Intensification of Livestock Feed Production in Ethiopian Highlands: Potential and Experiences of the African Highlands Initiative 1

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By

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1. Introduction

Livestock production is an integral part of the subsistence crop-livestock systems of Ethiopian highlands, not only as a source of draught power, manure and transport to support the crop sector but it is also a source of cash, nutrition and asset for the rural communities. It is considered as a mobile bank that could be hired, shared, inherited and contracted by rural households. Although livestock's contribution to facilitate the crop sector has been recognized all along, livestock productivity in Ethiopia is declining to a level that may affect sustainability of crop-livestock systems. Major constraints are lack of feed, in terms of quality and quantity, and basic veterinary services. Despite the attempts to improve agricultural productivity through research and development interventions in the last few decades, the major research and development investments have been concentrating on the crop sector with little attention to livestock related challenges. For instance, crop breeders have been attempted to increase cereal yield for the last 30 years with little attention to crop residue, which is the major source of animal feed in Ethiopia. There are complementarities and competition for organic matter, space, water and other resources in the crop-livestock systems. As livestock plays a central role in the livelihood systems the focus of technology choice should shift from crop or livestock systems to crop-livestock productions systems. In this paper we are reviewing the role of existing feed resources, and the potential for improving feed systems and intensification pathways in an integrated way. We present some experiences from the an irrigation project of IFAD and a watershed based integrated natural resources management (INRM) project of the African Highland Initiative (AHI).

2. Agricultural profile of the Ethiopian Highlands

The Ethiopian highlands, which are defined by an altitude of more than 1500 meter a.s.l., cover about 44% of the country, and supports about 70% of the livestock production. The Central Ethiopian Highlands are above 1800 meter a.s.l., with an annual mean rainfall exceeding 800 mm. The rainfall is bimodal and more than 65% falls between June and September. The mean minimum and maximum temperatures are 9 and 24 ^{o}C, respectively. There are two distinct cropping systems in the highlands, depending mainly on the altitude-induced temperature differences. The lower highlands, lying between (1800-2300 meter a.s.l., are suitable for multiple cropping cycles per year with or without

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tree components. The upper highlands, above 2300 m asl, are cereal-dominated or mono-cropped, such as barley-fallow-barley or barley-potato-barley systems. Land holding in the upper highlands is much larger than in the lower highlands, which determines whether the system is intensively managed or not, and whether cattle keeping is mainly cut-and-carry or free grazing. Livestock production is an important component of the farming system. In the central highland zones alone, there are about 8813 million cattle, 4606 million sheep, 3393 million goats, 1214 million asses, 606 thousand horses and 72.6 thousand mules (Central Statistical Authority, 1998). However, Livestock productivity is low due to four major constraints. i) poor animal nutrition ii) disease and parasites iii) poor livestock management and iv) low yielding local breeds. For reviewing some experiences of intensification of feed production systems in Ethiopian highlands, two AHI benchmark sites, Ginchi and Areka, are considered in this paper.

1.1 The cereal-livestock production systems of the upper highlands.

This system represents the top Ethiopian highlands characterised by chilly weather, extensive farming and with an altitude above 2700 masl. Ginchi, 80 km west of Addis Ababa, represents the upper high lands, with the average farm size of 3.38 ha. About 24% of the farmers own more than 4 ha (Hailu Beyene and Tilahun Mulatu, 1999). Cattle are the most important livestock in the system and the average number of livestock per holding is about 4.7 cattle, 1.2 sheep, and 0.6 equines. Oxen account for 36% of the cattle as a source of draught power for cultivation and threshing. In the upper side of the watershed the system is predominantly barley-fallow-barley accompanied by a few potato, Enset and faba bean fields, while in the lower side of the watershed teff, wheat and barley are dominant accompanied by field peas and chickpea. Crop and livestock sub-systems are highly integrated, and crop residue is the major feed source. Some of the farmers also return the farmyard manure to their field although there is a strong competition between using the manure as firewood or an organic fertiliser. PRA survey conducted in 1989 showed that the major constraints on livestock production were feed shortage and diseases (Hailu Beyene and Tilahun Mulatu, 1999).

