t pickup per trip for transporting stover. The majority of farmers harvested the stover from their own plots in the lowlands. Roadside grass and concentrates were valued at the market price for the year 1997, plus transportation costs where applicable.

Feed costs and their % contribution to the total feed costs for the feeds used by the six case study farmers in Kilimanjaro are presented in Table 43. Based on the values from Table 43, cost per MJ ME for different feedstuffs are presented in Table 44.

Table 44. *Cost per MJ of ME for different feeds used by six case study farmers in Kilimanjaro in 1997 (Tsh)*

Wealth group	High income		Medium income		Low income	
Farmer	A	B	C	D	E	F
Maize stover[1]	11	12	11	5	11	11
Sunflower seed cake	9	9	9	9	9	9
Wheat feed	8	8	8	8	-	8
Roadside grass	6	6	6	6	6	6
Multipurpose trees (MPTs)	4	2	3	4	4	4
Planted fodder	3	3	3	3	3	3
Banana leaves	3	2	3	3	3	3
Banana pseudostems	3	2	3	3	3	3
Bean straw	-	-	1	1	2	-
Weeds	0	0	0	0	0	0

[1] The ME for maize stover considered in this table included the ME present in stem which is not normally eaten. When this is excluded the cost per MJ of ME from stover doubles.

Source: Based on data in Tables 42 and 43

5.4.5 Economic implications of strategies to improve forage utilization in Kilimanjaro.

5.4.5.1 *Cost implications of handling and transporting loose stover or after manual box-baling, using data from the six case-study farmers*

The importance of maize stover, despite its low contribution to the annual feed supply (only 4%) for smallholder farms in Kilimanjaro was discussed above. During the PRA field studies farmers prioritised maize stover as a high priority for technical research. The farmers specifically requested ways of reducing the bulkiness of stover to increase the payload transported and thus reduce the cost per unit of stover.

Each of the six case-study farmers gave the actual cost of maize stover used in the year 1997. The costs given were based on the farmers' practice of transporting the stover as loose material in a 1.0 t pick-up. During discussion with each of the six farmers, cost comparisons were made to illustrate the costs if the stover was baled using the manual box-baling strategy. The hypothetical costs saving for stover baled either whole or stripped for LSH, are presented in Table 45.

One limitation to the box-baling practice that was perceived by farmers during the PRA was that a farmer would have to pay for the full hiring cost of a 1.0 t pick-up (Tsh 15,000) regardless of the amount of stover available. However, under the baling technique, two or more farmers could share costs by putting identification tags on their bales and transporting the bales in a communal pickup. The cash saved as a result of baling could be used to transport more stover or be diverted to buy other supplementary feed (e.g. concentrates).

Table 45. *Cost implications of handling and transporting loose stover, manually box baled whole stover or manual box baled leaf, sheath and husks stripped from stover, for six case study farmers in Kilimanjaro in 1997*

Wealth group	High		Medium		Low	
Farmer	A	B	C	D	E	F
Stover transported (kg DM)	432	648	144	675	144	144
Edible LSH in the stover[1] (kg DM)	225	337	75	351	75	75
Costs (Tsh)						
Actual – loose stover	45,000	72,000	15,000	34,000	15,000	15,000
If baled whole stover[2]	30,960	46,368	10,320	18,114	10,320	10,320
If baled LSH[3]	15,480	23,184	5,160	12,076	5,160	5,160
Cost saved (Tsh)						
If baled whole stover	14,040	25,632	4,680	15,886	4,680	4,680
If baled LSH	29,520	48,816	9,840	21,924	9,840	9,840
Percentage savings (%)						
If baled whole stover[4]	31	37	31	47	31	31
If baled LSH[5]	66	68	66	64	66	66

[1] Based on 52% LSH in whole stover (Table 23)
[2] Cost per MJ ME when stover is baled whole and transported in 1.0 t pick-up is Tsh 16 (Figure 4), but it is Tsh 6 when transported in 7.0 t lorry (Figure 5). Farmer D used a 7.0 t lorry.
[3] Cost per MJ ME when stover is LSH and transported in 1.0 t pick-up is Tsh 8 (Figure 4), but it is Tsh 4 when transported in 7.0 t lorry (Figure 5). Farmer D used a 7.0 t lorry.
[4] Mean = 35%
[5] Mean =66%

5.4.5.2 *Stripping stover for leaf, sheath and husks (LSH) followed by manual box-baling*

During the PRA field studies, farmers complained that the stem part of the stover was not well eaten by the animals unless physically or chemically treated. This observation is supported by considerable research (Zemmelink, 1980; Aboud, 1991; Osafo *et al.,* 1997; Methu, 1998) showing that ruminants select against stem in sorghum and maize stover. Also during the PRAs farmers indicated little or no chemical treatment of stover being practised. In view of this, it was considered that a strategy that would ensure transportation of the more edible parts of the stover would be of advantage to the farmers. LSH is the edible part of maize stover as confirmed by Methu (1998). Technical research to evaluate the economics of stripping for LSH associated with manual box-baling was presented earlier.

