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Husbandry Strategies for Improving the Sustainable Utilisation of Forages to Increase Profitable Milk Production from Cows and Goats on Smallholder Farms in Tanzania

- **Socio-economic Lessons**

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Contents

Tables

Husbandry Strategies for Improving the Sustainable Utilisation of Forages to Increase Profitable Milk Production from Cows and Goats on Smallholder Farms in Tanzania

DFID Livestock Production Programme Project R6619

Socio-economic Lessons

1. Introduction

This report highlights socio-economic issues that have been raised by the project "Husbandry strategies for improving the sustainable utilisation of forages to increase profitable milk production from cows and goats on smallholder farms in Tanzania". The intention is to set out findings from this project which will help improve livestock-related research in future, and also to draw attention to some wider issues relevant to dairying in Tanzania.

The paper illustrates the different perspectives raised when a participatory approach to research is adopted, and will hopefully demonstrate the merits of such an approach where the research is intended to address the practical needs of smallholder farmers.

The research followed a process where issues were seen through the eyes of farmers rather than through the eyes of an expert. This perspective influenced every stage of the research, and led to very different decisions about what issues to focus in on as the process proceeded from seeking a general understanding to the testing of specific strategies.

The project was funded by the UK Department for International Development under its Livestock Production Programme. The work was undertaken by Nicholaus Felix Massawe, and supervised by Sokoine and Reading Universities. Further socio-economic support was priovided by Livestock In Development. Field work was undertaken in Kilimanjaro, Morogoro and Mwanza.

This report comprises a discussion of some of the main socio-economic issues raised by the research. Readers seeking further detail on technical research findings are referred to the project's final technical report, and to the PhD thesis which resulted from this research.

2. Policy Findings

2.1 Effect of milk price

The current study examines the effect of adoption of a technical strategy to increase milk production on the farm's enterprise budget. The adoption of manual box-baling of stover produced a calculated 11% gain and that of baling LSH a 22% gain. While taken on their own these benefits accruing from the adoption of the technology are impressive, they are less so when compared (as shown in Table 1) with the potential benefits of changes in the overall price of milk, a 25% increase in milk price giving an 85% increase in enterprise budget.

While farmers and researchers are more likely to focus on technical strategies (such as manual box-baling studied in the present project), this finding suggests that policy-level changes may have the potential to achieve much greater gains. Dairy development therefore requires more than simply a technology focus; it also needs to take place within a supportive policy environment.

Table 1 *Relative effect of technology and price changes on the dairy enterprise budget (margin) in 1997.*

	% change in enterprise budget (%)
Actual 1997	
Feeding baled whole stover	+11
Feeding baled LSH	+22
25% Increase in milk price	+85
50% Increase in milk price	+170
75% Increase in milk price	+255
100% Increase in milk price	+340

2.2 Farmer awareness of existing technology

From PRA exercises conducted in the present study it was evident that few farmers were aware of available technologies to solve their production problems. This suggests that neither research findings nor extension materials were reaching the farmers effectively. Poor uptake may also be evidence of failure of research-extension-farmer linkages and feedback loops, and suggests that development potential is being limited by lack of access by farmers to existing information.

2.3 Constraint identification and analysis

The study invested considerable effort in discussing the nature of the constraints facing dairy farmers in the three project study sites.

Table 2 shows specific constraints listed by farmers in Mwanza and Table 3 a constraint ranking for Morogoro, both of which focus on forage related constraints.

Figure 1 shows a problem linkage diagram for Kilimanjaro, and takes a much broader perspective, looking at influences on milk production and profitability more generally. This shows the complex and inter-related position of dairying in broader livelihoods of dairy farmers in Kilimanjaro, and illustrates how technical constraints alone are only a relatively small part of the wider picture influencing dairy households.