1.2. Enset/Coffee – Livestock production systems of the lower highlands

This system is typical of the middle semi-humid highlands with an altitude of about 1900-2400 m asl, where human population density is high, land holding is small, and the perennial crops made a substantial share of the farming system. Due to very high population pressure with over 450 people/km^2, land holdings are small and livestock are few. The Areka AHI benchmark site at Wollaita, about 430 km south-west of Addis Ababa, with average land holding of less than 1.0 ha, represents the lower highlands. The average number of livestock per holding is less than 1.5 cattle. Only 15% of the farmers own oxen. Ploughing and other animal power operations are executed through sharing or hiring of oxen. Crop residue and aftermath grazing are the predominant feed sources in Areka. The cropping system is highly diversified and agroforestry based. Different forage crops are grown around the home garden in association with coffee, Enset (*Enset ventricosum*) and fruit trees. The space allocated to forage crops is less than 1% of the cultivated land. Crop-livestock integration is strong in such a way that farmers use crop residues as feed source, and return the manure to the soil, mainly around the home garden.

In both systems, livestock production is of lower priority than crop production and hence arable land is allocated mainly to crops. For most farmers animal production is considered as a means to facilitate crop production, and as a source of security when ever there is crop failure or immediate need for cash. Due to the importance of cattle as source of animal power rather than sources of meat and milk production, cattle require high levels of energy in their diets and only medium levels of protein. Forages are cultivated only when they don't compete much with crops for land, inputs and labour. Livestock production depends on free grazing for most of the year, where land size is relatively large. However, natural grass lands in Ethiopian highlands are generally confined to degraded, shallow soils, to fallow crop land, and to soils which cannot be successfully cropped because of either depleted soil fertility or other physical constraints (Jutzi et al., 1987). The natural pasture grassland is therefore exploited for several decades through overgrazing and overstocking, and often remains with a production capacity of not more than 2 tones of dry matter/ha. Currently, there is a need for alternative feed sources, including forage crops.

2.1 Feed resources and their distribution over seasons

Feed shortage is critical during the dry season (Table 1). Most of the feed in the Ethiopian highlands is obtained from the natural pasture and crop residues (Table 1 and 2). Feeds are in abundance from December to February, and rationing starts afterwards. Quality feed is usually allotted to draught oxen, mainly in the peak farming months, when land preparation and planting operations are commonly practised. In the months of May and June, when there is almost no green feed, but a very high demand for draught power, crop residues is the major feed source. Crop residue from pulses is considered as quality feed resource and it is fed mainly to oxen and milking cows in mixture with straw from cereals. Crop residues from the cereal fields are low in metabolisable energy and protein content. This problem can be addressed to some extend by mixing crop residues with various forage legumes. This practice enhances rumen fermentation and therefore to some extend the availability of energy from the total diet. Improved grass forages provide a good source of energy almost throughout the year.

Table 1. Feed calendar in the central Ethiopian highlands

		Use of feed resources					
Months	Feed shortage	Crop aftermath	Free grazing	Straw cereals	Straw legumes	Cut and Carry	Demand for improved forage
Dec - Feb	XXX	XXX	X	X			XX
March - June	XX		XX	XX	XX	XX	XXX
July - Sept	XX	X	XXX	XX	XXX	XX	X
Oct - Nov	X	X	X	X		X	X

xxx = very important, xx = important x = less important

Table 2. Feed resources available to livestock in the Ethiopian highlands

Feed resources	Area (million ha)	Availability tonne DM/ha	Total DM (x million t)
Grazing	7.280	4.50	32.760
Cereals residues	4.607	1.40	6.500
Aftermath grazing		0.40	1.843
Pulse residues	0.808	0.50	0.404
By products			0.150
Total	12.695		41.507

Source: Ministry of Agriculture (1984)

In the upper highlands, field peas, faba beans and chick pea are the major pulse crops grown in rotation with cereals. In the lower highlands (like in Wollaita), faba beans, peas, haricot beans and chickpeas are dominant components of the system. Whenever farmers have the choice, they prefer crop varieties with high biomass production, taking into consideration that pulse residues have almost similar economic value like that of grain yield. Pulses are known as very important protein suppliers adjuncts to energy-rich cereal crop residues. Moreover, the land area allocated to pulses has been expanding in the recent years thanks to disease and frost resistance varieties, e.g stem maggot resistant bean varieties. The production trend also indicates that the newly introduced varieties produce much higher biomass than the traditional old varieties, which may also boost the availability of feed resources.