In Table 44 ME was adopted as a unit for expressing feed costs, the aim being to find strategies that could supply ME at low cost. The analysis of costs associated with handling maize stover as LSH in combination with manual box-baling based on data from the six case-study farmers was assessed by looking at the cost of ME in LSH (Table 46).

Table 46 *Analysis of cost of LSH based on data from six case study farmers in Kilimanjaro in 1997*

Wealth group	High		Medium		Low	
Farmer	A	B	C	D	E	F
Amount of stover[1] (kg DM)	432	648	144	675	144	144
Cost incurred[2] (Tsh)	45,000	72,000	15,000	34,000	15,000	15,000
Amount in LSH[3] (kg DM)	225	337	75	351	75	75
Potential ME from LSH[4] (MJ)	1935	2898	645	3019	645	645
Cost per kg DM[5] LSH (Tsh)	200	214	200	97	200	200
Cost per MJ ME[5] (Tsh) (based of farmer data and farmer practice)	23	25	23	11	23	23
Cost per MJ ME if LSH handled under baling strategy of LSH[6] (Tsh)	7	7	7	4	7	7

[1] Actual stover handled by farmer
[2] Actual cost paid by farmer
[3] Based on 52 % LSH in whole stover (Table 23)
[4] The ME value of LSH is 8.6 MJ/kg DM (FAO, 1981, 1991)
[5] Farmer D used 7.0 t lorry to transport stover hence low cost per MJ ME
[6] From Figures 4 and 5

Table 46 showed a large reduction in cost per MJ ME from Tsh 23 to Tsh 7 when comparing farmer practice and the strategy of baling (LSH). Also interesting to note in Table 46 is that for farmer D who used a 7.0 t lorry to transport the stover the cost per MJ ME was also low compared to other farmers. This agrees with the results of Experiment 3 (Figure 5).

5.4.5.3 *Maize stover storage component*

The farmer practice of storing stover and other fibrous feeds (e.g. roadside grass) has been described earlier. The direct observations made during the PRA field studies revealed lack of or poorly constructed feed storage sheds. The strategy of box-baling maize stover for transport should be combined with advocating construction of better sheds for storing the bales.

Estimating the space requirement for storing stover can be based on the principles applied to reducing space while transporting loose and baled stover in a 1.0 t pick-up. The volume of the pickup used was 4.6 m^3 and this loaded 160 kg loose stover indicating about 35 kg/m^3. The same pickup could transport 264 kg (22 bales) of stover as baled material from the medium size box, indicating about 57 kg/m^3. This is an increase of 63% of the material stored in the same space.

Storage is an important component as it helps to keep feed for use during the periods of feed scarcity. Good storage is associated with the cost of constructing a forage barn. During the phase 2 PRA field-studies in Kilimanjaro, the issue of forage storage was discussed, but farmers pointed to lack of capital to construct the forage shed as a barrier. Joint effort was suggested as a starting point for the farmers to help themselves. Participatory budget estimates were carried out with farmers, to construct a forage shed large enough to store about 4 – 6 trips of loose stover transported in a 1.0 t pick-up (shown in Table 47).

Table 47 *Budget estimates for constructing forage shed to store 4 - 6 trips of loose stover transported in a 1.0 t pick-up*[1]

Item	Quantity	Unit Price[2] (Tsh)	Cost (Tsh)
Corrugated iron sheets (each)	5	4,800	24,000
Timber (5 x 10 x 300 cm)	10	700	7,000
Posts (about 3.5 m tall)	6	500	3,000
Nails (kg)	2	600	1,200
Labour charge (mandays)	2	2,500	5,000
Sub-Total			40,200
Add 10 % contingency			4,800
Grand Total			45,000
Annual value of the shed[3]			5625

[1] The volume of the shed is about 36 m^3 (i.e. corrugated iron sheets cover 4 m run, timber = 3 m run and the posts are 3 m high after allowing 0.25 m in earth and 0.25 m raised platform).
[2] Prices are based on 1997 market prices.
[3] Farmers estimated life span of the shed to be 8 years, hence equal annual instalments of Tsh 5625

The shed considered in Table 47 could store a maximum of 1260 kg of loose stover (about 8 trips of loose stover in 1.0 t pick-up) or 2052 kg of baled stover (171 bales). Based on the annual value of the shed shown in Table 47, and assuming the shed is fully filled, the annual storage costs are Tsh 5 and Tsh 3 per kg DM for loose and baled stover respectively. These storage costs are almost negligible when calculated on monthly or daily basis.

Farmers complained that the total budget (Tsh 45,000) was high and would not be affordable in one season. Farmers further pointed out that unlike construction of a house which can be carried out in steps and be finished in 2 – 3 years, the forage shed would need to be constructed and roofed within a short period to avoid spoilage of posts and side cuts. The problem was therefore how to get a lump sum of money to construct the shed.