Table 2. *List of specific constraints identified in PRA field studies in Mwanza location.*

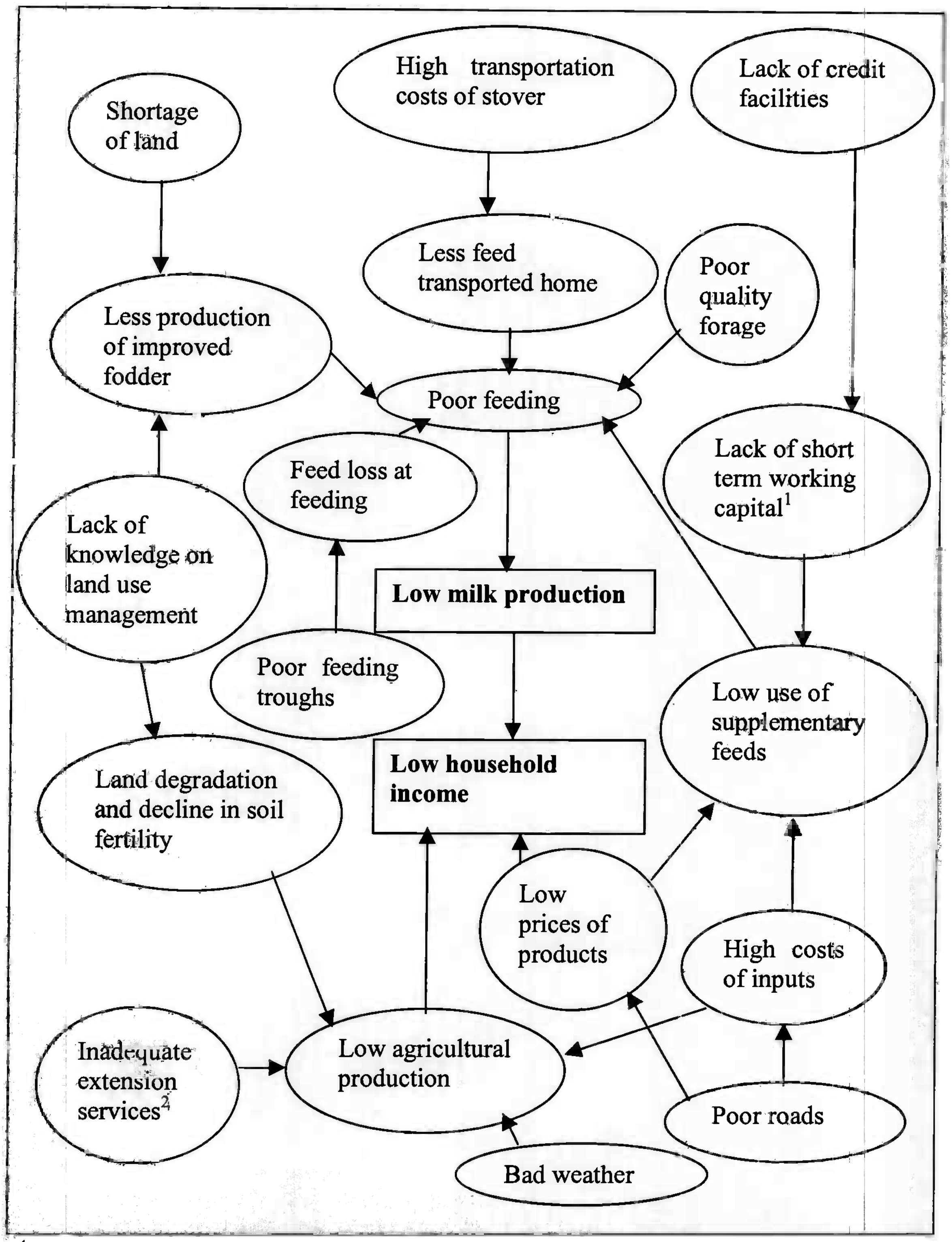
Multiple objectives of livestock keeping. Milk not first priority, so farmers reluctant to invest too much time, effort or money in milk production. Draught power was the first priority, followed by milk and manure.
Large herds perceived to discourage storage of feeds for dry season feeding. Farmers 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.
Crop residues were grazed *in situ*, resulting in large losses due to trampling; however uneaten residues were returned to soil.
Large losses of forage in communal grazing land due to trampling, because no proper grazing plan.
Cotton seed cake (CSC) was not readily available for purchase for use as a supplement.
Animals were kept together in a common kraal, so not possible to practice selective feeding.

Table 3. *Ranking 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 advice	1.9
c) Land scarcity	2.4
d) Transport	2.8

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

Figure 1. *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.

