Feed Resources Assessment and Potential Implications for Interventions in the Menz Sheep Breed Areas, Ethiopia

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1. Introduction

1.1. Problem Setting

Livestock perform multiple functions in the Ethiopian economy by: providing food, cash income, promoting saving, social functions, and employment. As demand for livestock products increases (e.g FAO 2009) and agricultural intensification gaining a momentum, livestock, particularly small ruminant, became an important agricultural enterprise in Ethiopia (Awgichew, 2000). Their special features like: efficient utilization of marginal and small plot of land, short generation length, high reproductive rate, low risk of investment and more production per unit of investment (as compared with cattle) make them to be preferred by the smallholder farmers. For example, sheep's multipurpose roles as source of income, meat, skin, manure, wool, as means of risk avoidance during crop failure and their cultural function during festivals are well recognized by farmers practicing mixed crop-livestock production in the Central Highlands of Ethiopia (Mekoya 1999). Emerging evidence also suggests that volume of small ruminants' (live and meat) exports from Ethiopia is growing (e.g. Sebsibe et al., 2011). Then, the point is to understand as to how existing feed resources complement these evolving interests in sheep business.

Ethiopia has a rich diversity of indigenous sheep breeds and ecotypes, reared in different environments from the mountainous highlands to arid pastoral lowlands (e.g. Gizaw, 2008a). As many as 9 breeds and 14 traditionally well recognized sheep population (Gizaw, 2008b) and ~ 25 millions heads are reported in the country (Gizaw, 2009). One of these breeds, the Menz-sheep, inhabits mainly the mixed crop livestock systems of the Central Highlands of Ethiopia: a narrow belt running from North to South in the Eastern parts of the Amhara Regional State and extends to the North Eastern parts of the Oromia Regional State (Figure 1).

The Menz sheep breed has a greater prominence for its meat flavor and smallholder farmers are keeping this breed as an important component of their livelihood activities (Gizaw et al., 2010). Depending on agro climatic condition and associated livelihood zone, Menz sheep constitute as high as 24% of the herd composition [in Tropical Livestock Unit (TLU)]. It also contributes to 22-63% of the net cash income derived from livestock production in these areas (e.g. Gizaw, 2008a). In spite of these roles, low productivity associated with poor feed quality and low feed availability are most often reported as the impediments for intensification (e.g. Mekoya et al., 2009) and in view of the increasingly important roles of the Menz sheep in the livelihood of smallholders, drawing lessons and synthesizing opportunities on feed sourcing and feeding strategies are relevant sets of research question for sustainable intensification.

1.2. Objectives

Although investments have been made in understanding as to how smallholders manage the Menz sheep breed (Bihon, 2009; Gebre, 2009; Gizaw, 2008a; Gizaw, 2008a; Getachew et al., 2010; Getachewa et al., 2009; Kassahun, 2000), a comprehensive assessment involving the different feed sourcing and feeding strategies and how these vary along livelihood diversity and its implication for intervention are generally lacking. These addressing issues on feed demand supply are loosely associated with livelihood (e.g. MoA 2002; Mekoya et al., 2009), feed quality, temporal and spatial dynamics and most often does not recognize sheep as system elements and their role in feed demand supply dynamics. Here we postulated that across the Menz sheep breed areas there are variations in terms of the relative importance of sheep in the livelihood of farmers and availability of feed (type and quality) and thus these imply different intervention measures. Therefore, the overarching objectives of the present study were to: i) diagnose the meso-scale feed demand, availability and management; ii) to discuss potential implications for feed based interventions.

