Working Paper

Constraints and options to enhancing production of high quality feeds in dairy production in Kenya, Uganda and Rwanda

B.A. Lukuyu, A. Kitalyi, S. Franzel, A. Duncan and I. Baltenweck

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

Constraints and options to enhancing production of high quality feeds in dairy production in Kenya, Uganda and Rwanda

B.A. Lukuyu, A. Kitalyi, S. Franzel, A. Duncan and I. Baltenweck

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

Correct citation: Lukuyu BA, Kitalyi A, Franzel S, Duncan A and Baltenweck I. 2009. *Constraints and options to enhancing production of high quality feeds in dairy production in Kenya, Uganda and Rwanda* ICRAF Working Paper no. 95. Nairobi, Kenya: World Agroforestry Centre.

Titles in the Working Paper Series aim to disseminate interim results on agroforestry research and practices and stimulate feedback from the scientific community. Other publication series from the World Agroforestry Centre include: Agroforestry Perspectives, Technical Manuals and Occasional Papers.

Published by the World Agroforestry Centre
United Nations Avenue
PO Box 30677, GPO 00100
Nairobi, Kenya
Tel: +254(0)20 7224000, via USA +1 650 833 6645
Fax: +254(0)20 7224001, via USA +1 650 833 6646
Email: icraf@cgiar.org
www.worldagroforestry.org

ICRAF Working Paper no. 95

Contributors

Ben A. LUKUYU	International Livestock Research Institute Postdoctoral Scientist (Feed Scientist) P.O Box 30709 GPO 00100, Nairobi Kenya Email: B.Lukuyu@cgiar .org
Aichi KITALYI	World Agroforestry Centre Country Representative Tanzania (Scientist in Livestock and Farming Systems) ARI-Mikocheni Campus, Mwenge Coca Cola Road PO Box 6226 Dar es Salaam, Tanzania Email: A.KITALYI@cgiar.org
Steven FRANZEL	World Agroforestry Centre Principal Agricultural Economist United Nations Avenue PO Box 30677, GPO 00100 Nairobi, Kenya Email: S.FRANZEL@cgiar.org
Alan DUNCAN	International Livestock Research Institute Livestock Scientist P.O Box 5689, Addis Ababa, Ethiopia Email: A.Duncan@cgiar.org
Isabelle BALTENWECK	International Livestock Research Institute Agricultural Economist P.O Box 30709 GPO 00100, Nairobi Kenya Email: I.Baltenweck@cgiar.org

Abstract

Dairy production provides a unique development strategy as a source of livelihood for most smallholder farmers not only providing income through milk sales but also, milk for home consumption. Other important benefits include manure as an input to arable production and livestock as a reserve for cash for investment. Dairy production is mainly constrained by limited availability and access to high quality feeds especially during the dry season. The aim of the present study, conducted in Kenya, Uganda and Rwanda during the year 2008, was to identify the feed resources available year round, where the gaps are and what is available to address these. The study areas were classified into geographical clusters. Consequently 3, 4 and 3 clusters were identified in Kenya, Uganda and Rwanda respectively. Mixed farming/ dairy production systems dominated the study areas in Kenya while in Uganda, coffee-banana systems, banana-cotton farming system and agro-pastoral systems dominated the study areas. Study areas in Rwanda were mainly agro-pastoral systems. The study involved a rapid assessment of feed resources using semi-structured questionnaires with farmer groups and key informants. In the light of constraints and opportunities identified by the study, several strategies and technological options to improve availability and access to high quality feeds were identified and are briefly discussed. These included strategies to widen the feed resource base and increase acreages of fodder, promote feed conservation, utilize low quality crop residues, control bush and improve natural pastures and improve calf rearing and nutrition. Other important non-technological options such as organizational/institutional and policy-level interventions have also been highlighted. These include promoting and strengthening feed markets and forage seed systems, creating an enabling policy environment and introducing the innovation systems approach to foster change. Feed production therefore needs to be stimulated to enhance dairy output in all three study countries although the nature of the interventions may vary according to the country under study.

Keywords

Dairy production, smallholder farmers, Kenya, Uganda, Rwanda, agro-pastoral systems, fodder, feed markets, forage seed systems.

Acknowledgements

The authors are thankful to P.Mudavadi, W.N. Sylvia, E. Karanja, J. Kugonza, R. Wabwire, B. Nzingamasabo and C. Ruganirwa for collecting data and compiling country reports on which this working paper is based. This study was supported by the East African Dairy Development project (EADD). It should be noted, however, that the responsibility for the content, findings and recommendations of the article rests with the authors. The views and opinions presented herein therefore do not necessarily reflect the opinions of EADD. Our gratitude is also extended to all the small-holder dairy farmers in all our study sites.

Contents

List of tables

Problem statement and justification

The main constraint facing small scale dairy farmers in smallholder mixed farming, pastoral and agro pastoral production systems across East Africa is the inability to provide sufficient quantity and quality feeds to their livestock on a consistent basis (Hall et al. 2008). Many feeds are common and widely known across the East African region including planted fodders such as Napier grass, fodder shrubs and herbaceous legumes. Napier or elephant grass (*Pennisetum purpureum)* is a perennial grass grown widely in East Africa as a fodder crop (Bayer 1990). Other feeds are crop by-products/residues such as sweet potato vines, banana leaves and pseudostems, stovers and straws, complemented with collection from and/or grazing of animals on communal land, forests, roadsides or fallow land. Small quantities of concentrates derived from milling by-products of crops and/or dairy meals from animal feed industries are also used by some farmers. In pastoral/agro pastoral systems, grazing on common property resources is the main source of feeds, which is complemented by feeding crop residues where accessible. However, feed quality may vary from area to area and even within a location. Concentrates of varying quality are available from different companies at any given site, while different species of legumes are available and suited to specific sites depending on altitude, rainfall and soils. Additionally, there are products only available at particular sites, such as by-products from a local industry like a brewery.

National and International Research Institutions have developed many feed production and utilization technologies – grasses, legumes, dual purpose crops, crop residues, rations based on agro-industrial by-products to name a few broad categories - but they have rarely been adopted by smallholder producers (Ayantunde et al. 2005; Hall et al. 2008). A need to conduct an inventory of feed resources was identified, given the variation between production systems and agro ecologies in terms of specific types of feeds used, their sources and degree of scarcity. This study aimed at identifying the present feed resources available year round, where the gaps are and what is available to address these. The study also examines farmer perceptions of the problems and how they cope with them. Knowledge of types and characteristics of available feeds and feeding systems that smallholder farmers use to intensify their dairy systems can be useful in the design of appropriate targeted feeding strategies. These strategies combine optimizing use of feeds already available on farm, introducing new fodder species and using external sources of feed supplements rather than uniform blanket promotion of productivity enhancing interventions. This approach enables feeds and feeding interventions to be considered in the context of the socio-economic and environmental conditions of the individual households as well as encouraging feed budgeting for the whole lactation period, which is a prerequisite for attaining lactation yield potential.

Methodology of the study

A rapid reconnaissance survey was conducted in Kenya, Uganda and Rwanda during 2008 (Figure 1). The districts selected were those covered by the East African Dairy Development Project, an initiative financed by the Bill and Melinda Gates Foundation. The interviews were conducted with the help of a checklist. The checklist was pre-tested with two farmer groups in two different sites in each country to ensure that it took into account country differences and collected relevant information. During pre-testing, it was realized that there is variation in the feeding systems and agro ecological zoning across project sites. To avoid bias, study sites were clustered based on land use, scale of intensification and farming systems. Six existing groups comprising 15-30 farmers each were selected per cluster ensuring there was at least one group per administrative district. The group leaders were asked to ensure farmers interviewed consisted of both typical and progressive farmers. Women and youth were also sought in order to ensure that their views were taken into account. Appointments with farmers for interviews were made through group leaders to encourage good participation in the meetings. Meetings were held in farmer households (HH) selected by the group.

The survey checklist gathered information on the current feeds and feeding practices for dairy cattle and their constraints. Other topics included farm sizes, contribution of grazing to feeding, fodder markets, feed conservation, forage pest and diseases, information access and an inventory of other actors in feeding systems. Interviews were conducted by the project dissemination facilitators (DF's). In addition to interviews, field observations were also made on selected farms to gather evidence of feeding practices, pests and diseases. Existing groups engaging in dairy activities were selected for interviews in all project sites. A few key informants were interviewed individually to triangulate information given by groups. Semi-structured interviews were conducted by field dissemination facilitators by use of open-ended discussions, using a structured checklist but allowing responses to take their own direction and participants to discuss or debate with each other.