Another important finding of this research, though it does not emerge clearly from these tables, is the differences in constraints not only between research locations or systems, but between households practising similar systems. These socio-economic differences influence decision making and are crucial determinants of what people can and cannot do, and therefore what problems they have, and what solutions are appropriate for them.

However, certain common constraints were noted and those of a forage related nature are listed and ranked in Table 4.

Table 4. *Summary of forage and forage related constraints and problems identified in all locations.*

Constraint/problem	Mwanza	Kilimanjaro	Morogoro
Shortage of dry-season forage			
Low quality forage	✓✓✓		✓✓✓
Lack of improved forage feeding strategies	✓✓	✓✓✓	✓✓✓
Lack of knowledge on forage conservation		✓✓	✓
High transport costs of crop residues and loss of leaves		✓✓✓	
Land degradation and decline in soil fertility		✓✓✓	✓✓
Fluctuations in type of feed offered		✓✓	
High cost of concentrates		✓✓✓	✓✓
Problems of milk marketing	✓	✓✓	✓
Poor feeding troughs leading to feed loss		✓✓	✓

✓ low severity ✓✓ medium severity ✓✓✓ high severity

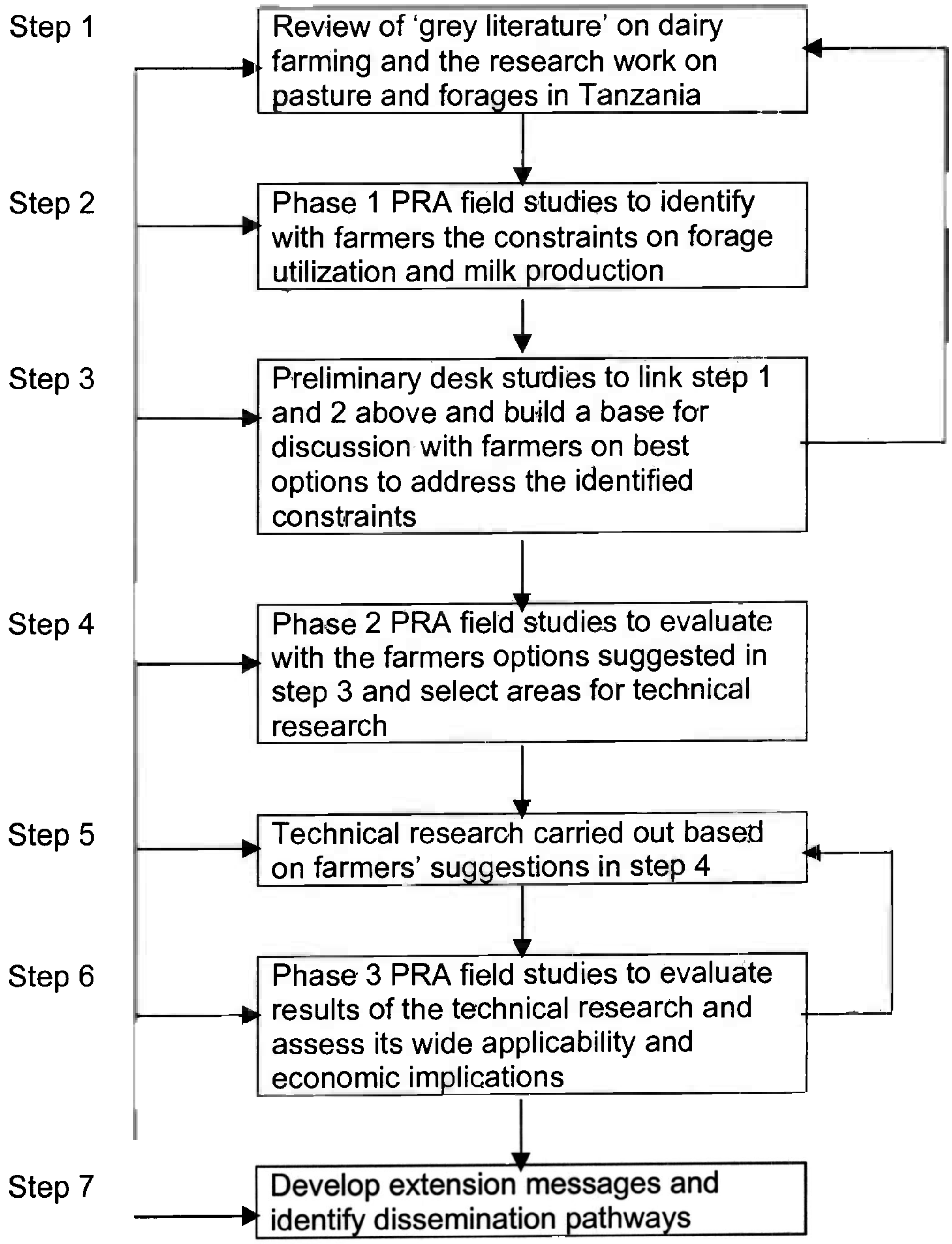
An understanding of constraints in the context of wider livelihood position, and the recognition of differences between people is an essential prerequisite for research aimed at identifying appropriate solutions to farmers problems. Where this is an objective, participatory research approaches are not just an option but a necessity. The findings presented here, especially in figure 1 suggest that such solutions will frequently not be technical, but may relate to wider policy issues.