2. Approaches

2.1. Stratification and Sites Selection

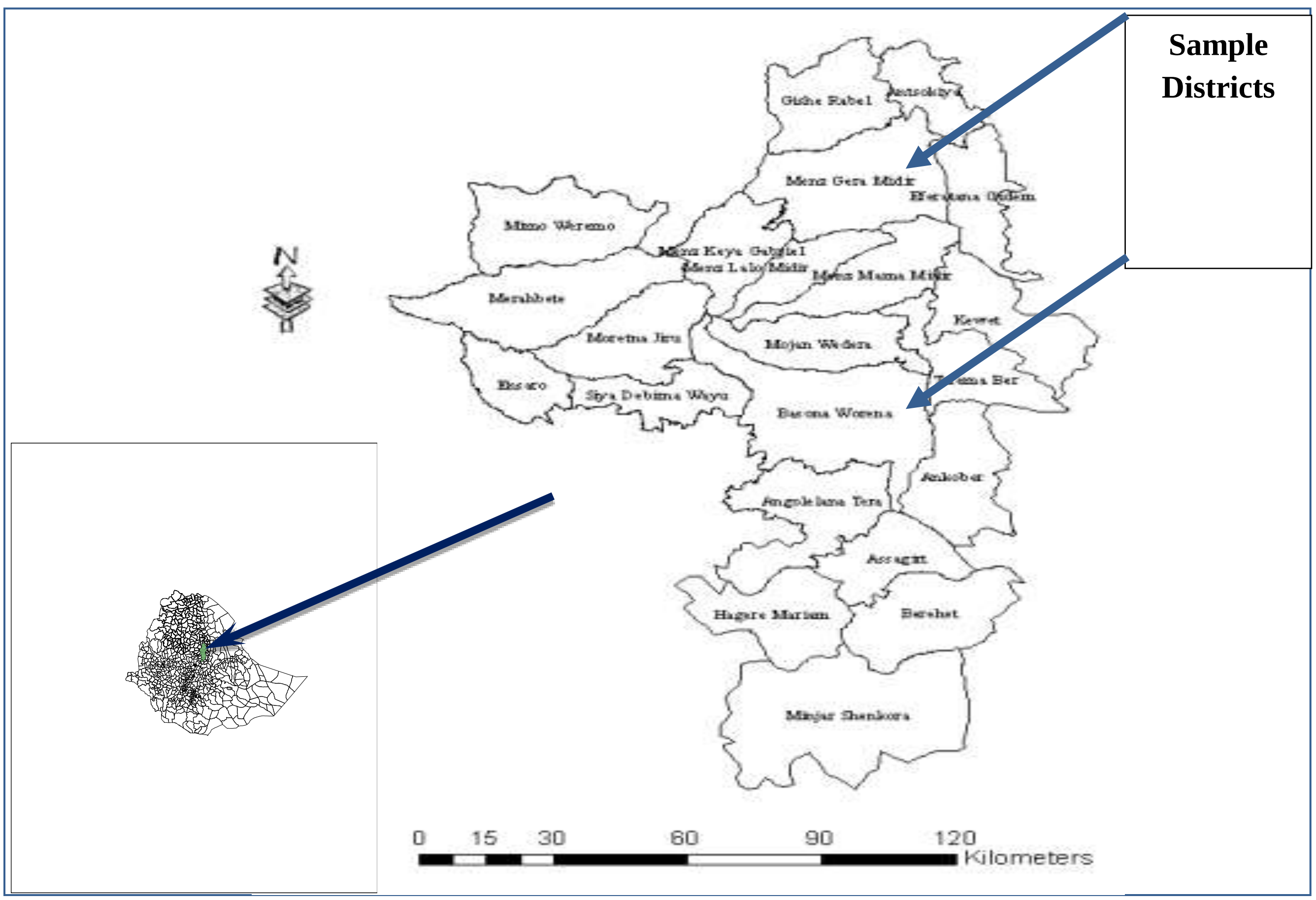
The Menz-sheep breed is spread mainly over the Central Highlands (~2500-3000 masl) of Ethiopia where agriculture is characterized mainly by mixed crop-livestock production systems (Gebre, 2009). In the higher altitude zones, despite enduring efforts, intensive crop production is constrained by frost, poor soil fertility and unreliable rainfall (Gebre, 2009). This, in fact, shaped the degree of dependency on sheep and crop enterprises and therefore the Menz sheep breed belt accommodates different livelihood types. For example, USAID (http://www.usaid.gov/data/) distinguishes two major livelihood zones in our focus study areas:

i) Barley-Sheep (BS) livelihood system. Here farmers are limited to barley production and sheep is the major component of livestock herd composition [(e.g. *Gishe Rabel, Menz-Gera Midir, Menz-Lalo Midir, Menz-Mama-Midir*, *Mojan* Districts[1] (Figure 1)]. Like the major parts of the

[1] District/Woreda is the fourth administrative units following, Federal, Region and Zone in Ethiopia

mixed crop livestock system, agriculture is rainfed and the system receives two rainy seasons: i.e Kremt[2] and Belg[3]. During the Belg rains mainly barley is planted and covers about >55% of the Kiremt season crop area. Overall the major crops grown in the area are barley; faba bean and wheat (Table 1). Flax and lentils are also occasionally grown for cash. In recognition of the important roles of pulses in this zone it is referred as Barley-Legume-Sheep (BLS) throughout this paper.

ii) Cereals-Legume-Livestock (CLL) *livelihood system*. In this system crops such as barley, wheat, legumes and teff are important (Table 1) and farmers integrate diverse livestock species unlike the BLS based system [e.g. Basona-worena, Angolelana Tera Districts (Figure 1)]. In the CLL system agriculture is mainly rainfed and most often the Belg rain benefits only the grazing land and not for crop production.