Results, observations and discussion of findings

Land use, farming systems and dairy cattle feeding systems

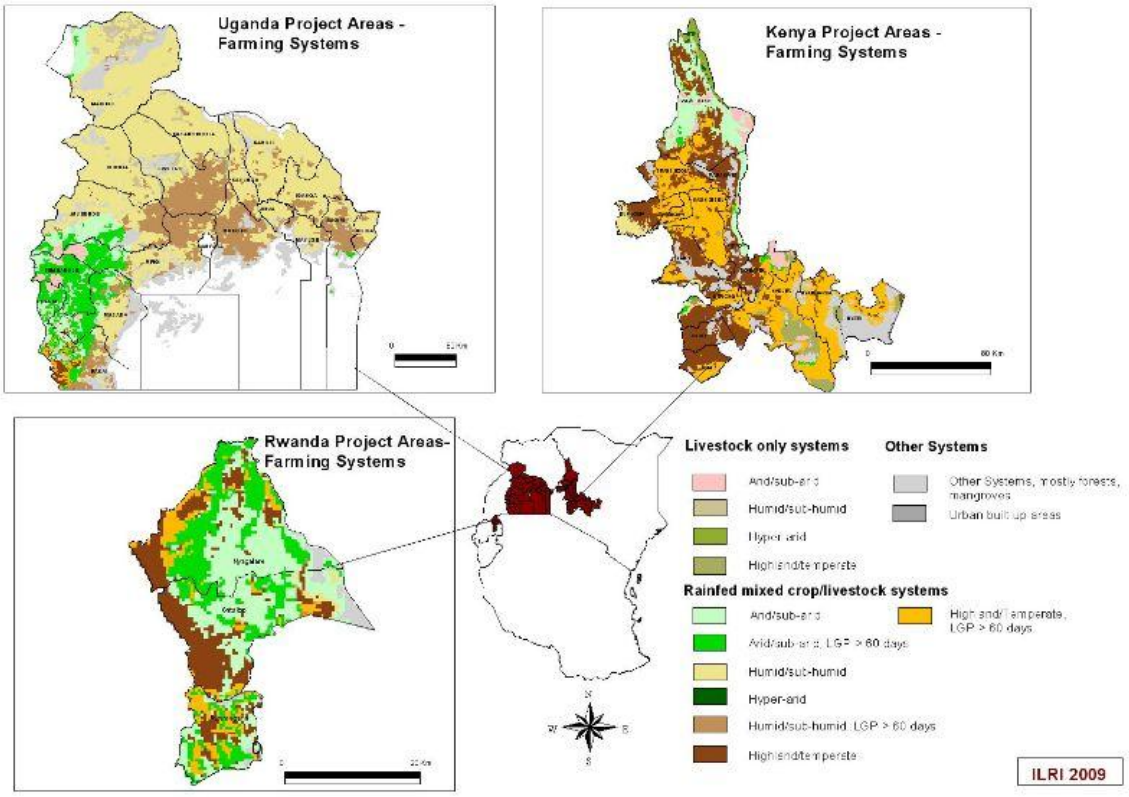

Figure1: A map of the project showing farming systems.

Kenya

Cluster 1 is located in the North Rift Valley Province of Kenya and comprises five hubs, that is, dairy producing and marketing centres established by the project (Table 1). It consists of mainly extensive systems with majority of land sizes ranging from 2 – 8 ha of land. Major crops grown include maize, beans, sweet potatoes, sorghum, cassava, Irish potatoes, vegetables and a variety of horticultural crops. Tea and pyrethrum are the main cash crops grown in Kabiyet and Lelan respectively. Wool production from exotic sheep is also a major farm enterprise in Lelan. Farmers ranked dairy production as the second most important enterprise to maize in Kipkaren; maize occupies about 75% of the cropping land. Natural pastures for grazing comprise the largest portion of livestock feed. Very few farmers interviewed practiced stall feeding (zero grazing). They attributed this to lack of labour rather than limited land for growing planted fodder. However, Napier grass (*Pennisetum purpureum*) Rhodes grass (*Chloris Gayana*), Oats (*Avena sativa*), maize for silage and Nandi setaria are grown by some farmers in Kipkaren, Kabiyet, Chepkorio and Metkei. There are no forages grown in Lelan probably due to abundant grazing land for livestock.

Cluster 2 is located in the South Rift Valley Province of Kenya and comprises five hubs. Land sizes range from 3-5 acres (1.2 – 2 ha). Major crops grown include maize, beans, sweet potatoes, bananas, sorghum, finger millet, Irish potatoes, vegetables and a variety of horticultural crops. Tea is a major cash crop in Longisa, Cheborge and Cheptalal, while pyrethrum is a major cash crop in Longisa. Coffee is also grown in Longisa and Kipkelion. In most areas more than 80% of the land is committed to dairy production activities except in areas where tea growing is the major farm enterprise (< 40%). Natural grazing is the major livestock feed resource. The main grass species dominating grazing lands in most areas are Kikuyu grass (*Pennisetum clandestinum)*, star grass (*Cynodon dactylon*), couch grass *(Triticum repens)* and wire

grass (*Aristida stricta)*. Napier grass is grown for fodder in all areas of South Rift Valley Province. Other forage crops grown include Rhodes grass in Siongiroi and Kipkeloin, Lucerne in Cheborge and Kipkelion. The fodder shrubs *Calliandra calothyrsus* and *Sesbania sesban* are grown on a few farms in Cheborge.

Cluster 3 is located in Central Province of Kenya and comprises four hubs. It is dominated by intensive systems with land sizes ranging between 0.6-2 ha. Major crops grown include maize, sweet potatoes, Irish potatoes, sorghum, vegetables and a variety of horticultural crops. Grazing lands are dominated by Kikuyu, star, couch and wire grasses. Farmers reported that wire grass is tough and unpalatable and often leads to tooth loss. Napier grass is grown in all areas in central Kenya. However, the acreage under grazing or pasture/fodder is small (<0.2 ha) in all areas, except Olkalou where these are 0.4 ha. Other forage crops grown in the area, though by very few farmers, include Rhodes grass, beetroots, mangold, sweet potato vines, rye grass, oats, vetch, lucerne and tree lucerne.

Uganda

Cluster 1 (Sembabule, Mpigi, Masaka) is located in western Uganda and comprises three hubs (Table 1). It is composed of mixed feeding systems ranging from free grazing to stall feeding. Stall feeding is mainly practiced in Masaka with total land holdings of less than 5 acres (2 ha). The main grasses comprise of *Pennisetum purpureum* and *Hyperrhenia* spp. with the under-layer of *Panicum maximum, Brachiaria* spp. and *Chloris gayana*. Banana and coffee are the main cash crops with root crops on the increase. Farmers grow a variety of crops such as sweet potatoes, groundnuts, arrow roots, and Irish potatoes. Livestock management is mainly carried out by women and children while men are mainly engaged in businesses since these require less labour and bring in quick returns. Farmers reported that dairy cattle production is gaining prominence. In Mpigi, most farmers keep unimproved local cows and practice open grazing with tethering while a few practice stall feeding for improved animals. Farmers who practice open grazing in areas neighbouring Sembabule are mainly pastoralists who keep large herds of local cows with a few cross breeds. They have larger pieces of land ranging from 80-100 acres (32-41 ha). Most grazing lands are infested with invasive bush species.

Cluster 2 (Kiboga, Mityana and Wakiso hubs) is situated in central Uganda with some parts comprising the peri-urban areas of Kampala city. Kiboga is a pastoral area comprising Kyankwanzi, Nsabya, Dwaniro, Butemba and Kapeke sub counties. Mityana is an intensive farming area with farmers practicing stall feeding with some tethering. The land sizes are 1-3 acres (0.4-1.2 ha). Most farmers keep 1-2 dairy animals. Grazing lands are heavily infested with termites. Wakiso is an intensive peri-urban area of Kampala. Most farmers keep cross breeds of Ankole-Friesian cattle. Napier grass forms the bulk of the basal feed resource.

*Cluster 3 (*Mukono, Jinja and Kayunga hubs) is situated in the eastern Uganda. In Mukono and Kayunga, average land sizes in the intensive areas range from 3-5 acres (1.2-2 ha) while in the extensive pastoral areas they average 20-25 acres (8-10 ha). The main cash crops are bananas and cotton. In Jinja, cattle are commonly tethered in homesteads and allowed to graze in common/public lands or crop fields after grain harvest. Common grasses in the cluster include *Hyperrhenia rufa*, *Panicum maximum* and *Setaria sphacelata*. There is greater reliance on annual food crops (millet, sorghum and maize) due to less stable rainfall conditions. Livestock is a main activity in the drier areas. Napier grass and natural pasture are the main livestock feed resources. Farmers mainly keep Friesian cross-bred cows with some local cattle breeds. Women actively participate in livestock production.

Cluster 4 (Masindi, Nakasongola and Nakaseke hubs) is dominated by the agro-pastoral systems. Luwero is in a semi intensive system where most farmers keep very large herds of unimproved local Ankole cattle often producing low milk yields. Unimproved natural pastures form the largest source of feed resource for livestock. However, undesirable bush species have invaded most grazing lands causing a major bush problem. Most vegetation is composed of dry Acacia/Combretum/Terminalia with the underlying grasses consisting of *Hyparrhenia* spp., *Themeda* spp., *Chrysopogon* spp. and *Sporobolus* spp.

Farmers reported frequent fires on grazing lands especially in the dry season. These drastically reduce feed resources and affect persistence of desirable forage species. Termites are a critical problem especially in Nakasongola. Water scarcity is critical in these areas forcing farmers to move long distances to search for water. The situation is more severe during the dry seasons and sometimes results in animal deaths. Farmers try to cope with this situation by selling off some livestock, usually at very low price, or alternatively by migrating to wetter areas

Rwanda

Cluster 1 (Nyagatare district) is a newly settled area. It was hived off a national park for settlement and comprises of extensive grazing systems (Table 1). The average land size per household is 8 acres (20 ha) in accordance with the Government land policy in place. Unimproved natural pastures form the main livestock feed resource which is dominated by *Chloris gayana*, and couch grasses. Very few farmers have planted Napier grass. This is partly attributed to limited rainfall and lack of knowledge on establishment of new fodder species. Most farmers have fenced their farms with live fences as a result of the Rwandan Government policy prohibiting free grazing outside owners' farms.