2.2 Forage legume adaptation to highland environments

Vetch are very important forage legumes in the central highlands, which are commonly under sown with cereals or grown as break crops. They are palatable and rich in proteins. Once vetch plants reach seed setting stage further seeding in the next season is not necessary as the seed can stay in the soil for at least two years. Vetch are well adapted to altitudes 1800 - 2500 m asl with more than 700 mm annual rainfall (Yilma Seyoum and Cajuste, 1980). They are recommended for green feeding, hay and silage with biomass yield of 4-5 t/ha. Lablab is a dual purpose forage legume, for animal and human nutrition. It grows best during the main rainy season, and once established it persists well into in the dry season. In the north-west highlands, lupines are used for food and green manure legumes, and they are well adapted to vertisols provided there is adequate rainfall. Other forage legumes such as desmodium and stylo are less taken up by farmers. Desmodium and stylo are commonly grown around the home garden under enset, coffee and fruit trees in Wollaita area. Research results for the lower highland show that most forage legumes could produce more than 8 t/ha dry matter within a season (Table 3). For altitudes higher than 1800 m asl *Vicia dasycarpa, Vicia atropurpurea, Medicago sativa* and native *Trifolium* spp. found to be important for improving the feed quality of cereal straw (Lulseged Gebrehiwot, 1985). Butterworth and Mosi (1986) found that when hay from desmodium is supplemented to residues of teff, oats, wheat and maize straw at a rate of 30% by weight, dry matter digestability increased by 10% compared to the straw alone, and feed intake of sheep increased by 20-30%. Currently, the AHI-Ginchi team is working on developing strategies to integrate soil-improving forage legumes into the cereal-fallow-cereal system of the upper highlands.

Table 3. Dry matter yield of some forage legumes in Bako area (1650 m asl, 1209 mm mean rainfall). 100 kg/ha of DAP was applied. Data is mean of at least three years.

Species	Seeding rate (Kg/ha)	Spacing between rows (cm)	DM yield (t/ha)
Dolichos lablab	35	40	9.0
Desmodium uncinatum			
cv. silver leaf	12	30	8.2
Stylosanthus guianensis			
cv. Cook	10	30	9.5
cv. Endeavor	10	30	10.0
cv. Schofield	10	30	9.8
Leucaena leucocephala			
cv. cunningham	6.7	100 x 15	5.3

Source: Lemma Gizachew and Alemu Tadesse (1988)

In the lower highlands, where population pressure is high, pastureland is scarce and livestock numbers are low, highly productive forages are grown around farmers' homestead under intensive management. The AHI-Areka team tested the adaptability and processes of integration of various legumes for feed and and soil-improvement, namely Mucuna, Croletaria, Tephrosia, Vetch, Stylo, Canavalia, Desmodium and others (Tilahun Amede and Kirkby, 2004). Besides, the data will be used to develop decision guide for farmers to understand which technology works where, and with whom. The current practice indicates that improved pasture is usually adopted only when farmers have highly productive dairy cows or cattle for fattening and sale. Of all tested leguminous fodder trees in the highlands, the native East African legume *Sesbania sesban* was proved to be the most adaptive and productive species. Steinmueller (1995) has evaluated the performance of Sesbania in three locations of the Ethiopian highlands (semi-arid, sub-humid and sub-moist central highlands). The three year experimental results showed that *S. Sesban* is the most productive multi-purpose fodder tree for vertisols and saline soils of the highlands above 2000 m asl. The major advantages of Sesbania are high cold tolerance, adapted to water logging, high nutritive value, and easy establishment through direct sowing. Advantages of *Calliandra calothyrsus* are good coppicing and pruning ability, tolerance to acidic soils, and relatively cold resistant. Advantages of *Leucaena leucocephala* are good coppicing ability, and excellent feeding vale. *L. leucocephala* is vulnerable to the psyllid, a sucking insect, but other *Leucaena spp*. are well resistant to this pest.

2.3 Pasture improvement

The natural pasture is estimated to contribute about 50 to 60% of the total feed supply, mainly in the upper highlands. However, most of the pasturelands in the highlands are water logged bottom lands and land interrupted by gullies and rocks, and degraded steep slopes. Low productivity and degradation of these lands calls for an immediate intervention. The aim should be to provide an adequate pasture for the grazing animal throughout the year, with particular emphasis to the dry season (Table 1). Systematic study on the growth dynamics of each forage species is, therefore, important to improve the quantity and quality of the pasture. To date, the most promising cultivated pasture legumes for animal feed in the highlands were found to be alfalfa and native desmodium, especially in less acidic soils. Cultivated pasture, with the exception of alfalfa, desmodium and Rhodes grass, has not yet been effectively introduced in to the traditional grazing areas. Forage legumes with potential role in the resilience of degraded pasturelands of the lower highlands include *Macrotyloma axillare*, Desmodium, Stylo and Desmodium (Solomon Mengistu, 1999). Only vetch is adapted for oversowing upper highland pastures.