Sources: Extracted from Gizaw et al , (2009)

Figure 1: Approximate locations of the Menz -sheep breed areas and the sample study Districts

[2] June –September
[3] February-May

Table 1 Key features of the study systems

Key features	Livelihood zone	
	Barley Legume Sheep (BLS, at *Gera-Midir,*)	Cereals-Legumes-Livestock (CLL, at *Basona Worena*)
Altitude (MASL)	1669-3563	1661-3293
Rainfall (mean annual in mm)	896	819
Temperature (mean Max-Min (^{0}C)	6.8- 17	8-20
Soils types by (% of areas)	CMv (35), LPe (55),VEr (10)	CMv (24), LPe (74),VEr (2)
Cropping pattern (% of cultivated areas)	Br(27);Wh(23);Fb (29),OPul (10) OCr(6)	Br(23), Wh(22) Tf(9)Fb (19); Opul (16)
Population (person km$^{-2)}$	67	92
Arable land (ha household^{-1})	0.8	1.2
TLU per km^{-2}	85	147
TLU farm^{-1}	4	6
Sheep farm^{-1}	11	3.8
Sheep to cattle ratio	3	0.6
Access to input and output market (scale)	+	++
Level of agricultural intensity (scale)	+	++
% of households benefited from safety net (in 2011)*	42	0

MASL is for meter above sea level; **CMv** is for Vertic Cambisol; **LPe** is for Eutric leptosols; **VEr** is for Eutric vertisols; **Br** is for barley, **Wh** is for wheat; **Fb** is for Faba bean; Opul is for other pulses; Ocr is for other cereals; agricultural intensity is defined by fertilizer rate, population density, livestock density; *Safety nets are part of a broader poverty reduction strategy interacting with and working alongside of social insurance; health, education, and financial services; the provision of utilities and roads; and other policies aimed at reducing poverty and managing risk

In addition to these biophysical settings and attendant livelihood activities (Table 1), access to input-output market is one key feature that distinguishes these two systems. In this respect the BLS system has poor input and output market linkage compared to the CLL system; in view of the poor road network. To see the status of feed supply and demand and implications for interventions, in the Menz sheep belt, two Districts in these two contrasting systems were selected [*Menz-Gera-Midir* for BLS; *Basona-worena-* for CLL (Figure 1)]. Table 1 shows key features of the two study areas.

2.2. Assessment of Livestock Feed Demand and Supply

2.2.1. Feed metabolizable energy supply

To assess feed resources in smallholders farming systems, where on-farm produced biomass is the major sources of feed, data on land use/land covers[4], their Dry Matter (DM) productivity, feed use factors[5] and values on feed quality traits [e.g. Metabolizable Energy (ME) and Crude Protein (CP)] for different feed types are important (Haileslassie et al., 2011). Pertinent information for the study areas (e.g. MoA 2002, information from District agricultural office) was inconsistent and not comprehensive. Thus, the present study used a combination of: field observation, transect walk and discussion with farmers, data from District and Zonal Agricultural Office[6], literature values and multiple regression models as appropriate.

Land use/land cover polygons constructed by MoA (2002) were used as the base and these were complemented with data from District and Zonal Agricultural offices. In fact the 2002 data is old and the assumption was that land use change has reached its climax some years back and the major driver related land use is more towards intensification like, selection of variety, fertilizer input and conservation. Put differently the livestock feed supply is more affected by the ongoing intensification than the change in cover type.

Crop Residues (CR) are one of the most important feed resources in both study areas. A combination of harvest index, yield data and use factors are the usual approach to estimate available crop residues for animal feed (Haileslassie et al., 2011, MoA 2002). We used literature

[4] Land use is a description of how people *utilize* the land and socio-economic activity (e.g. cultivated land). **Land cover** is the physical material at the surface of the earth (e.g. bareland)
[5] Feed use factor is the percent of total DM production that is allocated for livestock feed
[6] Zone is the third administrative units following the federal and the regional states administrative units in Ethiopia

values for the harvest index (MoA 2002) and yield by crop type as reported by District Agricultural Office and use factor modified after discussing with farmers.

District data set does not indicate DM yields for grazing lands. Literature suggests a wide range values (1-12 tonnes ha^{-1} yr^{-1}) for agro-ecologic zone similar to the present study sites (Bediye and Feyissa 2007). Estimated DM yield using NDVI for 2007 production year suggested also a DM yield as high as 10 tonnes ha^{-1} yr^{-1}. However, field observations from standing hay and discussions with farmers and experts did not verify these values and thus the present study used a multiple regression approach for DM yield estimation. We built the regression equation (Eq 1) based on known values of dependent variable (DM) and independent variables involving edaphic factors (CEC7), landscape position (altitude in meter) and climatic variables [rainfall in mm (MoA 2002)]. The relations among explanatory variables and DM productivity were significant at P=0.01, 0.05 and 0.1 respectively. These associations were positive for CEC and negative for landscape position and rain fall.

$$DM = 7 - (0.002 * Al) + (0.075 * CEC) - (0.002 * R) \ldots\ldots (Eq1)$$

Whereby *DM* is for dry matter yield in Kg ha^{-1} yr^{-1}; *Al* is altitude in meter above sea level; *CEC* is cation exchange capacity of soil in centi-mol per kg (cmol+kg^{-1}) and *R* is annual rain fall in mm. Data on independent variables for the two study systems were extracted from MoWR (1998).