Cluster 2 (Gatsibo district has more intensified farming systems where farmers grow wide varieties of both food and forage crops. Unimproved natural pastures form the bulk of livestock feeds however some farmers grow Napier grass and legumes such as *Dolichos purpureum* plus a few fodder trees such as *Calliandra calothyrsus*. The majority of the farmers reported that they obtained livestock feed from their own farms and only bought feed off farm during the dry season when shortages were greatest. Most farmers reported grazing in their own farms whereas a few supplemented grazing with planted fodder. The zero grazing system is emerging in this region as a result of the national policy requiring farmers to utilize their own land for feeding livestock.

Cluster 3 (Rwamagana district) has intensive farming systems. The main crops grown include maize, sweet and Irish potatoes, and beans. In addition to unimproved natural pastures most farmers have also planted Napier grass. Other available livestock feed resources on farms include maize stover, potato vines and rice straw. Most of the farmers practice zero grazing while a few combine zero grazing with some grazing. Fodder markets are evolving with the local cooperative society selling hay and farmers trading Napier grass and other forages.

Herd structure, milk production and calf feeding

In the Kenyan study areas dairy cattle herds comprise mainly Friesian and Ayrshire cross breeds (Table 1). They are preferred by the majority of farmers because of their high milk production potential. Farmers do not prefer pure bred dairy animals because of their high feed demand and high management requirements. In north rift valley, farmers keep between 5-30 herds of cattle per household (HH) while in south rift valley, herds range from 5-15 per HH. In central Kenya farmers keep low herd sizes ranging from 3-7 head per HH. As expected, large herds are kept by farmers in extensive grazing systems where land sizes are larger. In general, herd composition includes adult cows, which together with heifers and calves accounts for nearly two thirds (75%) of all animals in herds. In all study areas some farmers reported keeping bulls for breeding and oxen for draught power, however most farmers use artificial insemination (AI). Many farmers reported retaining male calves on their farms until after weaning. These are sold afterwards to earn income for households.

In all study sites, with a few exceptions, cows are milked by the women twice daily. The average milk production per cow per day ranged between 3-14, 3-9 and 4-7 litres in north rift valley, south rift valley and central Kenya respectively. Calves in zero grazing systems are bucket fed while those in extensive systems are allowed to suckle for a few minutes before and after milking. There is no standard management system of calves with respect to feeding milk; farmers adopt their own feeding schedules which are not consistent. There appears to be competition for milk for household consumption, for sale

and for calf feeding. In addition to feeding milk, the majority of farmers in all study areas allowed calves to graze freely on unimproved natural pastures. Farmers ensure calves have access to water.

In central Uganda, there are three main types of indigenous cattle, i.e. the Small East African short horned Zebu, Ankole longhorn and Karamajong. The main improved dairy breed types are purebred Friesian, Jersey, Guernsey, Ayrshire and their crosses mainly with the indigenous breeds. They are basically kept in either

- small-holder intensive systems where typical zero grazing farmers keep 1 to 3 dairy cows and a total herd of around 2 to 6 cattle at any one time,
- medium-scale semi-intensive systems where farmers keep 10-15 cattle grazing on fenced paddocked land of 5-10 ha or
- large-scale extensive operators where agro-pastoralists own more than 10 ha of land and keep more than 50 cattle.

The production systems are very different in many respects but share similar feed challenges at different scales. Whereas farmers in intensive systems use grade animals and invest heavily into feeding, buildings and equipment, farmers in extensive systems use local breeds and invest minimally. Some farmers in extensive systems feed salt and have a hired herdsman. Typical milk production (excluding milk consumed by suckling calf) from Friesian grade/ crossbred was reported to be 5 – 9 litres/day while indigenous cows produce 1 – 4 litres/day.

Many farmers in Rwanda typically have predominantly Ankole cattle. Typically land parcels are larger than in other study countries and allow for more cattle. Herd sizes range from 1 or 2 cattle to 50 or more, depending on the farmer's financial resources. Milk yields are in the range 4-5 litres per cow per day. Interviews indicated that since 2004, farmers have been moving towards or planning to move towards exotic breeds since the Government is actively encouraging zero-grazing with exotic cattle, deeming this as the only appropriate way to increasing milk production. Hence some farmers were worried that the market and value for Ankole cattle will diminish, reducing a large source of income. However supply of exotic cows is limited as they need to be imported from other countries. The Government is also actively supporting replacement of local bulls with artificial insemination (A.I). It is supporting this transition by heavily subsidizing A.I. This has implications for feeding cattle. Calves in semi-intensive and intensive systems are mainly suckled before and after milking. Due to low income from milk, farmers reported selling manure and calves to earn extra income. Formal market price per liter is over 2.5 times greater than in the informal market.

Table 1: A summary of feeding systems and cattle breeds kept in various clusters

Country	Cluster	Hubs	Farming systems	Cattle breeds kept	Cattle feeding system
Kenya	1	Kipkaren, Kabiyet Chepkorio, Metkei Lelan	Maize-dairy (Kipkaren). Tea-dairy (Kabiyet). Mixed farming in other areas.	Friesian and Ayrshire cross breeds	Grazing with some stall feeding in Kipkaren
	2	Longisa, Siongiroi, Cheborge, Cheptalal, Kipkelion	Pyrethrum-dairy (Longisa) Tea-dairy (other areas)	Friesian and Ayrshire cross breeds. Few local cattle	Mainly grazing with some stall feeding
	3	Olkalou, Nyala (Laikipia), Nyandarua north, Nyandarua south	Mixed farming with mainly dairying	Friesian and Ayrshire cross breeds	Mainly grazing with some stall feeding
Uganda	1	Sembabule, Mpigi, Masaka	Coffee-banana	Mainly Ankole, with some Ankole- Friesian crosses	Mainly grazing with some stall feeding
	2	Kiboga, Mityana, Wakiso	Mixed farming	Mainly Friesian cross bred cows with some Ankole	Mainly stall feeding with some grazing
	3	Mukono, Jinja, Kayunga	Banana-coffee	Mainly Friesian cross bred cows with some local cattle	Mainly stall feeding with some grazing
	4	Masindi, Nakasongola Nakaseke	Pastoral	Unimproved local cattle with some Ankole crosses	Mainly grazing
Rwanda	1	Nyagatare district	Mixed farming	Mainly Ankole	Free grazing only (in fenced paddocks)
	2	Gatsibo district	Mixed farming	Mainly Ankole and some crosses	Semi grazing system
	3	Rwamagana district	Mixed farming	Mainly Ankole and some crosses	Stall feeding with some grazing

Feed inventory

Forages and crop residues: In all surveyed sites farmers reported a seasonal fluctuation in livestock feed availability with the greatest feed scarcity being felt during the dry season (Table 3). Napier grass and natural pastures formed the bulk of feed resources during both the wet and dry seasons. Cattle are usually kept year-round on unimproved pastures dominated by natural species, which include *Cynodon dactylon, Digitaria sanguinalis, and Cynodon nlemfuensis*. These unimproved pastures are often overgrazed for most of the year. In the eastern region of Uganda, there is a serious degradation of grazing lands with undesirable species (bush problem) that have completely smothered grazing pastures. The unpalatable species of spear grass (*Imperata cylindrica*) is dominating pastures species around the wetlands. Farmers face the same problem in some extensive areas of Metkei of north rift valley of Kenya and some areas around Mbare hub of Nyagatare district in Rwanda. In Uganda pastoralists' attempt to control the bush problem by burning rangelands in uncontrolled manner with fires often going out of control and destroying acres of grazing land. This interferes not only with the persistence of desirable grasses and shrub species but also the biodiversity of those areas. Additionally, there is infestation of the grazing lands with termites which also destroy pasture grass.

There was a wider range of feed resources being fed on farms during the dry than wet season, suggesting that there is opportunistic feeding during times of feed scarcity. During the dry season commonly utilized feeds were crop by-products like maize stover, wheat/rice straws, bean haulms, purchased hay and in some cases Napier grass. Farmers also fed unconventional feeds such as tree leaves known as *Ficus indicus and Acacia species*, kitchen waste, sugar cane tops and local brewers waste. The bulk of feed resources offered to dairy cattle in both wet and dry seasons were sourced on-farm in all areas. However, farmers reported having only small acreages of planted fodder on farms because they depended mainly on natural pastures on farms or public land. In some areas a few farmers purchased feeds, during the dry season such as hay, maize stover, cut grass, and silage. Most farmers hired labour to gather feeds for livestock from communal lands. A list of feeds offered and their relative importance is shown in Table 2. Herbaceous legumes and fodder trees were grown and utilized by only a few farmers in all surveyed clusters. Farmers attributed this to lack of technical know-how on establishment and management as well as lack of seed/planting material. However, the few farmers who grew fodder trees had insufficient numbers of them (*Calliandra calothyrsus, Sesbani sesban*) to even maintain a dairy cow and isolated patches of other legumes such as Dolichos, lablab, Lucerne or Desmodium.