3. Research Process

Although the participatory approaches taken in the current research may not in themselves be new, their application to inform the direction of animal science research in Tanzania is relatively unusual. The research processes used in the current work has much to offer other researchers interested in increasing the client-orientation of their research.

The research was carried out in seven main steps (Figure 2). The steps were linked, giving both logical progression and feedback. Three PRA Phases were planned to ensure that farmers had a chance to participate and evaluate various stages of the research.

Figure 2. *Outline of the steps involved in the research process.*



As stated in the introduction to this paper, the research process followed meant that the research was free to move in whatever direction seemed most appropriate to address the main issues facing the client group. Whilst some constraints relating to time and funds also influenced decisions, the research questions being asked and those which were subsequently tested in more detail were based on identifying appropriate solutions to real problems identified with dairy farmers.

3.1 Linking literature surveys with farmer research groups

Having worked with farmers to identify their constraints, the study searched the literature (normally a restrictive, on-station, scientific exercise) to identify technology options which might be of use to address those constraints. From lists of literature-based strategies, farmers were able to select technologies that they thought might be promising and these became the subject of farmer-initiated research. Tables 5, 6 and 7 show the technologies that were discussed with farmers in Kilimanjaro, Morogoro and Mwanza respectively, in response to the constraints they identified.

Table 5. *Literature-based strategies that were presented for discussion with farmers in Kilimanjaro.*

	Strategies
1	Inter-cropping maize with leguminous tree forage
2.	Treatment of maize stover
3.	Baling of maize stover prior transportation
4.	Use of N fertilizer or manure on cultivated pastures
5.	Supplementation with concentrates
6.	Strategic feeding of crop residues
7.	Construction and use of forage storage sheds
8.	Preferential feeding and manipulation of stock numbers
9.	Contour bunds planted with forage and MPTs
10.	Optimal cutting regime for planted fodder
11.	Use of proper feeding troughs

Table 6. *Literature-based strategies that were presented for discussion with farmers in Morogoro (Mgeta).*

	Strategies
1.	Plant fodder grass such as Setaria or Guatemala and legumes such as *Glycine spp* and *Desmodium spp.*
2.	Plant contour lines of forage trees and legumes such as *Gliricidia, Sesbania Calliandra, Leucaena* etc.
3.	Harvest and store crop residues such as maize stover and bean straw for rainy season feeding when pastures are lush.
4.	Conservation of locally available grass such as *Cymbopogon spp* & Napier grass.
5.	Practise strategic feeding of purchased concentrate.
6.	Preferential feeding for lactating does.
7.	Maximize the use of local forage species such as "ngugu" (*Pennisetum purpureum*), "mitamba" (*Ficus spp.*), "mikenge" (*Albizia gummifera*) and "mififi" (*Morus alba*).
8.	Use farmyard manure on cultivated pastures.
9.	Construct contour bunds planted with fodder plants (e.g. as practised under SCAPA Project)
10.	Select better grazing locations when tethering goats, maximise grazing time when tethering and use optimal tether length as suggested by Sendalo (1995).
11.	Reduce number of animals to match the feed resources available.
12.	Form farmer associations to facilitate product marketing and acquire inputs.