Major tree species in both study systems are mainly *Eucalyptus camaldulensis* and *Eucalyptus glubus* and these are not fodder trees and therefore trees biomass as animal feed source was not considered for the present study. However, most often, undergrowth are important sources of graze and browse. Using the percent crown cover data for the different land use/land cover reported by MoA (2002), biomass available for animal feed in forest land cover type was also include in the present study. For feed quality traits literature values (e.g. Bediye and Feyissa 2007; and http://www.vslp.org) were used. Data on concentrates and industrial by products is generally lacking. Although farmers are claiming feeding livestock on some residues of local brewery and concentrates, quantitative data was not available. The only available quantitative

7 CEC is a cation exchange capacity of a soil

data is CSA (2011) at Zonal scale and CSA (2002) at District scale. We used these values to estimate total ME supply for improved feed sources (energy denser feed such as concentrates).

Quantifying the ME share of different animal species in mixed crop-livestock system is important for species focused feed management. Most often such exercises, for example in mixed crop livestock systems, are complicated by the open and communal grazing systems and farmers' selective feed sourcing and feeding techniques (Plate 4). For example Getachew et al. (2010), suggested that about 44% farmers in the Menz sheep breed belt herd their sheep together with other species (cattle, equines and goat, (note also plate 1), 41.7% keep the sheep flock separately and 14.2% of the farmers keep them sometimes separately and sometimes with other livestock species depending on the availability of labor. According to the same authors there is the possibility of mixing with other adjacent sheep flocks and other livestock species within a village particularly while grazing on common property resources. From discussion with farmers the general trend suggests that >90% of the feed for the sheep comes from grazing on private and common grazing lands and the balance from stubble grazing. The hay and crop residues are generally for large ruminants (oxen and lactating cows) except for few households who are targeting sheep fattening for special festive season (e.g. Getachew et al., 2010). Data on the frequency of biting, the diameter of their mouth, and duration of time they grazie and the features of selective picking are important parameters to estimate the share of small ruminants from the total feed ME. In the present study we assumed that small ruminants have full access to all feed resources and thus factored Live Weight (LW) of sheep into overall available feed ME and considered the overall herd's feed demand-supply figures as a proxy indicator of sheep's feed status in the study systems.

2.2.2. Feed metabolizable energy demand

Livestock feed ME demand is a function of heard structure, activity, livestock productivity (King 1983; McDonald et al., 1988). For the present study the total feed ME requirements of an animal were calculated as the sum of the maintenance energy and additional energy to account for the effect of standing and walking, milk production, body weight gain and draft power. We collected data on livestock herd structure, productivity and activities from District and Zonal Agricultural Office and CSA (2011) and CSA (2002). To triangulate these information we made field observations and discussion with farmers during transect walk. Using literature value on forage gross energy; weight gain, forage intake, Butter Fat (BF) and Solid Not Fat Content (SNF): the efficiency of ME utilization for milk, weigh gain and maintenance were calculated. Then ME estimation techniques for tropical regions suggested by King (1983) was applied.

Calculating the energy requirements of draught animals is data intensive and varies considerably by the duration of work, weight and age of the animal. We made discussion with farmers as to which animal groups are involved in traction and transportation services and then we considered 10% of the maintenance ME for traction and transport as suggested by IPCC (1996). Then using the supply side as a carrying capacity and the demand side as stocking rate, the present study estimated the ratio of stocking rate to carrying capacity. Using ratio value equivalent to 1 as references we described system as overstocked or understocked.