An idea of farmer to farmer joint effort and self-help was put forward. This idea works on the assumption that a group of farmers pool their resources and construct forage sheds in sequence until all farmers in the group own a forage shed. Farmers indicated that the majority of farmers could afford to contribute Tsh 1,500 per month and that the group should not exceed ten farmers. The calculations showed that through joint-efforts, and by contributing Tsh 1,500 per month, ten farmers in a group could each have a forage shed within a period of thirty months. The life span of the shed was estimated at 8 years. This option would not need research but would require community sensitisation and formation of voluntary groups.

5.4.5.4 *Is excess feeding of maize stover an economically viable strategy?*

High offer rates to allow for selection and refusals of about 50% of the amount offered has been suggested as a strategy to increase the intake of sorghum stovers (Owen, *et al.*, 1989; Aboud, 1991; Osafo, *et al.,* 1997). Although this strategy promotes higher intakes, it generates large quantities of refusals. A recent study on excess feeding of maize stover to lactating dairy cows (Methu, 1998) showed a significant increase in stover intake and milk yield. Methu (1998) used three offer rates of maize stover to investigate effects on intake, selection and milk yield. The offer rates were 30.5 (low), 58.5 (medium) and 86.2 (high) g DM/kg LW.d respectively. The stover was supplemented with 3.18 kg DM/d of cotton seed cake containing 339 g/kg DM crude protein (intake of CP = 1.08 kg/d). The milk yields were 10.0, 11.2 and 12.2 kg/cow/day for the three different offer rates respectively. Although there are no documented data on the quantities of stover offered per cow by smallholder farmers, the offer rates used by Methu (1998) are considered much higher than actual rates used by farmers. The low offer rate used by Methu (1998) would probably be the high offer rate under smallholder farms. Missing from Methu's study was the cost of excess stover offered compared to the revenue obtained from the extra milk produced.

In the present study, the economic viability of excess feeding of maize stover was assessed using the results reported by Methu (1998) and the cost analysis in Figure 4. This was intended to develop conditions where it might be reasonable to recommend an excess feeding strategy. The results of the analyses are shown in Table 48.

Table 48 *Feed costs and revenue from milk for a dairy cow offered maize stover at three different rates and supplemented with 3.18 kg/d cotton seed cake (CSC) as in Methu (1998)*

Rate of offer of stover	Low	Medium	High
Basic information			
Stover offered[1] (kg DM/d)	12.9	25.4	37.8
Stover intake (kg DM/d)[1]	8.1	11.3	12.9
Stover refused[2] (kg/DM/d)	4.8	14.1	24.9
Cost of CSC (Tsh/d)	318	318	318
Milk yield (kg/d)	10.0	11.2	12.2
Revenue from milk[3](Tsh/d)	2000	2240	2440
Total revenue[4](Tsh/d)	2941	3294	3588
Comparisons			
Cost of stover offered if loose[5] (Tsh/d)	1367	2692	4007
Cost of stover offered if baled[6] (Tsh/d)	916	1803	2684
Total feeding cost if stover is loose[7] (Tsh/d)	1685	3010	4325
Total feeding cost if stover is baled[7] (Tsh/d)	1234	2121	3002
Feed cost per kg of milk if stover is loose (Tsh)	169	269	354
Feed cost per kg of milk if stover is baled (Tsh)	123	189	246
Total cost/day if stover is loose[8](Tsh)	2479	4427	6360
Total cost/day if stover is baled[8] (Tsh)	1815	3120	4414
Margin if stover is loose (Tsh/d)	463	-1133	-2772
Margin if stover is baled (Tsh/d)	1127	174	-826

[1] Based on data of Methu (1998)
[2] Farmers in Kilimanjaro indicated no interest in the use of refused stover as manure by putting it in the cow shed as bedding because they use Grevillea and dry banana leaves for bedding
[3] Value of milk was Tsh 200 per kg
[4] Total revenue calculated on the basis that milk contributes 68% of total benefits (Table 36)
[5] Stover cost was Tsh 106 per kg DM (Experiment 1) for stover handled loose
[6] Stover cost was Tsh 71 per kg DM (Experiment 1) for stover handled as bales
[7] Total feed costs calculated by adding the cost of CSC to cost of stover offered
[8] Total cost calculated on the basis that feeding cost contribute 68% of total costs (Table 36)

Table 48 shows that the costs would be higher if stover was handled loose and that profit would be higher if stover was handled as bales. Feed cost for producing 1 kg of milk would increase with increasing offer rate and this would result in a decrease in profit. Refused stover could be converted to manure (Methu, 1998), but PRA with farmers in Kilimanjaro indicated no interest in this because they use *Grevillea robusta* and dry banana leaves for bedding.

5.4.5.5 *Approaches available for improving quality of maize stover*

Maize stover is categorised as a low quality forage. The approaches proposed for improving crop residues such as cereal straw are chemical treatment by alkali (Kategile, 1978; Urio, 1977; 1981; Biwi, 1986) and urea (Kiangi, 1981; Schiere and Ibrahim, 1989; Kilongozi, 1992). Attempts to use urine in place of urea have been made with rice, barley and wheat straws (Saadullah *et al.,* 1980; Haque *et al.,* 1983; Wanapat *et al.,* 1985; Virk *et al.,* 1993) but little is known concerning the use of urine to upgrade maize stover. Recent attempts by Methu (1998) to compare cattle urine and commercial urea in up-grading maize stover were inconclusive. A survey carried out in Kilimanjaro (Mgheni, 1993) showed that there were no taboos against the use of urine in animal feed, but farmers were not using it. In most cases farmers were not aware that urine could be used to improve the quality of the stover fed to their animals.