Table 7. *Literature-based strategies that were presented for discussion with farmers during Phase 2 PRA in Mwanza location*

	Strategies
1	Harvest maize stover and other crop residues
2.	Destock cattle to match the available forage resource
3.	Formulate and enforce by-laws on how to graze communal land
4.	Expand and manage the reserved pasture plots
5.	Cut, dry and store natural pastures from valley bottoms
6.	Use purchased cotton seed cake for feeding lactating cows

3.2 Farmer to farmer visit and learning

Six farmers and their village extension officer were taken from Samaki Maini to Arumeru to see how their counterparts had used contour bund technology in a coffee/banana production system to grow fodder for their livestock. While the technique of farmer-to-farmer visit is not new, its application to extension of livestock nutrition technology is rare. Farmers liked the process and commented that the visit was more interesting than viewing demonstration plots on research farm open days. Since the technology was only suited to those farmers who were farming on sloping ground, the degree of uptake might be questionable. However, the success of the process suggests that other researchers might benefit from using a similar approach.

Such an approach means involving farmers more in the research rather than regarding them as passive recipients – which has proven itself poor at meeting their needs to date. It also means moving beyond a strictly research-based approach into one in which farmers are simultaneously learning and sharing ideas.

3.3 List of farmer practices which need research verification

The PRA exercises in this study resulted in the identification of a number of widespread existing farmer practices which are not recognised and are not a part of current formal extension messages (some are listed in Table 8). Some of these might be usefully investigated further with farmers to establish whether they might be more widely used.

Table 8. *Farmer practices reported during PRA which require scientific verification.*

	Unverified Farmer Practices
1.	*Ngitili* - Grazing reserve areas.
2.	*Magadi* – use of magadi (soda/salt) as a pre-treatment for forage to increase palatability and intake.
3.	Banana pseudostems as forage replacement.
4.	Banana sucker – allowing an extra sucker to grow on each plant for use as dry season feeding.
5.	Use of MPTs for deworming.

4. Multiple objectives of keeping livestock & relation to suitability of technology

Researchers often take a commodity-based view of livestock research and forget that technologies which may appear beneficial from the perspective of a particular commodity output, may have adverse effects on other aspects of the livestock enterprise or the whole-farm enterprise.

The production objectives of keeping livestock varied with the locations in this study. Milk was ranked first in Kilimanjaro and Morogoro, but was ranked third in Mwanza (Table 9). The farmers' objectives of keeping livestock influenced the use of available feed resources on the farm. Farmers allocated the best feed to the most productive animals e.g. where the objective was draught power, the best feed was allocated to oxen. If the objective was milk production, the best feed was allocated to lactating cows. Clearly the benefits accruing from the adoption of technology will differ along with the objectives of the farmers and output of the animals concerned.

This is an important lesson for researchers, who need to make sure their work is based on an understanding of the wider livelihood context in which livestock are kept, and the objectives of livestock-keeping of different types of people, which are often different than pre-conceived ideas.

Table 9. *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		
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

4.1 Diversity of systems

Researchers often build a simplistic model of the livestock enterprise and ignore the diversity of systems that are practised within and between specific areas and households. Evidence of diversity from this study suggests again a need to base research on an understanding of what is really there rather than what researchers think is there.

Table 9 already introduced the diversity of objectives for keeping livestock in Tanzania. Table 10 shows the variation in non-feed costs for six farms in Kilimanjaro and Table 11 the range, complexity and between-farm variation in feed use for farms in the same area.

Table 10. *Non-feed variable costs (in Tanzanian shillings, Tsh) associated with the dairy enterprise for each of six case-study farmers in Kilimanjaro in 1997.*

Wealth group	High		Medium		Low	
	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	
Treatment charges	16000	25000	22000	26000	26000	
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)						
Hauling 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			94500

Table 11. *Feeds utilised (kg per TLU) in the year Jan. 1997 - Dec. 1997 by six case study farmers in Kilimanjaro.*

Wealth group	High		Medium		Low	
	A	B	C	D	E	F
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

4.2 Seasonal variation

The data on seasonal variation in farm practices and seasonal use of particular forages (shown in Table 12) is important because it illustrates the many dimensions of existing farmer practice and the difficult and uncontrolled environment in which smallholders make their livelihoods. Any researcher seeking to change existing systems must clearly first understand the systems and people they would seek to change.