3. Result and Discussions

3.1. Farmers Feed Sourcing and Feeding Strategies

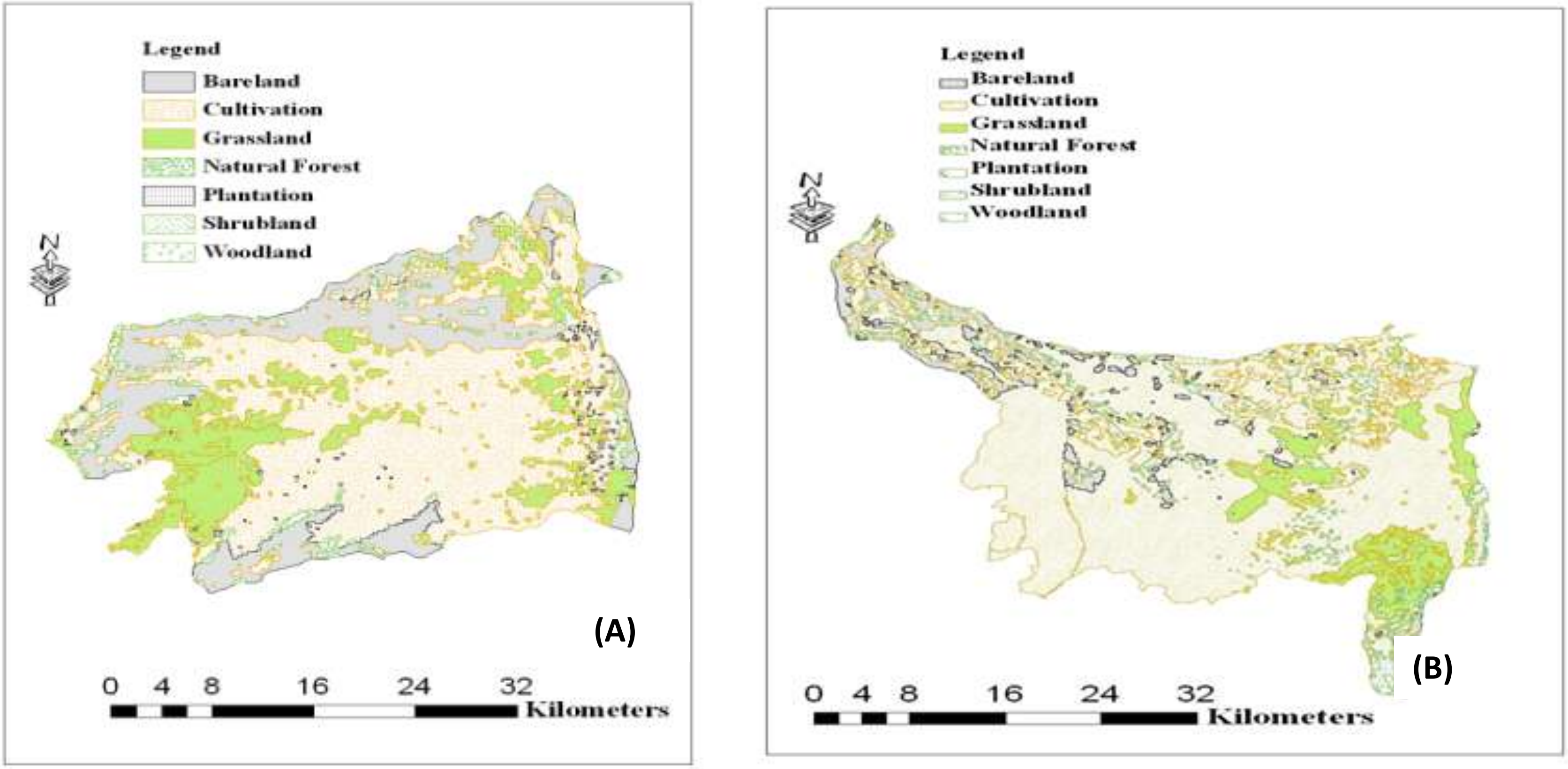
3.1.1. Major land use and land cover types

Existing land use/ land covers in both the study areas are major sources of livestock feed. But as to their area extent, available data show tremendous discrepancies. MoA (2002) data, on which this study mainly based on, proposes 5 major land use/ land cover types including: cultivated, grass, shrub, wood, bare and forest lands (Figures 2A and B). In general, cultivated land is major land use type in BLS and CLL systems. It constitutes ~ 53 and 72 % of total areas of BLS and CLL respectively. Apparently these values are higher compared with data reported by the respective District Agricultural Offices. These variations can be accounted for by the differences in the scale and land use/land cover classification approaches.

Although barley and wheat are important cereal crops in both systems, CLL system showed a higher level of crop diversity for legumes (i.e. types) and other cereals: suggesting potential variability in animal feed quality and quantity. Literatures, evidently, account these differences for by minimum temperature during the growing period and levels of land degradation (e.g. Getachew et al., 2010). The differences in the degree of land degradation can also be comprehended from the areas of bare land cover type in the two systems [22% for BLS 8% for CLL (Figures 2A and B)]. Our field observations and discussions with farmers also substantiate these arguments (Plate 3). The two systems also varied in extent of their grazing land area (i.e. grass land) and levels of woody vegetation associated therewith. In this respect the BLS system showed ~20% total areas under grazing land/grass land, whilst the CLL showed only 11% (Figures 2A and B). From field visits we observed that in the BLS system the grass land use/land cover was major sources of grazing areas, and conserved and standing hay (Plate 4), while in CLL system only grazing and conserved hay were important.

Although farmers at BLS systems claim that standing hay require low labor inputs and facilitate easy mix of the hay (with under growing lush grass after short rainy season e.g. Plate 4); experts criticize this practices for deteriorating feed quality (when compared with conserved hay). The question as whether the relative costs of labor outweigh the benefits needs further study.

Neither data from MoA (2002) nor these from District Agricultural Offices disaggregate the grazing areas into private and communal ownership. But Getachew et al., (2010) reported about 0.25 ha grazing land per households in BLS system. This suggests small proportion of private grazing, hence the importance of improving production from communal areas.