2.4 Legume rotation

Legumes are commonly grown in rotation with cereals in the cereal-dominated highlands. Traditionally, the major cereals like teff (*Eragrostis abyssinica*), wheat or barley is grown in rotation with pulse crops. Faba beans and chickpea are grown following wheat or teff.

Peas and lentils are grown in rotation with barley. Farmers rotate cereals with pulse crops for dual objectives. Firstly, legumes can restore soil fertility through N-fixation and residual effects (Tilahun Amede and Kirkby, 2004). Secondly, legumes can break the cycle of host-specific pests and diseases, which otherwise will remain in soil dormant and revive whenever the true host comes into contact. Jung et al. 1989 compared the after-effect of faba bean, red desmodium and alfalfa on the yield and nitrogen budget of the succeeding wheat in central Ethiopia. They found out that winter wheat grown after legumes took up 18, 47 and 65 Kg N/ha after faba beans, red desmodium and alfalfa, respectively. The amount of nitrogen recovered by wheat was only 24 - 44% of the potentially available nitrogen. The rest N was lost by leaching, which could have been recovered if a crop was grown in association with or immediately after the legumes are harvested. Getnet Assefa et al, 1991 compared the effect of different non-legume and legume preceding crops on the yield of subsequent barley crop on red soils of Holleta for more than three seasons (Table 4).

Table 4. Average grain yield of barley planted following various forage preceding crops at different P and N rates.

Preceding crop	Barley grain yield (t/ha) by different P & N rates				
	0 /O P/N	20/30	40/60	60/90	Mean
Trifolium decorum	50.7	49.8	54.9 A	50.8	51.5 A
Trifolium quartinianum	48.9	47.2	53.8 A	46.3	49.0 A
Vicia faba	46.2	52.1	51.0 A	-	-
Vicia dasycarpa	49.8	48.9	47.8 AB	51.1	49.4 A
Traditional fallow	45.9	48.6	48.5 AB	48.3	47.8 A
Barley	44.2	47.9	41.5 BC	47.0	45.1 AB
Oats/vetch mixture	41.8	43.9	36.4 C	42.0	41.0 B
Mean	46.8	48.3	47.7	47.5	47.5
P	NS	NS	0.01	NS	0.01

Source: Getnet Assefa, Lulseged Gebrehiwot and Tadesse Tekletsadik, 1991

As shown in table 4, barley following forage legumes in crop sequence produced significantly higher grain yield than when grown after fallow or barley, regardless of the amount of nitrogen and phosphorus applied. Barley after desmodium and vetch gave the highest grain yield possibly because, in addition to N-fixation, higher amount of crop residue could have been delivered and incorporated into the soil.

2.5 Integration of forage grasses

Although some improved pastures with Rhodes grass exist in the Ethiopian highlands, the most widely grown forage grass is Napier (*Pennisetum purpureum*). Napier is usually planted in fodder banks or on strips to mark boundaries of plots. In Areka and Ginchi, napier has been integrated in community soil and water conservation practices, where it is grown in strips along contours to form a natural terraces. It is also planted to stabilise soil and water conservation structures such as *fanya juu*. Cut and carry is more suitable for this tall grass than direct grazing, although it does withstand grazing. For many smallholder dairy systems, napier grass forms an important part of the animal diet. Its digestibility is high, especially when harvested young, providing high amounts of dietary energy. In Ginchi, experiments have been carried out with fodder oat. Oat produced more biomass than napier, and oat-vetch mixtures seems to produce maximum amounts of biomass (Assefa et al., 2002). One of the constraints of oats is that it is an annual which needs to be resown each year.