While farmers in Mwanza and Kilimanjaro were able to score the seasonal abundance of forage species, farmers in Morogoro, indicated that while feed availability did not show any seasonal trends, it was influenced by restrictions due to cropping.

Table 12. *Scoring of seasonal forage feed availability in Mwanza and Kilimanjaro*

Forage type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mwanza (n=17)												
Grazed grasses	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		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

0 = none available, 5 = abundant

5. Farmer's criteria for assessment of technologies

The study allowed farmers to select which technologies they found most promising for implementation and looked at the criteria which farmers used to assess potential suitability of technologies. The most important criteria for farmers were the money required to implement the strategy, the compatibility with the farming system and the availability of knowledge to put the strategy into place. Researchers on the other hand tend to lead discussions on technology by emphasising production benefits or benefit/cost ratios and therefore fail to address the criteria that farmers want information on.

The results of farmer assessments of the literature-based technologies are shown in Tables 13, 14 and 15 for Kilimanjaro, Mwanza and Morogoro respectively.

Table 13. *Farmer evaluation of literature–based strategies for technical research in Kilimanjaro.*

Strategies	Frequency (n=12)	Rank
Contour bunds planted with fodder grass and MPTs	10	1
Manual box baling of maize stover prior to transportation	9	2=
Construct and use of stover storage sheds	4	8
Technology on cutting regime for improved fodder	5	6=
Construct and use of improved feeding troughs	5	6=
Destocking to meet feed resource availability	6	5
Conservation of excess forage as silage or hay	7	4
Inter-crop maize with pigeon pea in the lowlands	9	2=

Table 14. *Farmer evaluation of Literature-based strategies for technical research in Morogoro (Mgeta).*

Strategies	Frequency (n=21)	Rank
Construction of contour bunds planted with fodder	15	
Multipurpose trees suitable for Mgeta environment	10	2
Research on locally available feed resources	9	3
Conservation of locally available feed resources	8	4
Planting of improved forage	6	5
Acquisition of credit facilities	4	6

Table 15. *Farmer evaluation of stall-feeding strategies for addressing the constraints in Mwanza location*[1]

Strategies	Frequency (n=12)	Rank
Harvest maize stover and other crop residues	8	4
Destock cattle to match the available forage resource	9	2=
Introduce and enforce by-laws on communal grazing	6	5=
Expand and manage the reserved pasture plots	9	2=
Cut, dry and store natural pastures from valley bottoms	10	
Use purchased cotton seed cake for feeding lactating cows	6	5=

Farmers participating in the evaluation of strategies in Mwanza location were selected on the basis of their interest in milk production. Therefore the results may not portray the true views of 'Sukuma' farmers whose primary objective of keeping livestock is draught power.

6. Factors limiting uptake and acceptability of options

The diversity of farms and farmers (noted earlier) has a major bearing on farmers' preferences for resource allocation and technology uptake. Farmers also have differing access to resources as shown in Table 16 and will prioritise technologies differently as shown in Tables 13, 14 and 15. Further differences occur at a household level as previously discussed.

For technologies to be robust in the face of this diversity, baskets of options are more likely to prove successful than standardised solutions, since single solutions cannot meet a whole range of different needs. This is an essential lesson which is quickly derived when using participatory approaches to livestock research in which farmers are partners and their views are valued..

Table 16. *Relative resource availability in Mwanza, Kilimanjaro and Morogoro.*

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

[1] Farmers' understanding of capital was based mainly on availability of hard cash (working capital). Farmers did not view farm assets 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.

6.1 Labour constraints

Researchers have a tendency to view labour as being free and abundantly available on small-holder farms. While it is true that labour resources are often relatively more abundant than capital resources (borne out by Table 16), labour constraints can still be a limiting factor to production and to technology uptake. This can be true for example where reliance on child labour for herding is competing against the need for children to attend school, or where complex livelihood strategies combine a number of activities, of livestock is only one.

Quality of labour is important too and in the present study, smaller bale sizes were preferred since they were more easily handled by children, whose job it often was to feed the animals.

This illustrates how socio-economic considerations were crucial in determining the acceptability of technological options in this study – a point which would have been missed has the baling research been conducted on-station.