Figures **2A** and **2B**. Land use land cover of the Barley –Legume Sheep **(A)** and Cereals-Legumes-Livestock systems **(B)**

3.1.2. Livestock feed metabolizable energy supply

Differences in land use/land cover between the study systems illustrate differences in quantity and quality of available feed resources. Land use/land cover primarily influences the total feed ME supplies through respective ME values (MJ kg^{-1}) and then through differences in their productivity. Table 2 depicts estimates of productivity and available feed ME by major land use types. The major contributors to the overall feed ME resources in BSL system are grazing (sum of grazing land and other land units) and crop land, in that order of importance. For CLL systems same land use and in same order of magnitude (Table 2). Figure 3 indicates the share of major feed ingredient in study systems.

Table 2 Feed ME- supply from different land use land cover in Barley-Legume-Sheep (BLS) and Cereals-Legumes and Livestock (CLL) livelihood systems

Land use /land cover types	Study systems					
	BLS-area (000'ha)	ME productivity (GJ ha^{-1})	BLS-ME (TJ yr^{-1})	CLL-area (000'ha)	ME productivity (GJ ha^{-1})	CLL-ME (TJ yr^{-1})
Crop land-cereals	35	10.5	486	63	26.2	1749
Crop land -Pulses	23	5.3	125	35	15.0	648
Crop land-others	39	1.5	2	2		
Stubble grazing	58	1.5	144	100	1.5	158
Grazing land (private and communal)	22	15	410	16	15.5	223
Others *	31	15.5	375	23	19.5	436
Total	**		1543	**		3214

*includes bare land, shrubs, open forest; forest land ** not necessary sums up to total district areas as some of the feed sources areas (e.g. stubble grazing) are double counting

It is apparent that the two systems vary considerably in terms of their livestock feed sourcing. In BLS systems green fodder from grazing is important feed sources while in CLL livestock are heavily dependent on CR (>65% the feed ingredient and of this legume constitute 27%). Disaggregating the residues into its different component would give better insight: but information on the proportions of residues is not available.

Recently CSA (2012) issued a zonal scale livestock and feed information. It suggests that green fodder (30.3%), CR (29.34%), improved feed (0.145%), private holding hay (20.5%), by products (4.85%) and others (15.82%) constitutes the major ingredients of livestock feed resources in the Zone where BLS and CLL systems located. District level disaggregated information released by CSA (2002) suggests green fodder (31.7%), CR (40.6%), private holding hay (22.4%) improved (0.19%) others (3.87%) as major ingredients of the feed resources in the BLS system. For CLL system, the same sources, shows similar feed ingredient but in different order of magnitude: green fodder (23.12%), CR (47.34%) hay 23.16%, improved (0.06%), by products (0.77) and others (5.56%).

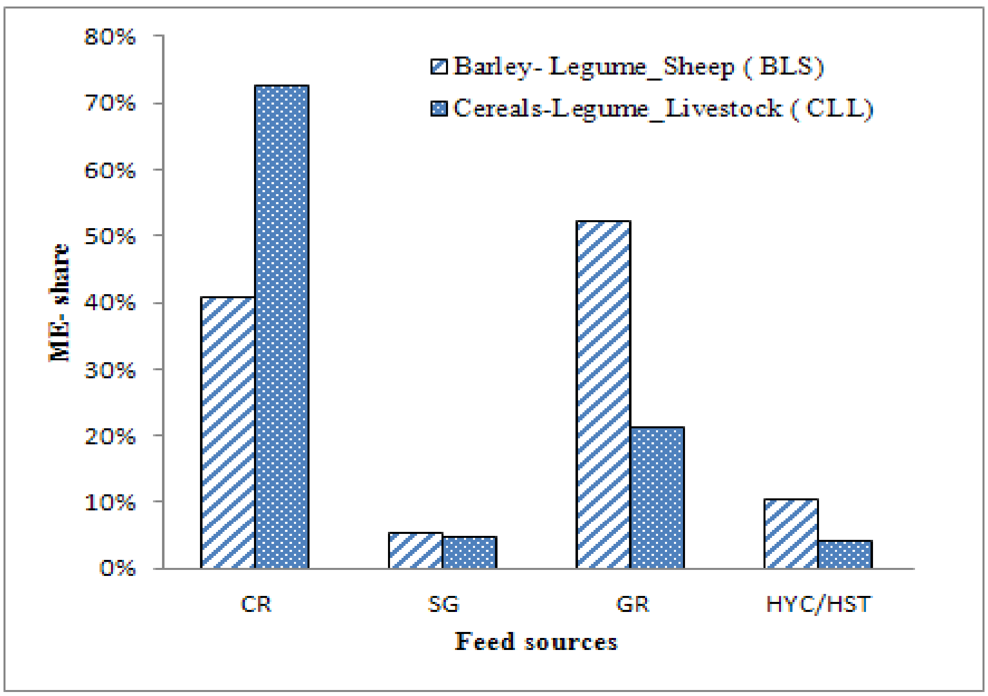


Figure 3 Contribution of the different land use/ land cover to the overall feed ME across Barley-Legume-Sheep and Cereals-Legumes and Livestock livelihood zones. (CR is for Crop residues; SG is for Stubble Grazing; GR is for grazing/green fodder; HYC is for conserved hay; HST is for

standing hay; CLL system is for Cereal-Legume-Livestock system; BLS is for Barley, Legume Sheep system.