Concentrate feeds: Study findings from all sites revealed that very few farmers fed compounded dairy concentrate, feed ingredients or feed supplements to dairy cattle regularly. Farmers attributed low usage to the high cost of commercial feeds. As a result farmers reported that use of concentrates increased their production cost. However, they usually invest in concentrate use during the dry season only when feeds are scarce. In Kenya, the common types of concentrates and feed ingredients used included wheat/maize bran, maize germ, ground maize (waste) and cobs, pollard, cotton seed cake, fish meal, sunflower cake, dairy meal, mineral licks or blocks, stock salt, calf pellets and molasses. In Uganda wheat/ maize bran and compounded dairy meal were available while in Rwanda only compounded dairy meals were used. In Kenya and Uganda, farmers expressed concern regarding the poor quality or sub standard commercial feeds sold on the market. Farmers reported this suspicion due to minimal effects on milk production following use of these concentrates.

Feed markets

Trading of fodder (selling and buying) was reported in almost all surveyed areas of Kenya and in the intensive systems of Masaka, Mpigi and Luweero in Uganda. Fodder trading in Uganda is evolving with Napier grass in two forms where farmers either offer cash or barter fodder for milk. There was no fodder trading reported in Rwanda. Natural pasture was the cheapest source of feed per kg DM basis in all seasons (Table 2).

Table 2: A summary of seasonal availability of fodder types and prices in surveyed areas of Kenya

Fodder type	Unit type	Unit description	Unit amount	Unit amount (DM basis)		Unit cost (USD)		Cost per kg DM (USD)	
				Dry	Wet	Dry	Wet	Dry	Wet
Boma Rhodes hay	bale	Weight, kg per bale	15	13.5	13.5	2	5	0.15	0.37
Wheat straw hay	bale	Weight, kg per bale	15	14.3	14.3	1	1	0.07	0.07
Cut natural pasture	sack	Weight, kg per sack	90	72	36	0.5	0.5	0.01	0.01
Napier grass	kg	yield from 0.25 acre (	1600	880	400	13	13	0.01	0.03
Oats grain	bag	weight kg per bag	70	69	69	4	8	0.06	0.12

Currency conversion: 1 US Dollar (USD) to 78 Kenya shillings (Ksh).

Feed storage

In study sites, the majority of cattle keepers did not have a livestock feed store or forage bank to store excess feed during the wet season for use during the dry season. In Kenya, farmers reported stacking maize stover under trees or just leaving it in the open. As a result they reported high losses due probably to rotting, exposure to rainfall or destruction by termites. In some areas of Longisa and Kipkaren hubs of Kenya and the most intensive systems of Uganda and Rwanda, cattle were released to graze directly on standing maize stover after harvesting the maize. This presumably led to trampling of stover and hence considerable wastage.

Forage diseases

Napier head smut disease was reported in all survey areas of Kenya and eastern regions of Uganda. Farmers reported that the disease was reducing dry matter yields of Napier grass on their farms. Napier grass head smut is a fungal disease caused by *Ustilago kameruniensis*. The disease changes Napier grass morphology and is characterized by smutted heads. It gradually reduces dry matter yields and causes losses of up to 46 % (Farrell 2002). Napier stunt disease was also reported in the eastern region of Uganda and isolated cases were reported in north rift valley of Kenya. Napier grass stunt is a new disease associated with a 16SrXI Group phytoplasma whose symptoms include foliar yellowing, small leaves, proliferation of tillers and shortening of internodes to the extent that clumps appear severely stunted (Jones et al. 2004). Both diseases currently threaten the dairy industries in Kenya and Uganda and are a potential threat to Rwanda.

Water availability

Water scarcity was reported in all areas of Rwanda, Uganda and some parts of Kenya. In Rwanda all farmers interviewed reported trekking up to 5-8 km per day in search of water for livestock and domestic use. Farmers reported that this affected milk production especially in the dry seasons. Farmers indicated that cattle spent more time walking than feeding. The longer cattle walk in search of water the more time and energy is used and the more performance is lost (Gerrish et al. 1995). Cattle performance is also lost through decreased feed intake and hence milk production. The ratio of drinking water to milk production is estimated at 2 litres of water per kg of milk (Brouk et al. 2001). Water scarcity reduces milk production. On average, lactating milk cows should drink from 85 to 100 litres of water/day (Brouk et al. 2001). However this is dependent on feed intake, weather conditions, milk production, and stage of lactation.

Table 3: Inventory of feeds indicating and their importance in different seasons across all study sites

Feed resource	Dry season Kenya: Jan-Mar; Aug - Sept Uganda: Dec-Feb; Jun-Aug Rwanda: Jan-Mar; July-Sept			Wet season Kenya: Apr –Jul; Oct -Dec Uganda: Mar-May; Sept-Nov Rwanda: Oct-Dec; Mar-Jun		
	Kenya	Uganda	Rwanda	Kenya	Uganda	Rwanda
Forages:						
Natural pastures	+++	+++	+++	+++	+++	+++
Napier grass	++	+		+++	+++	++
Harvested roadside grass	++			++		
Maize thinnings				++		
Green stover *(after harvest of green maize cobs)*				++		
Other planted fodder *(Rhodes grass, Oats, Nandi setaria, Sudan grass, Kikuyu grass)*	+	+		+	+	+
Weeds *(from public or crop land)*				++		
Grass hay	++	+	++	+		+
Crop residues:						
Maize stover	+++	+++	+++	++	+	+
Wheat straw	++			+		
Ground maize stover	+++			++		
Ground maize on cobs	+++			++		
Banana pseudo stems	+	++		+	+	
Sugarcane tops						
Kitchen waste *(banana peelings/ leaves, cassava and Irish potato peelings, pineapple waste pumpkin leaves etc.).*	++	++	+	+	+	
Sorghum/millet stover	+	++			+	
indigenous tree leaves and fruits *(Saunet, Uswet avocado, loquart, acacias, stinging nettle etc)*	+	+				
Fodder trees *(Calliandra/ Leucaena spp etc)*	+	+		+	+	
Sweet potato vines	+	++	+	+	+	+
Bean haulms	+	++	++			
Pumpkin leaves	+					
Concentrates:						
Dairy meal	++	+	+	++	+	+
Spoilt maize grain	+					
Legumes *(Dolicho, lab lab, Lucerne, desmodium etc)*				+	+	+
Root fodder *(beet roots[+], mangold)*	+					

+ = Not important (rarely used)

++ = Important (used occasionally)

+++ = very important (main feed resource, frequently used)

Farmers' perceptions on causes of feed shortages on farms

In all areas surveyed sites, farmers advanced various reasons for feed shortages which are summarized in Table 4. Of importance is the fact that farmers recognized feed shortages as a major constraint in dairy production especially during the dry season. They advanced various reasons for feed scarcity that can be summarized as follows:

Knowledge gaps: Farmers acknowledged the need for greater feed availability on farms; however they noted lack of technical knowledge of production, management, utilization and conservation of forages which are key areas to improving feed availability. Knowledge gaps in the area of pasture establishment and management were also highlighted. This is particularly important because most of the project areas in Uganda, Rwanda and some parts of Kenya are situated in agro-pastoral systems and dominated by unimproved pastures. In these systems, poor pasture establishment and management result in overgrazing, reduced carrying capacity and hence reduced productivity. Other knowledge gaps reported by farmers that contribute to reduced feed availability included water harvesting, forage disease control and on farm feed planning. Farmers attributed lack of knowledge to scarce extension materials and personnel. In the past decade or so there have been declining public resources of government that are available for the extension service (Weinard 2002).

Competitiveness of planted fodder with other uses of land/labour: Study areas were clearly undergoing different intensification levels. Whereas farmers in extensive systems had problems with adequate labour and managing pasture on available land, those in intensive systems had problems making choices of whether to grow crops for food or feed for livestock. Farmers in mixed intensive farming systems reported keeping cattle as well growing a wide range of crops. In these intensifying systems farmers reported a need to balance between food and feed. There was evidence that areas under planted forages are reducing as demand for food increases.

Input issues: The two main input constraints reported by farmers related to availability and cost of forage seed/ planting materials and inadequate labour for feed production. Farmers reported that planting materials were bulky to transport. However, most forage seed in all study countries is imported and is hence costly and also subject to government seed handling regulations which are lengthy, laborious and often delay seed reaching the market.

Community organization issues: The constraint of overgrazing was reported in pastoral systems. This was mainly attributed to traditional customs of communities living in these systems requiring them to keep large herds of cattle not only for social and aesthetic value but also as a cash reserve.

Economic viability constraints: These included high cost of inputs/labour in feed production and conservation and hence high cost of feeds related to low milk prices. Indeed farmers reported that the highest cost they incurred on farms was for livestock feeds. They also reported lack of capital to invest in feed production. These are important because the ability to invest and the returns to investment in feed production provide the incentive for farmers to increase milk production. Hence, the need to assess the viability of potential feed interventions to solve these constraints e.g. introduction of storage facilities, box baling, use of concentrates, cannot be overlooked.