In a literature review on the use of crop residues as animal feeds in developing countries, Owen and Jayasuriya (1989) noted that, experiences in many parts of the tropics have showed alkali treatment to be not only expensive but unsuitable at village level, because of its hazardous nature. There was also little treatment of crop residues with urea in the tropics despite much research done. Experiences with the use of urea to treat maize stover in Tanzania showed that although the results were promising, the technology was expensive and labour demanding. These constraints together with unreliable sources of urea and the fact that stover needed transporting from the lowlands to highland sites in Kilimanjaro contributed to lack of adoption of the technology (Laurent and Centres, 1990).

Physical treatment of stover such as chopping, soaking in water, soaking in *"magadi"* and stripping to yield edible leaf, sheath and husk parts could easily be used by farmers. Currently farmers in Kilimanjaro only practise chopping and soaking in water and soaking in *"magadi"*. They do not practise stripping. Farmers indicated that sprinkling the stover with *"magadi"* improved taste and increased intake. The only cost associated with the use of*"magadi"* was the labour time (about 4 h per month) in fetching the *"magadi"* from the source. There is no information on evaluating the effects of the farmer practices of soaking in *"magadi*" on the utilisation of the stover. However, Msangi (1994) found no effect on milk production for cows fed *"magadi"* treated maize stover, although there was a significant effect on feed intake.

5.4.5.6 *Multipurpose trees (MPTs)*

The importance of MPTs in the annual feed supply to smallholder farmers in Kilimanjaro was presented earlier. However, there is scant information on the anti-nutritional factors of local MPTs, which might affect nutrient supply to animals fed these feeds. The tannin concentration of most local MPTs and the effect of tannin on protein availability to animals fed these feeds has not been investigated. Researching these aspects is suggested in parallel with developing the use of MPTs as supplements to ensure sufficient energy and protein is fed to animals during the critical dry periods. The suggested more-basic research on MPTs would provide information required when recommending the amount of given MPT species to be used as a supplement. There is considerable farmer indigenous technical knowledge (ITK) of MPT species which are poisonous and harmful to animals and those that have positive medicinal effects. For example *Rauvolfia caffra* "msesewe" is claimed by some farmers to have a de-worming effect. There is no research to prove or reject this farmer claim. However it is notable that a research Project funded by the Livestock Production Programme of DFID (managed by NRIL) and involving collaboration between the University of Nottingham and

and Sokoine University of Agriculture has just commenced (April 1999). This Project will investigate the anthelmintic properties of Tanzanian MPTs in Morogoro region.

In the present study, strategies on MPTs involved partial budgeting for evaluating the intercropping of *Sesbania* spp. and pigeon peas with maize. Farmers accepted the idea of using pigeon pea, but were not aware of *Sesbania* spp. MPTs that could be planted on contour bunds, as is practised by SCAPA project farmers in Arumeru District were also evaluated. The MPT species found in the SCAPA project area were *Calliandra, Gliricidia, Sesbania* and *Leucaena.* However as land is very limited in the study area, there is a need for careful research to investigate both biomass production and nutritive value before recommending a specific MPT. Use of leguminous MPTs would help boost the protein content of feed supplied on farm.

5.4.6 Testing of some strategies for increasing profitable milk production.

5.4.6.1 *Background to development of the spreadsheet data used in the sensitivity tests*

Data from the six case-study farmers were pooled to produce a master spreadsheet based on the averages. The pooling of data provided a more realistic seasonal distribution in the use of different feed types and gave a better platform for assessing the economic implication of various strategies for increasing profitable milk production. It was also used to to make a 'hypothetical' farm to represent farmers in Kilimanjaro. However, as cautioned earlier, the sample of six case-study farmers was too small to allow true representation of the location.

The master spreadsheet composed of a feed spreadsheet and a cost spreadsheet that were linked such that a change in one component in any of the spreadsheet was reflected in the summary part that indicates the enterprise budget (margin).

Components of the feed spreadsheet were:-

- Weight of feed units used as fed basis
- Number of units offered for each of the feed types on a monthly basis
- DM % of each of the feeds offered
- ME concentration of each of the feeds offered
- TLU kept on farm (based on 250 kg LW per TLU)
- LW of dairy cows kept (400 kg)
- Milk price (Tsh 200)

Components of the cost spreadsheet were:-

- Cost per unit for purchase and transport of feed
- Cost of labour per hour (Tsh 250)
- Labour hours/unit (for feeds that required labour in gathering e.g. cutting of planted fodder and gathering and feeding of banana leaves and banana pseudostems)
- Other non-feed costs associated with the dairy enterprise

Using the above information, the spreadsheet could calculate the ME offered to a 400 kg cow per month and per day. The ME required for maintenance for a 400 kg cow was calculated to be 46.4 MJ ME/day (Equation 39 in AFRC, 1993) and was fed into the spreadsheet. The spreadsheet then subtracted the ME required for maintenance from the daily ME offered and the balance ME was considered to be used for milk production. The spreadsheet gave daily milk yields of about 5.0 l/day in all months except in November and December when the average dropped to 3.0 l/day. Mean actual yield from the six case-study farmers was 5.5 l/day. The spreadsheet ran milk production for 12 months giving an annual value of 1736 l. However, since the six case-study farmers had lactation lengths of 11 months, correction was made to 11 months. The corrected lactation yield that was considered as saleable milk was 1591 l.