Despite the divergences of values among the different information sources, all the data sets exemplified insignificant proportion of supplementary feed sources. This is presumably a paradox and has a far reaching consequence on the livelihood of smallholders: in view of increasingly important role of livestock in farmers' livelihood and growing interests of farmers to be engaged in livestock farming. The present study also argues that with increasing intensification CR became a major source of livestock feed: for example in CLL system. Although feeding on CR is considered a promising strategy to enhance resource use efficiency, many scholars of view that, as it stands now, CR has low feed quality and has potential tradeoffs with soil fertility management and conservation agriculture (Blümmel et al., 2000; Haileslassie et al., 2011 (in press)]. From an experiment conducted by Singh et al. (2011), to evaluate the effect of feeding CR of different cereals and legumes on weight gain of Yankassa rams, it was concluded that feeding the residues of cereals alone resulted in a mean weight loss of 14% for sorghum, 16% for maize and 11% for millet, while feeding the residues of cowpea or groundnut alone resulted in the weight gain of about 13 and 12%, respectively. Most of such differences between cereals and legume residues accounted for by protein contents and associated higher values of major feed quality traits. Bediye and Feyissa (2007) also summarized that when CR alone fed to an animal, depending on the live weight, only 55-68% protein requirement can be met.

One of the major limiting factors for productivity of animal in the mixed crop livestock system, in general, is low proportion of Crud Protein (CP) in the diet (Preston, 1982) and lack of understandings of constraints governing the utilization of low protein feed by ruminants. Low productivity on these diets can usually be related to low voluntary intake even if feeding is ad-libitum and the latter defines the rate of productivity (e.g. weight gain).

In this regard there is no data specific to the study areas. Weighted mean values (based on SLP data); for BLS and CLL systems were 6.22 and 5.67% DM respectively. This value is generally low for a reasonable weight gain of a growing lamb. The challenge is also not only the overall limitation of CP in the feed but also its temporal variability (e.g Gizaw et al., 2010). For example MoA (2002) related ME (MJ kg^{-1}), CP (% of DM) and DM digestibility (% of DM) with rainfall in CLL system (Figure 4) taking Debre-Berhan as an example. Apparently the three feed quality traits exhibited low values during November to May (Figure 4). In relation to this, number of question may arise: in areas where grazing areas contribution is low the benefits from better feed quality during the rainy season is questionable and even in BSL system where grazing land constitute a significant share of feed sources, these land units are located in the valley bottom (Plate 2) and practically water logged and thus may not be accessible for sheep and farmers complain also that these land unit are major sources of liver fluke infection.

Farmers are strategically synchronizing sheep marketing with availability of better feed quality and quantity and associated weight gain. Traditionally Ethiopian New Year (in September), Ethiopian Christmas (in January) and Ethiopian Easter (in April) are key marketing seasons. Farmers claim also a good body condition of the sheep during the New Year and Christmas markets: but concerned about the low price offer due to oversupply. In view of better price offer, Easter market is the desire of many farmers; but this market is constrained by low feed quality and quantity and thus weak body condition of the animal. The question is as to how farmers in the two systems cope with the feed shortage and what opportunity exists to exploit these markets.