Table 4: Farmers' perceptions on causes of feed shortages on smallholder farms

Identified constraint	Type of constraint	Farmers reasons/factors contributing to feed shortages
Forage wastage during wet seasons	Knowledge gap	▪ Poor production, management and utilization of improved fodders ▪ Poor feed conservation and storage
	Economic viability	▪ High cost of inputs for conserving feeds e.g. silage and hay
Low acreage under forage and fodder	Input issue	▪ Lack of forage seed and planting materials
	Economic viability	▪ Competition for land with food crops hence less land for feeds ▪ Low milk prices or lack of milk market reduces motivation for investment in fodder production
Poor natural pasture management	Knowledge gap	▪ Lack of knowledge on pasture establishment and management
	Community organization issue	▪ Overstocking
Water scarcity (for livestock use and fodder production)	Natural trend	▪ Unpredictable weather conditions
	Knowledge gap	▪ Lack of water conservation technologies and facilities
Limited labour to produce forages on farms	Economic viability	▪ High cost of labour
	Input issue	▪ Unavailable labour force
Forage diseases and pests	Knowledge gap	▪ Napier head smut and stunting disease, leucaena psyllid and aphids
Lack of feed budgeting on farms	Knowledge gap	▪ Lack knowledge on feed budgeting ▪ Unpredictable quality of concentrate feeds
	Economic viability	▪ High cost of purchased feeds (forages and concentrates) ▪ Lack of capital to invest (no micro-finance support to invest in animal feeds)

Farmers coping strategies during the dry season period

In all survey areas, farmers outlined coping strategies used to overcome feed shortages during dry seasons. These strategies ranged from utilization of crop residues, purchase of off farm feeds, use of public land for grazing and use of commercial feeds amongst others (Table 5). However, most strategies would require farmers to commit more cash to feeding cattle during the dry season with accompanying increased costs of milk production. It was clear that not all farmers can afford such strategies and therefore opt for cheaper strategies such as use of public land for feeding cattle. These strategies are associated with disease risks and reduced production due to under-feeding and long distances that livestock have to walk.

Table 5: Farmers coping strategies their limitations and strengths during dry seasons

Farmers coping strategies	Strength	Limitations
Commonly used strategies		
Feeding of crop residues	▪ Readily available during dry seasons	▪ Poor quality - low crude protein (CP) metabolisable energy (ME)
Search for pasture *e.g. harvesting grass or grazing along the road public lands*	▪ A cheaper feeding strategy	▪ There is a risk of picking up ticks from grazing public areas hence tick borne diseases ▪ Cattle use valuable energy walking at the expense of milk production.
Purchase feed off farm (natural grass, Napier grass, hay, silage etc)	▪ Ensures feed is always available especially during the dry season	▪ Feeds tend to be costly during dry seasons ▪ May lack cash to purchase feeds
Rationing of feed depending on animal category and state	---	▪ May lead to underfeeding hence reduced milk production
Frequent watering of cattle	▪ Prevents dehydration	▪ Does not replace dry matter requirement
Rarely used strategies		
Hiring grazing land (common in Uganda and Kenya*)*	▪ Could be a useful option where land is available and is affordable	▪ It involves additional production costs of hiring land
Feed more concentrates	▪ Has potential to increase or maintain milk production during the dry season	▪ Increases costs of production
Maintain local breeds	▪ Tend to handle poor quality feeds better ▪ Low feed demand	▪ Low milk yield from local breeds
Feed mineral lick before early morning grazing	▪ Could improve utilization of poor quality forages	▪ Increases costs of production
Selling off excess stock *(*usually an option in pastoral systems*)*	▪ Avoids overgrazing and degrading pastures ▪ Avoid total loss (cattle deaths)	▪ Low return on livestock sales i.e. Cattle prices are usually low during this time

Potential 'best bet' options for improving high quality feeds in study sites

This study identified problems facing farmers and potential opportunities that require sustainable solutions that would lead to access to and/or increased production of high quality feeds. Farming systems in study areas were evidently at different levels of intensification with different available feed resources and access to market. In order to develop appropriate technologies and target extension advice it is important to review some of the management strategies that farmers currently use and suggest potential 'best bet' feed interventions to solving some of the problems identified. In identifying the appropriate interventions, it is clear that blanket solutions do not exist. First, the demands on feed resources are different in various livestock production systems. Feed demands are higher in intensive mixed crop-livestock farming systems than extensive grazing systems. These differences must be acknowledged. Second, the sustainability of livestock production is mainly a result of local resource availability and prevailing policies and institutions. Any intervention therefore needs to be designed according to prevailing local and national priorities and resource availability, balancing human needs and

environmental concerns and finally we need to learn lessons from past experiences and consider the economics of each intervention which ultimately will determine uptake of technologies (Table 6).

Table 6: Possible interventions to address feed constraints: intervention status/attributes and lessons learned from previous work.

Description of potential 'best bet' intervention	Status/attributes of intervention	Lessons for EADD
1. Strategies to widen the feed resource base and increase fodder acreages on farms:		
There is a great scope for introducing planted fodder (grasses and legumes) in various farming systems depending on suitability, to increase acreages of planted fodder on farms. - A range of superior accessions for a range of environments and farming systems have been identified throughout the tropics over the last 20 years (Dzowela 1988, Barnes and Addo-Kwafo 1996). Examples include Napier grass, *Macrotyloma axillare* (Archer), *Stylosanthes guianensis*, *Clitoria ternatea, Centrosema pascuorum*, *Bracharia brizanth, Panicum maximum*, *Panicum coloratum*, Boma Rhodes, *Nandi setaria*, Sudan grass, forage sorghum hybrids (Sudex), Lucerne, *Desmodium uncintum*, *Desmodium intortum*, *Lablab purpureum L*. and *Neotonia wightii* amongst others.	A few fodders like Napier grass have been widely adopted but most have had very little adoption due to scarcity and cost of planting material - Requires increased forage seed production and market linkages to improve chances of adoption. - May also require micro-sizing forage seed packages to enhance access by small scale farmers. - Requires Government policy explicitly promoting forage seeds production and marketing	Need to consider constraints to production and recommendation domains in technology design (Lenne and Wood, 2004; Sumberg and Reece 2004. Sumberg 2005)
Fodder trees and shrubs as *Calliandra calothyrsus and Sesbania sesban* also have potential in some of the farming systems. Fodder trees have been adopted successfully in a range of farming systems (Paterson et al. 1999; Franzel et al. 2003).	- Have seen considerable adoption but with limited utilization - They are less affected by seasonal dry conditions due of their extensive root system, have long life spans, are rich in protein, are easy and cheap to harvest. They take up little land as they can be planted along boundaries	Need to address factors affecting fodder trees and shrubs adoption (Patterson et al. 1998) and take advantage of the elements that facilitate widespread adoption (Wambugu et al. 2001; Franzel et al. 2003).
There is also scope for developing use of food-feed crops like sweet potato vines, maize, sorghum, finger millet, cassava, barley, and oats in most of the study sites.	Dual purpose crops have high adoption probability in intensifying systems	Dual purpose crops can provide grain for human consumption and residues for livestock nutrition from the same land with similar amounts of inputs, including water (Lenne and Thomas 2005; Sumberg 2004, Sumberg 2002).
2. Promote suitable small scale simple, practical and low cost forage conservation strategies:		
a. Box baling of maize stover and other crop residues. - Bales of hay are made by trampling stover into	Practical application: - Reduces transport cost where crop residues have to	Box baling has been successfully

wooden frames placed on the ground. Bales are tied with sisal twine inserted in the frames, before the stover.	be moved over relatively long distances - Helps in feed budgeting - Requires labour of at least two people to bale hay	demonstrated in Tanzania (Massawe et al. 1998a; Massawe et al. 1998b).
b. Silage making: - Tube silage is made by using polythene tubing tied at one end. Two workers are able to make silage packages weighing 500 kilograms (EADD silage flyer No 4). - Small scale above ground silage can also be made using a shallow pit	- Napier grass, green maize, sorghum, and sugar cane tops have shown considerable potential for wider application and adoption of ensilage methods	- Small-scale tube silage making has been successfully demonstrated in Kenya (Methu et al. 2003).
3. Strategies for utilizing low quality crop residues on farms		
<u>a. Storage and utilization:</u> - Rapid removal of stover from the field after grain harvest - Storage under cover, with some movement of air will allow completion of the drying process - Chopping stover before feeding using a power driven chopper, a hand operated chaff cutter, a panga or a guillotine blade.	There is scope for utilizing the large amounts of crop residues currently available and greatly under-utilized on farms in terms of livestock feeding. This strategy has potential to: - Reduce leaf loss and senescence hence maintaining quality (Owen and Aboud, 1998). - Reduce the absorption of moisture during damp weather thus preventing or reduceing the formation of mycotoxins (Ncuebe et al. 1993). - Increase digestibility and intake of fibrous residues (Van Soest 1994).	Farmers need training and information on these simple and practical practices. Farmers and especially young farmers' education on the possibilities of increased and sustainable production methods has large pay-offs.
<u>b. Supplementation with nitrogen</u> Supplementing low quality cereal stovers/straws could provide maintenance requirements to the dairy cattle, especially during the dry season, when only low quality forages are available.	- The utilization of poor roughages can be increased by a nitrogen supplement (Preston and Leng 1987).	- The need for training and information on utilization of crop residues - Need to test dry season feed supplements in areas with high amounts of stover.
<u>c. Mixing crop residues based 'home made' rations:</u> An opportunity exists for on farm feed formulation using locally available feed ingredients	Farmer mix feed rations using locally available feed ingredients in any proportions and are often not aware of their quality and cost.	- Feed analysis of on-farm based feed ingredients is required to enable compounding of rations. - Feed ration formulations advice to small scale dairy farmers must be based on cost-benefit analysis - Some areas may need further research