6.2 Non-technical constraints

Non-technical constraints are often a reason for poor uptake of otherwise effective technologies. Proper identification of these constraints can help in the design of technologies and the design of effective research programmes. The majority of the constraints shown in the problem-linkage diagram in Figure 1 are non-technical and can be summarised as follows:

i) Inadequate extension services
ii) Inadequate rural infrastructure e.g. roads
iii) Lack of credit facilities
iv) Poor research-extension-farmer and other stakeholder linkages
v) High prices of agricultural inputs e.g. concentrates and veterinary drugs
vi) Low prices of agricultural products e.g. milk
vii) Lack of clear land tenure system

Farmers in the three-study locations assessed credit as the most limiting non-technical constraint that affected adoption of improved technologies, especially where the technology required considerable cash income for its initial adoption. Lyimo (1997) reported many farmers responding to questionnaires saying that they had not adopted improved technologies introduced into their area because of lack of cash or working capital. The Government of Tanzania has failed to persuade credit institutions to extend services to the rural areas. The reason for this is that credit institutions have not been given sufficient assurance that loans will be repaid in the event of crop failure or livestock death.

The PRA studies also indicated that the land tenure system influenced adoption of technologies. Farmers lacked confidence to invest for the long term and make permanent changes to the land e.g. plant of trees. This was because farmers were not sure of long term access to their land. The land tenure system as a factor hindering long term investment on land improvement was severe in Mwanza where grazing land was communally owned. In Kilimanjaro and Morogoro land tenure was more satisfactory as the land was individually owned under a clanship control.

Where such constraints occur, any technology development process which ignores them will be doomed to failure, since it is likely to produce technology which is not appropriate to farmers' real situations. This again emphasises the importance of a participatory approach to even technical livestock research, so that technology can be tailored accordingly.

6.3 Farm system description

Descriptions of farming systems help researchers to have a better understanding of the reality of on-farm implementation of technology. Also, while many such descriptions have been published in the past, the systems are constantly changing and evolving and updated information from a study such as this needs to be made widely available as early as possible after completion.

Tables 2, and 3 and Figure 1 show the constraints in the farming systems in this study, Table 9 the reasons for keeping livestock, Table 12 the seasonality of forage availability and Table 16 the relative resource availability. Taken together with Table 17 which describes the feed resources and human population of the areas, these provide useful additional information on the farming system. Further information may be drawn from the thesis on which this paper draws.

The strong lesson from this research is that if livestock research is not based on an understanding of farming and particularly livelihood systems, it will produce results which are not of use to anyone but the wealthy who have the luxury to be able to experiment and tolerate failure.

Table 17. *Major feeding systems, feed resources and human population density in the three study locations*

Parameter	Location		
	Mwanza	Kilimanjaro	Morogoro
Feeding system		Stall-feeding	
Pastures	Natural pastures	Improved pastures and natural pastures cut along roadside and valley bottoms	
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

6.4 Changing research needs

It is evident that dairy production systems in Tanzania are evolving and changing to meet shifts in the demographic, socio-economic and policy environment. Frequent participatory evaluation of technologies is required so that research can keep pace with the changing environment and appropriate technologies delivered. This needs to be seen as an ongoing process rather than a pursuit for absolute truths.

6.5 Manual box-baling

The principle behind this technology is that baled forage is easier (and cheaper) to transport, easier to store and results in less wastage. However, mechanical baling requires an investment in technology that could not be afforded by individual farmers and paying a contractor to bale forage would be not be economically viable in most small-holder dairy farming systems. Manual box-baling is a low-technology solution that requires little capital outlay, and was derived as an appropriate solution to farmers problems through the stepwise analysis outlined elsewhere in this report. Therefore whilst it is not technologically complex and is in itself not scientifically impressive, it has the capacity to produce real gains and was of great interest to many farmers.

An open box frame is constructed and placed on the ground. Sisal twine is laid across the box, with ends left long enough to be tied later. Using the weight of the operator standing on top of the forage, as much forage as possible is pushed into the box on top of the twine. Finally the twine is tied tightly to complete the bale. By using only stripped leaf material from maize stover the system maximises the amount of palatable material that can be transported, minimising the cost per unit of metabolisable energy.