Experiences from Southeast Asia have shown that smallholder farmers more readily adopt forage grasses than legumes (CIAT, 2004). The are several reasons for this. Forage seeds are hardly available in rural areas. Most legume forages need to be planted through seeds, whereas grasses can easily be planted through vegetative cuttings or splits. Once a small patch of improved grasses has been established on-farm, it is relatively easy to expand it vegetatively. Grasses establish faster and produce more biomass than legumes. The most pressing feed need for many smallholder livestock farmers is an adequate supply of medium to high quality feeds throughout the year. Grasses fill this gap easier than legumes.

In the Ethiopian Highlands, the first use of cattle is to provide draught power. Improved forage grasses provide all the needs for these animals. For dairy cattle, a diets of young napier grass can provide several liters of milk per cow per day. Protein supply is the limiting factor. By adding legumes to a grass based diets, milk yields are expected to increase.

Many farmers in the lower highlands have reserved a small portion at the bottom of their farmland for native grasses that use for cut and carry, or grazed by calves. This farm niche forms an excellent opportunity to introduce improved species such as napier grass, either alone or intercropped with the legume *Centrosema pubescens*. Other places where native grasses are used for grazing are directly in front of the house, the so-called *dejaf*.

2.6 Factors affecting integration of forage legumes

Despite farmers' recognition of the potential contribution of forage legumes to crop-livestock farming systems in the Ethiopian Highlands, their integration is relatively slow. Growing feeds is a new concept for most farmers; they are used to collect natural forages from roadsides, from weeding crops, fallow lands or forests. Some farmers also mention fear that forages become weeds. For farmers who are convinced of the value of improved forages, availability of seeds and planting materials often form a bottleneck. Steinbach (1997) indicated 6 other factors affecting integration of forage legumes into subsistence farming systems.

i. Available arable land per capita
ii. Number of crops that can be grown per year
iii. Market access to animal products
iv. Labour availability

v. Farmers' perceptions of the risks and
vi. Rewards of investing in their livestock enterprises

All the above listed factors are potential barriers for Ethiopian farmers to integrate forage legumes into their farming systems. Additional factors could be the rigid traditional farming system and food habit, whereby farmers give higher priority for crop than animal production.

Table 5. Temporal and spatial niches for forage integration in Ethiopian highlands

Niches	Adoption of techno-logy	Technical possi-bility	Potential impact	Potential constraints	Where will it work?	Potential species
1. Introduction of high biomass producing traditional pulses	xxx	xxx	xxx	- resources for variety development - seed supply - increased labour demand	Crop/livestock-oriented farming systems	Faba beans, Peas Lupines, Chickpeas Haricot beans Lentils
2. Undersowing forage legumes in perennial crops	xx	xxx	xx	Competes with spices or root crops	In tree-crop based systems	Desmodium Stylo Vetch, Pueraria Axillaris, Peas Mucuna
3. Undersowing in cereals	x	xx	xx	-Weed control -Reduce yield -Product contamination	In cereal dominated systems	Desmodium Desmodium Vetch, Lablab
4. Intercropping/relay cropping	xxx	xx	Xxx	- Fits mainly in maize and/or sorghum systems - Competes with beans or sweet potato	- In lower highlands -Where market for animal products is good	Haricot beans Peas, Croletaria Mucuna, Lablab
5. Strip planting and hedges	x	xx	xx	-Competes for cropland and labour -hosts rodents and birds	-Where land is not scarce -Erosion is problem - Along	Sesbania, Tree lucerne Leucaena, Calliandra Napier, Setaria

Niches	Adoption of techno-logy	Technical possi-bility	Potential impact	Potential constraints	Where will it work?	Potential species
					boundaries	
6. Short-term fallow	xx	xx	xxx	Fits only in regions with extended rainfall	Where pasture-land is available	Vetch, Desmodium Crotelaria Medics
7. Improved fallow	xxx	xx	xxx	Only where land is not scarce	Cereal-fallow-cereal system	Vetch, Alfa alfa Desmodium, Stylo Desmodium.
8. Improved pasture	xxx	xx	xxx	- succession by non-leguminous species - establishment problem	Specialised animal production	Rhodes grass, Oat, Brachiaria, Alfalfa, Desmodium Stylo, Desmodium Vetch
9. Fodder banks for cut and carry	xxx	xxx	xxx	- Protection against stray animals	Smallholder systems	Napier, setaria, brachiaria, stylo, vetch, lablab, calliandra,
10. Food-feed crops	xxx	xxx	xx	- Competition for land	Smallholder systems	Pigeon pea, Lablab