d. Urea treatment Treatment procedure may vary according to circumstances. Smith et al. (1989), found that 5% urea (in solution) added at a rate of at least 20%, weight for weight solution to dry stover, followed by an incubation period of five weeks gave the greatest improvement.	- Has potential for increasing digestibility and intake of fibrous residues - Has been widely researched and comprehensively reviewed (Sundstol and Owen 1984). However, its uptake at farm level has been slow. Cost is often cited as a reason for this.	- Needs to be tested using locally occurring alkalis such as Magadi, which occur naturally in parts of East Africa. An economic viability assessment is needed to enable farmers to make good decisions
4. Strategies to control bush and improve natural pastures:		
a. Training and information Develop training materials based on on-farm adopted pasture improvement technologies for extension workers and farmers.	Has potential to catalyse uptake of technologies	These technologies need to be demonstrated to farmers in a participatory manner
b. Mechanical bush and weed control Mechanical removal of bush and weeds has been shown to be effective. Frequent uprooting and slashing, exhausts food reserves in the root systems leading to their stunted growth and eventually death. Hoes, pangas or slashers are very useful tools for this activity. The hoe, in particular, is a good tool because its action on the soil ensures sustainable soil management. Uprooting and slashing should be done, preferably, before the plants begin to shed seed.	This control method is cheap but labour intensive and may need some capital input. As a result, only a few areas can be cleared.	Requires working with partners including Government in some cases.
c. Fencing Fencing is a pasture management tool.	Fencing by use of posts and barbed wire can be quite expensive. Cheaper materials such as bush poles e.g. *Ficus spp.* treated by engine oil against termites can be used. Live fences are even cheaper and last longer. They also keep intruders away when well established but the establishment and maintenance costs, in terms of trimming, may be high. Trees suitable for live hedges include *Euphorbia tirucalli*, *E.candelabrum* and *Erythrina abyssinica*.	Requires working with partners including Government in some cases.

d. Introduction of improved pasture species The can be done by either over-sowing grasses or legumes into existing natural pasture or re-seeding pasture afresh. This requires minimum cultivation and no use of fertilizer.	- Low cost and practical on most small scale farms however my be expensive and labour intensive if used in extensive systems - This increases forage quality and productivity of natural pastures. - It is a simple and cost effective pasture improvement strategy. - Benefits of over sowing are long-term.	- Leaflets on skills of pasture establishment, management and use need to be produced.
Strategies for improved calf rearing and nutrition		
To overcome poor calf nutrition there is need for improved calf feeding strategies. This will improve daily weight gains and reduce calf mortality on smallholder farms. There also potential to improve post weaning performance hence resultant heifer reaching service age earlier.	- Farmers often under-feed calves in order to sell more milk for cash. - No supplementation is considered for calves. - Calf rearing often neglected when considering feeding of dairy cattle.	- Introduce and test a fortified plant protein based calf 'Oasis' starter meal for rearing calves with farmers (Odongo and Njuho, 1990) - Introduce recommended calf rearing practices in both intensive and extensive systems (Lanyasunya et al. 1998; Gitau et al. 1994). - Raise profile of calf feeding amongst training and dissemination activities - Develop information leaflet on calf rearing

Other non technological options for improving high quality feeds in study sites

Efforts to improve access and productivity of high quality feeds should not be limited to technological interventions alone although new knowledge on fodder continues to be important. In order to introduce and promote new feed technologies for improved availability of feed to farmers in a cost effective and sustainable manner; it is important to consider other non technological options such as fodder markets, forage seed systems, Government policy and involving all relevant stakeholders in solving feed problems (table 7).

Table 7. Non-technological options for improving high quality feeds

<table>
<tr><td colspan="2">Strategies to promote fodder and feed markets</td></tr>
<tr><td>Current situation in study sites</td><td>Potential interventions</td></tr>
<tr><td>▪ Fodder is traded informally at the village level i.e. market access is limited to buyers in immediate locality
▪ There is lack of exposure of local markets/smallholders to other markets/production systems
▪ There is growth of peri-urban livestock production that may create demand for feed/fodder.
▪ Due to land scarcity, demand for fodder is likely to increase specially in intensive systems. Both dairy and non-dairy farmers are likely to turn to marketing of fodder and residues for income generation.
▪ Some farmers lease land for growing fodder
▪ It is common for farmers to plant fodder or graze on public land or buy fodder from farmers without livestock or those who have excess</td><td>▪ Promoting cultivation of fodder for sale by individual fodder farmers
▪ Forming common interest groups of interested dairy and non-dairy farmers and leasing land from big farmers for growing fodder.
▪ Facilitation of direct marketing arrangements where rural fodder producers are linked to urban dairy producers.
▪ Sourcing of feeds through hubs (and information about it) that could provide regular, consistent supply to allow transformation from subsistence to use of more external feed inputs
▪ Expansion of retail fodder market chains

In order to achieve this, identifying and supporting fodder farmers with technical knowledge and linking them to markets is important. With a reduced extension work force it will be necessary to focus efforts on farmers or groups of farmers who are receptive to change and willing to participate in the extension process (Drost et al, 1996).</td></tr>
<tr><td colspan="2">Development of sustainable seed systems for forages</td></tr>
<tr><td>▪ Lack of forage seed
▪ High cost of forage seed
▪ Inappropriate packaging for small scale farmers
▪ Privatization of forage seed sector but government bodies, such as national tree seed centres, are often competing with the private sector.
▪ Low interest of “formal” private sector, e.g., seed companies, in forage crops
▪ The Kenya Tree Seed and Nursery Operators Association (KATRESNO) was formed in 2005 through ICRAF’s help to promote seed marketing. Over an eight month period in 2006, 43 members sold over 1 tonne of seed, sufficient for over 30,000 farmers to plant (Franzel and Wambugu, 2007).</td><td>▪ Identify local seed vendors and provide them with training and support. Train fodder shrub seed vendors in seed collection, storage, packaging, and business skills and help them link to buyers. These can yield important benefits (Franzel 2009 pers com)
▪ Strengthen seed marketing in Kenya through KATRESNO and replicate in Uganda and Rwanda.
▪ Development of farmer-led seed multiplication systems at village and community levels (Ball and Doughlous 1992; Almekinders et al. 1994; Ravinder et al. 2006).</td></tr>
<tr><td colspan="2">Addressing policy issues</td></tr>
<tr><td>▪ Napier head-smut and stunt diseases are devastating Napier grass fields in Kenya and Uganda. There is no regulation in any of the</td><td>Livestock policy issue
▪ Sensitize relevant government agencies about need to regulate movement of vegetative planting material.</td></tr>
</table>

study countries that controls the movement of vegetative planting materials. o Farmers can transport infected material from infected zones to diseases free zones at will. This escalates the spread of these diseases. ▪ In Rwanda, there is a Government law requiring farmers to replace use of local bulls with artificial Insemination (AI). o Has an implication on matching available feed resources with high management-demanding exotic livestock breeds. ▪ In Rwanda, a Government requirement that farmers should confine and only graze livestock on their own farms is in place. The implications are that: o they will either have to de-stock, or o they will need to enhance the introduction of planted fodders to meet their feed requirements. ▪ Lack of feed quality control (e.g. feed quality variability creates production risk, and drives producers away from formulated feeds) ▪ Lack of security about land rights discourages investment in long term fodders such as fodder trees and pasture improvement	▪ Link farmers to feeds and feed services at milk marketing centres (hubs). Farmers should be able to acquire feeds on a check off system so that their feed costs are subtracted from their milk revenue. ▪ Advise policy makers to promote the use of new methods and approaches, rather than requiring all farmers to use them. ▪ Advise policy makers on the need for farmers to have secure land tenure in order that they invest in land improvements, and on effective approaches for improving land tenure security. Options beyond the realm of livestock policy ▪ Improve availability and access to feed resources to match the expansion of the AI programme. ▪ Urgently need to enhance high yielding fodder production programs to sustain the feeding systems; and introduce pasture improvement programs such as fencing and putting up farm structures to house livestock. ▪ Encourage formation of feed manufacturers associations who will be mandated to lobby and help governments in feed quality control
Addressing partnership issues in feed production	
Stakeholder inventory conducted in all project sites showed that: ▪ There was a wide range of stakeholders ranging from community-based organizations, non-governmental organizations, learning institutions, dairy cooperatives, private companies, micro- finance institutions, milk processors, media, extension providers and local and central government. ▪ Most actors involved in livestock feed production operate independently and are weak in partnerships) ▪ Each actor addressed different activities to solve different problems in different areas along the feed value chain ▪ There were a lot of overlaps in areas of operation and sometimes duplication of efforts.	▪ Adopt innovation systems approach (ISA) in solving feed problems. 'ISA is a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance (Biggs, 2007)' ▪ The SCALE (System-wide Collaborative Action for Livelihoods and the Environment) methodology is useful for implementing an ISA. SCALE brings a range of civil society stakeholders together to plan and implement campaigns to promote new practices (AED 2006). By engaging with a wide range of stakeholders, representing all aspects of a given system (in this case, dairy production), SCALE generates change across many levels and sectors of society, using a combination of different social change methodologies. ▪ Building partnerships with a range of stakeholders has been shown to be successful in dissemination of fodder legume technologies. (Franzel et al. 2003; Peters and Lascano 2003). For example, researchers as part of a stakeholder grouping in a feed development effort can supply knowledge and ideas about new technology such s the ones outlined above but there is a need to link closely with other actors for successful implementation.

Conclusions

This rapid assessment study of feed resources in Kenya, Uganda and Rwanda clearly highlights that:

1. Dairy production provides a unique development strategy as a source of livelihood for most smallholder farmers not only providing income through milk sales but also, milk for home consumption.
2. Farmers' current feeding practices are opportunistic with little evidence of adoption of new technologies to enhance production.
3. There are opportunities for feed production to be stimulated in all three study countries to enhance milk production although the nature of the interventions may vary according to the area and country under study.