Table 18. *Weight, time and labour cost of manual baling of maize stover.*

Bale size	Weight (kg)	Time (minutes)	Labour cost (Tsh)
Large (100x50x40cm)	15.1	13.9	58.3
Medium (75x50x40cm)	12.2	16.7	70.0
Small (50x50x40cm)	9.4	17.7	74.2

Table 19. *Comparison of weights and costs involved in maize stover handling in 1.0t pick-up.*

Treatment	Weight of stover loaded		Total cost of labour & vehicle hire (Tsh)	Cost per kg DM (Tsh)
	Air dry (kg)	DM (kg)		
Loose stover			15236	106
Large bale			15941	79
Medium bale			16607	71
Small bale			17268	73

Table 20. *Weight of maize stover loaded in a 7.0 t lorry as loose or bales.*

Treatment	Weight of stover loaded (kg)
Loose stover	754
Large bale	1580
Medium bale	1688
Small bale	1809

Table 21. *Weights of stover loaded in a 1.0 t pick-up as LSH and whole stover.*

Treatment	Weight of baled LSH (kg)	Weight of baled whole stover loaded (kg)
Large bale	380	225
Medium bale	384	264
Small bale	374	261

Table 22. *Farmer evaluation of the three wooden boxes for size preference.*

Box size	Frequency (n = 19)	Percentage
Large	1	
Medium	7	
Small	7	
Medium and Small	4	

Table 23. *Evaluation of the three bale sizes by farmers through voting.*

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

Table 24. *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	31	37	31	47	31	31
If baled LSH	66	68	66	64	66	66

[1] Based on 52 % LSH in whole stover
[2] Cost per MJ ME when stover is baled whole and transported in 1.0 t pick-up is Tsh 16 but it is Tsh 6 when transported in 7.0 t lorry. 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, but it is Tsh 4 when transported in 7.0 t lorry. Farmer D used a 7.0 t lorry.

6.6 Storage shed

Farmer practice for storing stover and other fibrous feeds (e.g. roadside grass) was found to consist mainly of stacking near or around the animal house or in partly completed (usual roofless) storage sheds. Lack of capital was quoted as a reason for not improving these forage stores. The study advocated combining the strategy of box-baling maize stover for transport with construction of better sheds for storing the bales.

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 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 and are shown in Table 25.

Table 25. *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			
Add 10 % contingency			
Annual value of the shed[3]			

[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 25 could store a maximum of 1260 kg of loose stover (about 8 trips of loose stover in a 1.0 t pick-up) or 2052 kg of baled stover (171 bales). Based on the annual value of the shed shown and with the shed 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 a 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.

It was suggested that farmer-to-farmer joint-effort and self-help might provide a solution. 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. Once more this illustrated the shift from research to research-extension.

The key lesson from this discussion is that even where the economic analysis conducted as a part of this research showed that storage sheds were profitable, this did not mean that farmers rushed to adopt the idea. The real constraint was that they did not have sufficient cash at the time it was needed to construct the shed. This illustrates the limitations of cost-benefit analysis. Though economic analysis is a useful decision making tool, it can be misleading without the wider understanding of livelihoods which allow its information to be placed in context.

6.7 Excess feeding

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 per day 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). The idea was to develop a strategy of when and where to recommend an excess feeding strategy. The results of the analyses are shown in Table 26.

Table 26. *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 (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[2](Tsh/d)	2000	2240	2440
Total revenue[3](Tsh/d)	2941	3294	3588
Comparisons			
Cost of stover offered (Tsh/d)	1367	2692	4007
Total feeding cost (Tsh/d)	1685	3010	4325
Feed cost per kg of milk (Tsh)	169	269	354
Total cost/day (Tsh)	2479	4427	6360
Margin (Tsh/d)	463	-1133	-2772

[1] Based on data of Methu (1998)
[2] Value of milk was Tsh 200 per kg
[3] Total revenue calculated on the basis that milk contribute 68% of the total benefits

Table 26 shows that the feed cost for producing 1 kg of milk would increase with increasing offer rates 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. The main reason that an excess feeding strategy would not be viable in this farming system is that the stover is not simply a cost-free crop residue – a cost is borne in the transportation from the maize growing areas to the livestock rearing areas.

This illustrates a reality gap in this case between the applicability of animal science research and the real situation farmers face, and suggests once more that technology cannot be developed in isolation from the smallholders who are meant to use it.

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