The baseline data presented in the master spreadsheet was considered as a control. The baseline data was based on the following:

- Labour charge per h of Tsh 250 (both family and hired labour were charged at this rate)
- Milk price of Tsh 200 (this price remained the same throughout the base year in 1997)
- Fibrous crop residues i.e. maize stover and bean straw were handled as loose material in 1.0 t pickups (traditional farmer practice)
- The average TLU on farm was 4.5 (based on 250 kg LW/TLU) and this was equivalent to 2.8 TLU (based on 400 kg cow)

Based on the pooled data from the six case-study farmers, the control had a corrected lactation yield of 1591 l/cow, enterprise budget (margin) of Tsh 93,549 and enterprise budget (margin) per 400 kg cow equivalent of Tsh 33,262. The sensitivity tests were carried out by introducing a change in the units of feed offered, and after working through the ME values and the costs of the feed in question, the effect on the enterprise budget (margin) was given at the summary part of the cost spreadsheet in the form shown in Table 49. The response or effect of a strategy was noted by looking at the change in enterprise budget (margin) per 400 kg cow equivalent.

Table 49 *Summary contents of the master spreadsheet used in the sensitivity tests to assess the economic implication of various strategies for increasing profitable milk production on smallholdings*

Costs (Tsh)		Benefits (Tsh)	
Opening herd value		Closing herd value	
Cost of individual feeds		Change in herd value[1]	
Total feed costs		Value of milk	
Non-feed costs		Value of manure	
		Sales of animals	
		Purchase of animals[2]	
Total variable costs		Total benefits	
Enterprise budget (margin) = Total benefits – Total variable costs			
Enterprise budget per 400 kg cow[3]			

[1] Change in herd value is calculated as closing herd value minus opening herd value and can be positive or negative as shown in Table 36.
[2] Purchase of animals is a cost component but is normally entered on the benefit side with a negative sign.
[3] Calculated by dividing the enterprise budget (margin) by 2.8 which was the average TLU kept on farm based on a 400 kg cow.

5.4.7 Strategies considered in the sensitivity tests

Six different strategies including the effect of manual box-baling of maize stover were tested for their effect on the enterprise budget as follows:

- Effect of manual box-baling of maize stover
- Effect of change in labour value that was used in gathering and feeding feeds from the farm

- Effect of change in the price of milk
- Effect of substituting high-cost feeds with cheap feeds
- Effect of planting more fodder (use of contour bunds)
- Combination of two or more strategies

The effect of acquiring credit could not be tested in the sensitivity analysis, but the results of injecting more input in the existing system would be expected to be positive and would improve the enterprise budget (margin).

5.4.7.1 *Effect of manual baling of stover on dairy enterprise budget (margin)*

The effect of manual baling of stover was tested by replacing the cost per unit of the stover used on farm by the cost of handling and transporting the same amount of stover under the manual baling technique. The effect was therefore measured in terms of cost saved and not in terms of extra stover transported. Cost per unit of stover used was Tsh 15,000 when handled loose (farmer practice). The same unit cost Tsh 9828 when baled whole stover was used and Tsh 4720 when baled LSH was used. The percentage improvement in enterprise budget (margin) was 11% for baled whole stover and 22% for baled LSH (the assumption made here is that LSH has the same ME as whole stover and would therefore maintain the same yield, however, the ME content of LSH is higher than that of whole stover and may well result in an increase in milk yield). The results are presented in Table 50.

Table 50 *Effect of box-baling of maize stover on the dairy enterprise budget (margin) in 1997*

Expected change	Corrected lactation yield per cow[1] (l)	Margin[2] (Tsh)	Margin per 400 kg cow equivalent (Tsh)	% change in enterprise budget[3] (%)
Mean margin in 1997[4]	1591	93,549	33,262	-
Baled whole stover	1591	103,893	36,940	+11
Baled LSH	1591	114,109	40,472	+22

[1] The model was set to run for 12 months (Jan – Dec) but farmers reported lactation length of 11 months and a correction was therefore done for 330 day deducting the extra month.
[2] Calculated by subtracting the total variable costs from the enterprise total benefits
[3] The mean margin per 400 kg cow equivalent (Tsh 33,262) under the farmer practice was considered as the base and any change from this is presented as a % change.
[4] Control (i.e. based on the farmer practice for the 1997 prices in Kilimanjaro)

5.4.7.2 *Effect of change in labour value on dairy enterprise budget (margin)*

The labour factor was considered for sensitivity testing as in future there may be less family labour available due to the younger generation migrating to towns in search of work or business and family labour may be limited to the husband and wife. Labour is therefore likely to be a limiting factor in the dairy enterprise, with greater reliance on hired labour.