The paper suggested several technological strategies and non technological options to improve availability and access to high quality feeds. However, it is worthwhile noting that the options suggested here should not be seen as definitive. The principal objective is to integrate all the strategies suggested here into a 'basket of technologies' to offer smallholder farmers and other development stakeholders using participatory approaches. A combination will probably be most effective. However, the economic assessments (cost benefit analysis) of these interventions must be calculated to help extension providers and farmers to make appropriate decisions. Ultimately this is what will determine whether the technology is taken up or not. The paper also shows the complexity of the farming systems within which small scale farmers operate and supports the supposition that dissemination of feed technologies should be conducted by building partnerships with a range of stakeholders and developing capacity. There is therefore need to build partnerships to enhance dissemination of high quality feeds

References

AED 2006 SCALE: *A tool for transformational development.* Academy for Educational Development. Washingon, DC.

Almekinders CJM, Louwaars, NP and de Bruijn GH. 1994. Local seed systems and their importance for an improved seed supply in developing countries. *Euphytica.* 78:207-216

Ayantunde AA, Fernández-Rivera S and McCrabb G. (eds). 2005. *Coping with Feed Scarcity in Smallholder Livestock Systems in Developing Countries*. Animal Sciences Group, UR, Wageningen, The Netherlands, University of Reading, Reading, UK, Swiss Federal Institute of Technology, Zurich, Switzerland and International Livestock Research Institute. Nairobi, Kenya. 307 pp.

Ball SS and Doughlous JE. 1992. Designing successful farmer-managed seed systems. Winrock International Institute for Agricultural Development. Development Studies paper Series. Winrock, Arlington, USA.

Bayer W. 1990. Napier grass- a promising fodder for smallholder livestock production in the tropics. *Plant research development* 31: 103- 111

Biggs S. 2007. Building on the positive: an actor innovation systems approach to finding and promoting pro poor natural resources institutional and technical innovations. *International Journal of Agricultural Resources, Governance and Ecology*. 6(2).

Brouk MJ, Smith JF, Harner JP and DeFrain SR. 2001. Drinking water requirements for lactating dairy cows. http://www.rbstfacts.org/rbst-facts/rbst-and-farm-economics/drinking-water-requirements-for-lactating-dairy-cows.html

Drost D, Long G, Wilson D, Miller B and Campbell W. 1996. Barriers to adopting sustainable agricultural practices. *Journal of Extension*, 34(6). Article 6FEA1.

Farrell G, Simons SA, Hillocks RJ. 2002. Pests, diseases and weeds of Napier grass, *Pennisetum purpureum*: a review. *International Journal of Pest Management*, 1366-5863, Volume 48, Issue 1, Pages 39 – 48

Franzel S, Wambugu C and Tuwei, P. 2003. *The adoption and dissemination of fodder shrubs in central Kenya*, Agnen Network Paper No. 131. ODI, London.

Franzel S and Wambugu C. 2007. The uptake of fodder shrubs among smallholders in East Africa: Key elements that facilitate widespread adoption. In: Hare, M.D. and Wongpichet, K. (eds) 2007. *Forages: A pathway to prosperity for smallholder farmers.* Proceedings of an International Symposium, Faculty of Agriculture, Ubon Ratchathani University, Thailand. 203-222.

Gerrish JR, Peterson PR and Morrow RE. 1995. Distance cattle travel to water affects pasture utilization rate. *Proc. Amer.* 31: 234-242.

Gitau GK, McDermott JJ, Waltner-Toews D, Lissemore KD, Osumo JM and Muriuki D. 1994. Factors influencing calf morbidity and mortality in smallholder dairy farms in Kiambu district of *Kenya. Prev. Vet.* Med., 21: 167-177.

Hall A, Sulaiman RV and Bezkorowajnyj P. 2008. *Reframing technical change: Livestock fodder scarcity revisited as innovation capacity scarcity - A conceptual Framework*. Systemwide Livestock Programme. http://www.vslp.org/front_content.php

Jones P, Devonshire BJ, Holman TJ and Ajanga S. 2004. Napier grass stunt: a new disease associated with a 16SrXI Group phytoplasma in Kenya. *Plant Pathology* 53, 519.

Lanyasunya TP, 1998. Effect of changes in calf rearing practices at smallholder dairy farms in Bahati Division, Nakuru District, Kenya. Msc. Thesis. Wageningen Agricultural University. The Netherlands, pp: 1-68.

Lenne JM and Thomas D. 2005. Addressing poverty through crop-livestock integration: the contribution of past research to future challenges. In: *Integrating Livestock-Crop Systems to Meet the Challenges of Globalization.* Rowlinson,P, Wachirapakorn C, Pakdee P and Wanapat M. (eds). Proceedings of AHAT/BSAS International Conference, Khon Kaen University, Thailand.

Lenne JM and Wood D. 2004. Is there logic for fodder legumes in Africa? *Food policy* 29: 565-585 .

Massawe NF, Owen E, Mtenga LA, Romney DL, Ashley SD, and Holden SJ, 1998a. The economics of maize stover transportation in Tanzania: 1. Cost effectiveness of loose vs manual baling and using different sizes of trucks. *Proc. Tanz. Soc. Anim. Prod.,* Abstract 2).

Massawe NF, Owen E, Mtenga LA, Romney DL, Ashley SD, and Holden S. 1998b. Stripping of leaf, sheath and husks combined with manual box baling as a strategy towards efficient and economical use of maize stover. *Proc. Tanz. Soc. Anim. Prod.,* Abstract 31.

Methu JN, Mwangi D, M, Kirui JW, Odongo DO and Karienye L. 2003. Participatory technology transfer: the case of making silage in polythene tubes in Kenya. *Animal production Society of Kenya Symposium*, Nairobi Keny.a

Ncube S, Mubaiwa E, Mpofu D, 1993. *The feeding value of stover stored in two different ways. Annual Report,* Division of Livestock and Pastures, department of research and specialist services, Harare,p. 94.

Odongo, N and Njuho PM. 1990. The effects of mixture of milk and gruel on calf performance. *East African Agricultural and Forestry Journal Vol. 56(2)*:43-50.

Owen E and Aboud AAO. 1998. Practical problems of feeding crop residues. Plant breeding and the nutritive value of crop residues, In: Reed JD, Capper BS, Neate PJH, (Eds.), ILCA, Addis Ababa, 133.156.

Paterson RT, Kiruiro E, Arimi HK. 1999. *Calliandra calothyrsus* as supplement for milk production in the Kenyan highlands. *Tropical Grasslands* 37:179-188.

Paterson RT, Karanja GM, Nyaata OZ, Kariuki IW and Roothaert RL. 1998. A review of tree fodder production and utilization within smallholder agroforestry systems in Kenya. *Agroforestry Systems* 41: 181–199, 1998**.**

Peters M and Lascano CE. 2003. Forage technology adoption: linking on station research with participatory methods. *Tropical Grasslands* 37: 179-188

Preston TR and Leng RA. 1987. *Matching ruminant production systems with available resources in the tropics and sub-tropics,* Penambul Books, Armidale, pp245.

Ravinder RC, Gurava RK, Thirupati RG, Wani SP and Bezkorowajnyi, P. 2006. Enhanced fodder production with innovative sustainable informal seed systems for food-feed crops: a case study of village seed banks, India.

Smith T, Chakanyuka C, Sibanda S and Manyuchi B. 1989. *Maize stover as a feed for ruminants. Overcoming constraints to the efficient utilization of agricultural by-products as animal feed.* In: Said AN, Dzowela B. (eds.), ILCA, Addis Ababa, 218.231.

Sumberg J. 2002. The logic of fodder legumes in Africa. *Food Policy*, 27, 285-300

Sumberg J. 2005. Constraints to the adoption of agricultural innovations: Is it time for a re-think? Outlook on Agriculture 24 (I) (in press)

Sumberg J and Reece D. 2004. Agricultural research through a 'new product development' lens. *Experimental Agriculture* 44 (3), 333-342.

Sundstol F and Owen E. 1984. *Straw and other fibrous wastes as by-products*, Elsevier, Amsterdam.

Van Soest PJ. 1994. *Nutritional ecology of the ruminant.* Second edition, Cornell University Press, New York.

Wambugu C, Franzel S, Tuwei P and Karanja G. 2001. Scaling up the use of fodder trees in central Kenya, *Development in Practice*, 11, 487-94.

Weinard J. 2002. Farmer-to-Farmer Extension: Opportunities and Constraints of Reaching Poor Farmers in Southern Malawi. MSc Thesis, Hohenheim University.