Key: xxx = Very high xx = Medium x = Very low

3. Recent intensification investments and livestock feed availability

3.1 Effects of small scale irrigation on livestock systems

There has been an increased investment in small scale irrigation in Ethiopia, especially in valley bottoms, mainly for production of vegetables, fruits and other high value products. There are visible trade-offs and complementary effects between the crop and the livestock sector in the existing and newly built irrigation schemes. A recent study conducted by IFAD (IFAD, 2004) indicated that there is a decline in the number of livestock per area with the expansion of irrigation across regions regardless of agro ecology, but there is also an increase number of draught oxen. Feed shortage was apparent between the months of April and June. The decline in grazing area due to conversion of dry season fallow lands to vegetable fields and increase in area enclosure in the hilly landscapes accompanied by frequent drought caused serious feed shortage which has enormously contributed to the reduction of cows, sheep and goats. Benin et al, 2003 also reported that increased irrigation was associated with a reduction in ownership of livestock but with increased adoption of technologies that enhance productivity in the Amhara region. Similarly communities, in Gedemmso, Oromia, which used to be a pastoralist area up to 1990, have been converted to a crop-livestock system with significant reduction in stock.

Area enclosure as a means to rehabilitate the landscape has been integrated in some regions, particularly in Tigrai and Amhara highlands. The protected areas above the enclosures are not open for livestock grazing, hence there is a limitation on free livestock movement with a shift towards partial stall feeding. In theory, the expansion of the potential irrigated area should allow farmers to produce more biomass all year round, partly as crop residues and partly by growing grasses on strips, borders and hilly patches. However, the by-products produced from the vegetable fields is not used as feed source as livestock are not accustomed to this type of feed. Another challenge is that farmers are not allowed to produce fodder from irrigated land due to local laws that give priority to food crops. In some case farmers indicate that there is labour shortage in rearing the animals as more kids are going to school now as compared to the past.

3.2. Integration of soil and water conservation structuresand its effect on livestock systems

Sefene etal., 2004 indicated that soil and water conservation measures were readily adopted by small holder farmers in AHI sites when accompanied by high value forage grasses used as biological stabilisers. Contour vegetation strips with multipurpose tree crops prevent soil erosion on sloping croplands, while at the same time provide useful products such as food, fodder or wood. Multipurpose trees, grasses and other herbaceous plants are often combined along the edges and uncultivated spaces of soil and water conservation structures, ranging from small contour to bench terraces on crop land. The trees, shrubs and grasses planted on terraced cropland can protect and strengthen terrace structures. They can do these in two ways: by providing a surface cover of grass and leaf litter and by creating deep root network in the soil. On the other hand, the current free grazing system, that allows free movement of animals became a major constraint for adoption of improved agroforestry practices. In some cases, forages grown on terrace edges attracted scavenging cattle which destroyed the structures and contributed to aggravated land degradation. As a response the government has drafted a policy that would limit free grazing and advocate for an improved NRM that would intensify forage production at various system niches.

3.3. Effect of shift to perennial crops on feed availability

When ever farmers are exposed to choices of crop species and varieties they consider not only grain/tuber yield for human food but also crop residue for animal feed. The current faming system in Areka consists of multiple crops whereby cereals occupy about 40% of the land and enset about 10%. Results from an optimization model to satisfy human nutrition recommended a shift from cereal farming to root crops/enset/coffee farming (Tilahun Amede & Delve, 2005). This would imply a change of crop residues from cereals straw to an enset roughage and coffee husk. When translated into nutrients for livestock, there was a decline in quality of feed due to increased proportion of less digestible components in the system, mainly coming from enset and coffee. There was no decline in total production in crude protein with the optimized scenarios. However, there was a significant decrease in energy production whereby the total energy supply was produced by about 24 and 37% for two different scenarios, in additions to the decline in quality because of the very high concentration of caffeine, tannins and potassium.

Conclusion

There are various options to improve feed availability for the smallholder integrated livestock systems in the Ethiopian highlands. Extensive research has been carried out resulting in various recommendations for growing leguminous forage in the lower highlands. Leguminous options for the upper highland seem to be restricted to species such as vetch and clover. Limiting factors for animal production are often dietary energy supply for animal draught power. Although grasses have higher amounts of energy than legumes, research on forage grasses for the highlands has been lacking behind. There seems to be many advantages and high potential for adoption of integrated grass and legume forage technologies.

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