Seven levels of labour value were tested. Level one assumed that the labour used was family labour and not generally paid for on a daily basis but shared in the revenue and margin obtained from the enterprise. Thus at level one the labour charge per hour was Tsh 0. At level two, labour was set at Tsh 125 per hour, based on current Tanzania Government minimum monthly salary of Tsh 30,000 which gives on average a daily pay of Tsh 1,000 for 8 hours working time. At level three labour was set at Tsh 250 per hour. This was based on the current value of casual labour of Tsh 2,000 for 8 hours working time. Level three of labour value acted as the control as the baseline enterprise budget (margin) was calculated at this labour value. Levels four to seven assumed labour values of Tsh 375, 500, 625 and 750 per hour respectively. The enterprise budget became negative when the labour charge per hour was Tsh 500 and above. The results are presented in Table 51.

Table 51 *Effect of change in labour value (Tsh/h) on the dairy enterprise budget (margin) in 1997*

Expected change	Corrected lactation yield per cow[1] (l)	Margin[2] (Tsh)	Margin per 400 kg cow equivalent (Tsh)	% change in enterprise budget[3] (%)
250[4]	1591	93,549	33,262	-
0	1591	238,632	84,847	+115
125	1591	166,091	59,054	+77
375	1591	21,007	7,469	-77
500	1591	-51,534	-18,323	-155
625	1591	-124,076	-44,116	-232
750	1591	-196,618	-69,909	-310

[1] The model was set to run for 12 months (Jan – Dec) but farmers reported lactation length of 11 months and a correction was therefore done for 330 day deducting the extra month
[2] Calculated by subtracting the total variable costs from the enterprise total benefits
[3] The mean margin per 400 kg cow equivalent (Tsh 33,262) under the farmer practice was considered as the base and any change from this is presented as a % change
[4] Control (i.e. based on the farmer practice for the 1997 prices in Kilimanjaro)

5.4.7.3 *Effect of change in milk price on the dairy enterprise budget (margin)*

Milk price used in the calculations of the enterprise budget was Tsh 200 per litre. Although the milk price remained constant throughout 1997, the Tanzania Dairy Sub-Sector Rapid Appraisal survey predicted that with some interventions on milk marketing, the milk prices are likely to rise in the rural areas (MoAC/SUA/ILRI, 1998). The sensitivity analyses were therefore carried out to find out the changes in the dairy enterprise budget as a result of change in milk price. The milk price was first set at Tsh 100 (assuming that the current price declines from Tsh 200 to 100). A change of Tsh 50 was assumed to be the minimum interval for a change from one price level to another, and the sensitivities were carried out at Tsh 100, 150, 200, 250, 300, 350 and 400. The milk price in Moshi town (located 40 km away) was Tsh 250 – 300. The enterprise budget (margin) was negative when the milk price was set at Tsh 100 but increased as the price increased. The results are presented in Table 52.

Table 52 *Effect of change in milk price (Tsh/l) on the dairy enterprise budget (margin) in 1997*

Milk price (Tsh/l)	Corrected lactation yield per cow[1] (l)	Margin[2] (Tsh)	Margin per 400 kg cow equivalent (Tsh)	% change in enterprise budget[3] (%)
200[4]	1591	93,549	33,262	-
100	1591	-65,590	-23,321	-170
150	1591	13,979	4,970	-85
250	1591	173,119	61,553	+85
300	1591	252,688	89,845	+170
350	1591	332,258	118,136	+255
400	1591	411,828	146,428	+340

[1] The model was set to run for 12 months (Jan – Dec) but farmers reported lactation length of 11 months and a correction was therefore done for 330 day deducting the extra month
[2] Calculated by subtracting the total variable costs from the enterprise total benefits
[3] The mean margin per 400 kg cow equivalent (Tsh 33,262) under the farmer practice was considered as the base and any change from this is presented as a % change.
[4] Control (i.e. based on the farmer practice for the 1997 prices in Kilimanjaro)

5.4.7.4 *Effect of replacing maize stover with less expensive feed types*

Table 44 showed that maize stover was the most expensive feed, costing Tsh 11 per MJ ME. This was followed by sunflower seed cake (Tsh 9), wheat feed (Tsh 8) and roadside grass (Tsh 6). Sensitivity analyses were carried out to see the effect of replacing maize stover with sunflower seed cake, wheat feed or roadside grass. On average, farmers used two units of maize stover costing Tsh 32,666. The sensitivity tests assumed that the ME supplied by maize stover, would instead be supplied by sunflower seed cake, wheat feed or roadside grass purchased with the money saved (Tsh 32,666) by not using maize stover. The results of such replacements are presented in Table 53. The percentage changes in the enterprise budget per 400 kg cow as a result of replacing maize stover with sunflower seed cake, wheat feed or roadside grass would be 9%, 19% and 29% respectively. Although replacing maize stover with roadside grass appeared more profitable than replacing with concentrate, this would be limited to availability if the majority of farmers opted for using the roadside grass.