WORKING PAPERS IN THIS SERIES

1. Agroforestry in the drylands of eastern Africa: a call to action.
2. Biodiversity conservation through agroforestry: managing tree species diversity within a network of community-based, nongovernmental, governmental and research organizations in western Kenya.
3. Invasion of *prosopis juliflora* and local livelihoods: Case study from the Lake Baringo area of Kenya.
4. Leadership for change in farmers organizations: Training report: Ridar Hotel, Kampala, 29th March to 2nd April 2005.
5. Domestication des espèces agroforestières au Sahel : situation actuelle et perspectives.
6. Relevé des données de biodiversité ligneuse: Manuel du projet biodiversité des parcs agroforestiers au Sahel.
7. Improved land management in the Lake Victoria Basin: TransVic Project's draft report.
8. Livelihood capital, strategies and outcomes in the Taita hills of Kenya.
9. Les espèces ligneuses et leurs usages: Les préférences des paysans dans le Cercle de Ségou, au Mali.
10. La biodiversité des espèces ligneuses: Diversité arborée et unités de gestion du terroir dans le Cercle de Ségou, au Mali.
11. Bird diversity and land use on the slopes of Mt. Kilimanjaro and the adjacent plains, Tanzania.
12. Water, women and local social organization in the Western Kenya Highlands.
13. Highlights of ongoing research of the World Agroforestry Centre in Indonesia.
14. Prospects of adoption of tree-based systems in a rural landscape and its likely impacts on carbon stocks and farmers' welfare: The FALLOW Model Application in Muara Sungkai, Lampung, Sumatra, in a 'Clean Development Mechanism' context.
15. Equipping integrated natural resource managers for healthy Agroforestry landscapes.
17. Agro-biodiversity and CGIAR tree and forest science: approaches and examples from Sumatra.
18. Improving land management in eastern and southern Africa: A review of policies.
19. Farm and household economic study of Kecamatan Nanggung, Kabupaten Bogor, Indonesia: A socio-economic base line study of Agroforestry innovations and livelihood enhancement.
20. Lessons from eastern Africa's unsustainable charcoal business.
21. Evolution of RELMA's approaches to land management: Lessons from two decades of research and development in eastern and southern Africa.
22. Participatory watershed management: Lessons from RELMA's work with farmers in eastern Africa.
23. Strengthening farmers' organizations: The experience of RELMA and ULAMP.
24. Promoting rainwater harvesting in eastern and southern Africa.
25. The role of livestock in integrated land management.
26. Status of carbon sequestration projects in Africa: Potential benefits and challenges to scaling up.
27. Social and Environmental Trade-Offs in Tree Species Selection: A Methodology for Identifying Niche Incompatibilities in Agroforestry *[Appears as AHI Working Paper no. 9]*
28. Managing tradeoffs in agroforestry: From conflict to collaboration in natural resource management. *[Appears as AHI Working Paper no. 10]*
29. Essai d'analyse de la prise en compte des systemes agroforestiers par les legislations forestieres au Sahel: Cas du Burkina Faso, du Mali, du Niger et du Senegal.
30. Etat de la recherche agroforestière au Rwanda etude bibliographique, période 1987-2003
31. Science and technological innovations for improving soil fertility and management in Africa: A report for NEPAD's Science and Technology Forum.
32. Compensation and rewards for environmental services.

33. Latin American regional workshop report compensation.
34. Asia regional workshop on compensation ecosystem services.
35. Report of African regional workshop on compensation ecosystem services.
36. Exploring the inter-linkages among and between compensation and rewards for ecosystem services CRES and human well-being.
37. Criteria and indicators for environmental service compensation and reward mechanisms: realistic, voluntary, conditional and pro-poor.
38. The conditions for effective mechanisms of compensation and rewards for environmental services.
39. Organization and governance for fostering Pro-Poor Compensation for Environmental Services.
40. How important are different types of compensation and reward mechanisms shaping poverty and ecosystem services across Africa, Asia & Latin America over the Next two decades?
41. Risk mitigation in contract farming: The case of poultry, cotton, woodfuel and cereals in East Africa.
42. The RELMA savings and credit experiences: Sowing the seed of sustainability.
43. Policy and institutional context for NRM in Kenya: Challenges and opportunities for Landcare.
44. Nina-Nina Adoung Nasional di So! Field test of rapid land tenure assessment (RATA) in the Batang Toru Watershed, North Sumatera.
45. Is Hutan Tanaman Rakyat a new paradigm in community based tree planting in Indonesia?
46. Socio-Economic aspects of brackish water aquaculture (*Tambak*) production in Nanggroe Aceh Darrusalam.
47. Farmer livelihoods in the humid forest and moist savannah zones of Cameroon.
48. Domestication, genre et vulnérabilité : Participation des femmes, des Jeunes et des catégories les plus pauvres à la domestication des arbres agroforestiers au Cameroun.
49. Land tenure and management in the districts around Mt Elgon: An assessment presented to the Mt Elgon ecosystem conservation programme.
50. The production and marketing of leaf meal from fodder shrubs in Tanga, Tanzania: A pro-poor enterprise for improving livestock productivity.
51. Buyers Perspective on Environmental Services (ES) and Commoditization as an approach to liberate ES markets in the Philippines.
52. Towards Towards community-driven conservation in southwest China: Reconciling state and local perceptions.
53. Biofuels in China: An Analysis of the Opportunities and Challenges of Jatropha curcas in Southwest China.
54. Jatropha curcas biodiesel production in Kenya: Economics and potential value chain development for smallholder farmers.
55. Livelihoods and Forest Resources in Aceh and Nias for a Sustainable Forest Resource Management and Economic Progress.
56. Agroforestry on the interface of Orangutan Conservation and Sustainable Livelihoods in Batang Toru, North Sumatra.
57. Assessing Hydrological Situation of Kapuas Hulu Basin, Kapuas Hulu Regency, West Kalimantan.
58. Assessing the Hydrological Situation of Talau Watershed, Belu Regency, East Nusa Tenggara.
59. Kajian Kondisi Hidrologis DAS Talau, Kabupaten Belu, Nusa Tenggara Timur.
60. Kajian Kondisi Hidrologis DAS Kapuas Hulu, Kabupaten Kapuas Hulu, Kalimantan Barat.
61. Lessons learned from community capacity building activities to support agroforest as sustainable economic alternatives in Batang Toru orang utan habitat conservation program.
62. Mainstreaming Climate Change in the Philippines.
63. A Conjoint Analysis of Farmer Preferences for Community Forestry Contracts in the Sumber Jaya Watershed, Indonesia.

64. The highlands: a shared water tower in a changing climate and changing Asia
65. Eco-Certification: Can It Deliver Conservation and Development in the Tropics.
66. Designing ecological and biodiversity sampling strategies. Towards mainstreaming climate change in grassland management.
67. Towards mainstreaming climate change in grassland management policies and practices on the Tibetan Plateau.
68. An Assessment of the Potential for Carbon Finance in Rangelands.
69 ECA Trade-offs Among Ecosystem Services in the Lake Victoria Basin.
69. The last remnants of mega biodiversity in West Java and Banten: an in-depth exploration of RaTA (Rapid Land Tenure Assessment) in Mount Halimun-Salak National Park Indonesia.
70. Le business plan d'une petite entreprise rurale de production et de commercialization des plants des arbres locaux. Cas de quatre pépinières rurales au Cameroun.
71. Les unités de transformation des produits forestiers non ligneux.
alimentaires au Cameroun. Diagnostic technique et stratégie de développement Honoré Tabuna et Ingratia Kayitavu.
72. Les exportateurs camerounais de safou (Dacryodes edulis) sur le marché sous régional et international. Profil, fonctionnement et stratégies de développement.
73. Impact of the Southeast Asian Network for Agroforestry Education (SEANAFE) on agroforestry education capacity.
74. Setting landscape conservation targets and promoting them through compatible land use in the Philippines.
75. Review of methods for researching multistrata systems.
76. Study on economical viability of *Jatropha curcas* L. plantations in Northern Tanzania assessing farmers' prospects via cost-benefit analysis
77. Cooperation in Agroforestry between Ministry of Forestry of Indonesia and International Center for Research in Agroforestry.
78. "China's bioenergy future. an analysis through the Lens if Yunnan Province.
79. Land tenure and agricultural productivity in Africa: A comparative analysis of the economics literature and recent policy strategies and reforms.
80. Boundary organizations, objects and agents: linking knowledge with action in agroforestry watersheds.
81. Reducing emissions from deforestation and forest degradation (REDD) in Indonesia: options and challenges for fair and efficient payment distribution mechanisms.
82. Mainstreaming climate change into agricultural education: challenges and perspectives
83. Challenging conventional mindsets and disconnects in conservation: the emerging role of eco-agriculture in Kenya's landscape mosaics.
84. Lesson learned RATA garut dan bengkunat: suatu upaya membedah kebijakan pelepasan kawasan hutan dan redistribusi tanah bekas kawasan hutan.
85. The emergence of forest land redistribution in Indonesia.
86. Commercial opportunities for fruit in Malawi.
87. Status of fruit production processing and marketing in Malawi.
88. Fraud in tree science.
89. Trees on farm: analysis of global extent and geographical patterns of agroforestry
90. The springs of Nyando: water, social organization and livelihoods in Western Kenya
91. Building cpacity toward region-wide curriculum and teaching materials development in agroforestry education in Southeast Asia.
92. Overview of biomass energy technology in rural Yunnan (Chinese – English abstract).
93. A pro-growth pathway for reducing net GHG emissions in China.
94. Analysis of local livelihoods from past to present in the central Kalimantan Ex-Mega Rice Project area.

The World Agroforestry Centre is an autonomous, non-profit research organization whose vision is a rural transformation in the developing world where smallholder households strategically increase their use of trees in agricultural landscapes to improve their food security, nutrition, income, health, shelter, energy resources and environmental sustainability. The Centre generates science-base knowledge about the diverse role that trees play in agricultural landscapes, and uses its research to advance policies and practices that benefit the poor and the environment.

United Nations Avenue, Gigiri - PO Box 30677 - 00100 Nairobi, Kenya
Tel: +254 20 7224000 or via USA +1 650 833 6645
Fax: +254 20 7224001 or via USA +1 650 833 6646
www.worldagroforestry.org