As a check, a sensitivity test was carried out to see the effect of not using maize stover since the individual interviews with the poorest farmers in Kilimanjaro indicated no transportation of maize stover. The poorest farmers used more of the feed resources that required only labour to gather and feed. Since the limitation for these farmers was cash to hire the truck, it was obvious that there was no saving to buy other feed for replacement as shown in the above paragraph.

Interestingly, the sensitivity test showed that without using maize stover transported from the lowlands, the average DM offered as % of LW was 2% in all months except November and December when it dropped to 1.5%. These offer rates allowed sufficient ME for maintenance and milk production of about only 1.5 litres per day (minimum yield) in November and December and about 5.0 litres per day (maximum yield) in March to June. These milk yields result in a decrease in lactation milk yield from 1591 litres to 1451 litres (a decrease of 9%), but surprisingly there was an increase in enterprise budget per 400 kg cow from Tsh 33,262 to 33,945 (an increase of 2%). The observed improvement in enterprise budget (margin) upon removal of maize stover in the system, and despite the observed decrease in milk yield indicates that maize stover was the feed with the greatest contribution to the cost of production per litre of milk. The cost per MJ ME derived from maize stover, as compared to other feed resources shown in Table 44, may also explain why there was a slight improvement in enterprise budget despite the decrease in ME supply.

5.4.7.5 *Effect of planting more fodder*

The effect of planting more fodder was tested by assuming that if farmers in Kilimanjaro adopted the use of contour bunds planted with fodder crops, then they would be able to increase fodder yield by 50%. According to farmers who adopted the strategy of planting fodder on contour bunds under the SCAPA Project area in Arumeru district a 50% increase in production of planted fodder was achieved. The predicted effect of planting more fodder is presented in Table 54. The enterprise budget (margin) increased by 81% as a result of adopting contour bunds. However the increase in enterprise budget (margin) would be 45% if the fodder increase is 25% of the production before adopting contour bunds.

5.4.7.6 *Effect of using a combination of strategies*

Combinations of strategies were tested to see if there could be an added advantage if two or more strategies were used together. The combined effects tested included planting of more fodder and reducing the stock kept from 4.5 to 3.5 TLU, planting of more fodder and raise the stock kept from 4.5 to 5.0 TLU, planting more fodder and practising manual baling of stover, and planting more fodder, practising manual baling of stover and reducing stock from 4.5 to 3.5 TLU. The results of these effects are presented in Table 55.

Table 53 *Effect of replacing maize stover with less expensive feeds on the dairy enterprise budget (margin) in 1997*

Type of replacement	Corrected lactation yield per cow[1] (l)	Margin[2] (Tsh)	Margin per 400 kg cow equivalent (Tsh)	% change in enterprise budget[3] (%)
Mean margin in 1997[4]	1591	93,549	33,262	-
Replace maize stover with sunflower seed cake[5]	1642	102,209	36,341	9
Replace maize stover with wheat feed[5]	1690	111,217	39,544	19
Replace maize stover with roadside grass[5]	1731	121,075	43,049	29
Remove maize stover from the feeding system[6]	1451	95,471	33,945	2

[1] The model was set to run for 12 months (Jan – Dec) but farmers reported lactation length of 11 months and a correction was therefore done for 330 day deducting the extra month

[2] Calculated by subtracting the total variable costs from the enterprise total benefits

[3] The mean margin per 400 kg cow equivalent (Tsh 33,262) under the farmer practice was considered as the base and any change from this is presented as a % change.

[4] Control (i.e. based on the farmer practice for the 1997 prices in Kilimanjaro)

[5] The money that would have been used to transport stover is used to purchase more of concentrate (sunflower seed cake and wheat feed) or more roadside grass

[6] Individual interviews with the 'the poorest of the poor' farmers indicated that most of them do not transport maize stover from the lowlands and do not have money to buy replacement hence they depend more on feeds that require only labour to gather and feed.

Table 54 *Effect of planting more fodder using contour bunds on the dairy enterprise budget (margin) in 1997*

Expected increase	Corrected lactation yield per cow[1] (l)	Margin[2] (Tsh)	Margin per 400 kg cow equivalent (Tsh)	% change in enterprise budget[3] (%)
Mean margin in 1997[4]	1591	93,549	33,262	0
Increase of planted fodder by 25 %	1885	135,639	48,227	+45
Increase of planted fodder by 50 %[5]	2117	169,744	60,353	+81

[1] The model was set to run for 12 months (Jan – Dec) but farmers reported lactation length of 11 months and a correction was therefore done for 330 day deducting the extra month

[2] Calculated by subtracting the total variable costs from the enterprise total benefits

[3] The mean margin per 400 kg cow equivalent (Tsh 33,262) under the farmer practice was considered as the base and any change from this is presented as a % change

[4] Control (i.e. based on the farmer practice for the 1997 prices in Kilimanjaro)

[5] Farmers who have adopted the technology of contour bunds in Arumeru District reported an increase of planted fodder by 50 % of current previous yield.

Table 55 *Effect of using a combination of strategies on the dairy enterprise budget (margin) in 1997*

Combined effect	Corrected lactation yield per cow[1] (l)	Margin[2] (Tsh)	Margin per 400 kg cow equivalent (Tsh)	% change in enterprise budget[3] (%)
Mean margin in 1997[4]	1591	93,549	33,262	-
Planting more fodder and keeping 3.5 TLU	3482	442,841	202,441	508
Planting more fodder and keeping 5.0 TLU	1639	74,160	23,731	-28
Planting more fodder and manual baling	2117	180,088	64,031	92
Planting more fodder, manual baling of stover and keeping 3.5 TLU	3482	453,185	207,170	523

[1] The model was set to run for 12 months (Jan – Dec) but farmers reported lactation length of 11 months and a correction was therefore done for 330 day deducting the extra month

[2] Calculated by subtracting the total variable costs from the enterprise total benefits

[3] The mean margin per 400 kg cow equivalent (Tsh 33,262) under the farmer practice was considered as the base and any change from this is presented as a % change

[4] Control (i.e. based on the farmer practice for the 1997 prices in Kilimanjaro)

5.5 OUTPUT 5 TRAINING OF TANZANIAN TO PhD AND THESIS.

Nicholaus Felix Massawe, BSc, MSc, carried out the studies reported in this Final Technical Report as part of his training for a PhD from the Department of Agriculture at the University of Reading. Supervision of this training was led by Professor Emyr Owen (Reading University) and Professor Mtenga (Sokoine University of Agriculture). Other aspects of training were undertaken by Mr. Steve Ashley and Ms Sarah Holden from In Development Ltd and Dr. Danni Romney of the Natural Resources Institute, University of Greenwich.

Massawe's PhD thesis was entitled "*Strategies based on participatory rural appraisal for improving utilisation of forages to increase profitable milk production on smallholder farms in Tanzania*". This was successfully submitted for examination in July 1999.

The project also contributed to the training of researchers and technicians at Selian Agricultural Research Institute (Arusha), Ikiriguru Agricultural Research Institute (Mwanza), Ministry of Agriculture Research and Training Institute, Tengeru (Moshi) and Sokoine University of Agriculture, and to the training of field officers and extensionists. Training was on improving farmer-extension-research linkage, in particular, how to collaborate with crop/livestock smallholders, to identify constraints and researchable constraints, and subsequently to undertake farmer-approved research to alleviate the constraints and disseminate the findings.

6. CONTRIBUTION OF OUTPUTS

6.1 Contribution to DFID's development goals.

Implementation of Outputs 3 and 4 will have an immediate, positive impact on livelihoods of Tanzanian smallholders, especially in Kilimanjaro. During Year 3, following demonstration of box baling (Output 3), two farmer groups in Kilimanjaro began implementing the technology. Box baling is particularly relevant to poorer farmers as it allows the sharing of transport vehicles thus reducing the cost of stover as dry-season forage. Outputs 1, 2 and 5 will improve researcher-extension-farmer linkage leading to farmer-demand for extension messages based on local technical (grey) literature.

6.2 Promotion Pathways.

Within Tanzania

Relevant reports and/or extension leaflets (in Swahili) have been or will be circulated to a) farmers participating in the project, b) Tanzania Ministry of Agriculture, Department of Research and Training, c) NGOs - Heifer Project International and Farm Africa, d) Sokoine University of Agriculture, Morogoro and d) the Tanzania Society of Animal Production (Annual Conferences in 1996 and 1998).

Tanzania and other countries in Africa and Asia

WRENmedia Agfax interview with Nicholaus Massawe "*Transporting maize stover*" (based on Output 3) was sent to 25 national and FM stations in Anglophone Africa and 10 national stations in Asia, in July 1999. Positive feedback has been received from Radio Uganda, Radio Tabora Broadcast and TV, Tanzania, Transworld Radio, Kenya and Kenya Broadcasting Corporation. The interview was also probably used in Ghana, Gambia, Cameroon, Namibia, Nigeria, Zambia, South Africa and Sudan. A press article "*Transporting the ideas of success*" based on the interview was distributed in October 1999. The article was published Nov/Dec 1999 in *Far Eastern Agriculture* (circulation 9,224 copies), *The Farmers Voice*, Cameroon (circulation 6,000) and *Agritopia*, newsletter of Ethiopian Agricultural Research Organisation. The article will have been sent to 4 international publications, 25 African publications and 10 Asian publications.

Publications

A list of publications to date is given on pages 107 and 108.

6.3 Suggested follow-up research.

The implications of Output 3 for reducing storage costs and improving forage rationing require research. Dissemination of Output 4 will require development of a simple decision support tool to enable estensionists to advise on which improved strategy to adopt in a given situation. Methods of disseminating information, e.g. farmer to farmer visit and learning, require research.

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8- PROJECT PUBLICATIONS AND REPORTS

8.1. Publications

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