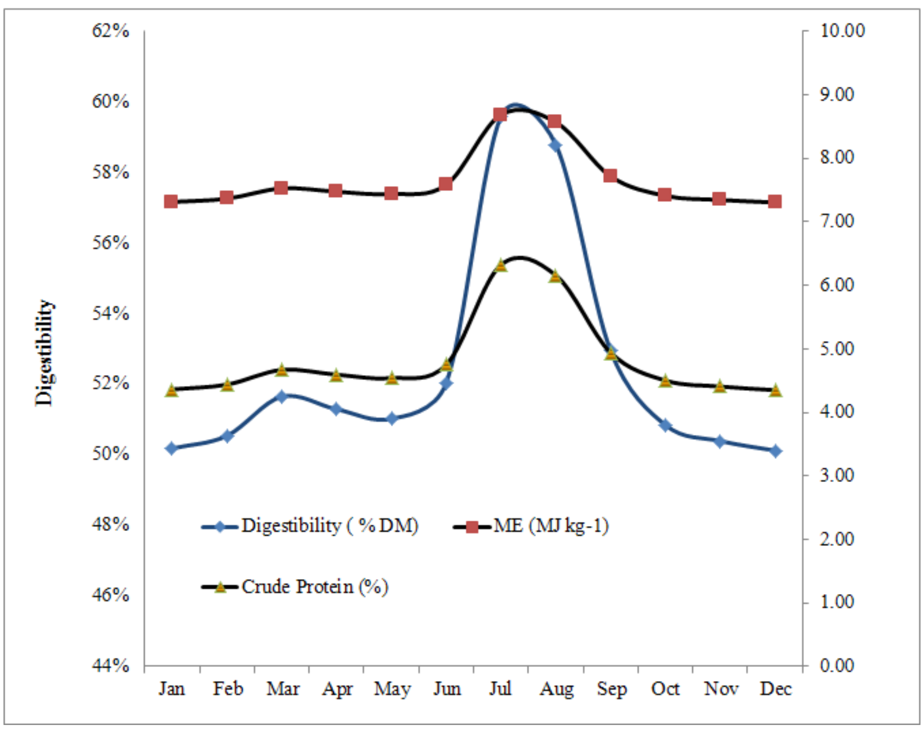


Figure 4 Variability of feed quality traits across temporal scale in Debre Berhan (CLL system)

Farmers coping strategies as reported by Getachew (2010) is different. According to this author about 39.5% of farmers in BLS system did nothing to support their sheep during feed shortage, 38.6% provide supplementary feed from own farm (crop residues, local beer by-product, hay and cultivated forages), 8% irrigate their grazing land and 6.7% provide supplementary feed from purchased sources and the remaining 7.2% reduce their flock size. The major CR used for supplementation in BLS system is faba bean (dry) (32%), wheat (16%) and barley (15%) residues. Feed quality improvement techniques for cereal residues such as urea treatment, chopping, pulverizing are hardly practiced. In view of the CR low feed quality, the prospect of achieving potential weight (23-30 kg) at the traditional culling age (yearling) of the sheep is questionable

3.2. Livestock Feed Metabolizable Energy Demand

Livestock is an important livelihood sources in BLS and CLL systems. Mean herd size was about 4 and 6 TLU household^{-1} respectively. In addition to the total holding, herd structure differed between BLS and CLL systems. For example, the ratio of sheep to large ruminates was 3 and 0.6 respectively. The proportion of lactating cross breed cows in CLL was 7% while in BLS system this value was insignificant. Likewise the ratio of oxen to total livestock was higher for CLL (data from District agricultural office). These summarized pictures of herd structure and species composition illustrate differences in the degree of dependency on the different livestock species, their products (sheep fattening market-oriented milk production), and services (support to cropping). It also shows the interaction between crop and livestock enterprises. For example, the ratio of oxen to total stock seemingly relates with the size of arable land holding in the two systems (Table 1). The point here is how these differences and the dynamic relationship between the objectives of livestock production, land use and the management of feed resources impact livestock feed ME demand.

Table 3 shows annual feed ME demand for activities (walking, feed intake), productivity (milk, weight gain) and maintenance for a mixed herd model (King 1983). The mean daily ME demand (MJ TLU^{-1}) for a mixed herd model was about 33 for BLS and 42 MJ for the CLL system. The differences can be accounted for by differences in proportion of cross breed cattle and associated LW. Differences in the daily mean feed ME demand of sheep (~6 MJ) was not vivid between the study systems. This has happened on account of lack of literature values distinguishing the productivity and activity levels of the flocks and digestibility and energy density of the feed in the study systems. But in terms of sheep's contribution to total feed ME demand variability was apparent: 31% for BLS and 9% for CLL systems. These values estimated by the present study were consistent with reported range (e.g. MoA 2002).

The lion share of feed ME is goes to maintenance followed by production and services (Figure 5A and B). The fact that maintenance showed higher share in the overall feed ME has stronger implication for interventions and so does the activity part. In order to perform the production functions on a sustained basis, essential nutrients in the form of ME, CP, minerals, vitamins and water (above these necessary for the maintenance of normal body functions), must be provided: meaning that the area needs more smart feeding, more efficient crop varieties and/or imported nutrients as fertilizer and/or feeds and/or fewer, more productive livestock (Preston, 1982). For a given animal species, the level of production achieved will, in turn, depend on the quantity and nutritive value of feed available. The major concern here is as to what proportion of this demand is satisfied and how does competition and selective feeding over all affect the sheep productivity in the two systems.

Table 3 Feed ME demand (TJ yr^{-1}) and ratio of stocking rate to carrying in Barley-Legume-Sheep and Cereals-Legumes and Livestock livelihood zones

Demand type	Systems			
	All livestock in BLS	All livestock CLL	Sheep-BLS	Sheep-CLL
Maintenances (TJ yr^{-1})	1,541	2,733	542	277
Activities (TJ Yr^{-1})	119	204	30	13
Production and services (TJ Yr^{-1})	900	1,114	606	347
Total-demand (TJ Yr^{-1})	2,649	4,051	1178	636
Supply (TJ Yr^{-1})	1,504	3,302	511*	297*
Stocking rate/Carrying capacity	176%	123%	-	-
Stocking rate/ Carrying capacity (MoA 2002)	171%	142%	-	-

*Assumed equal access to all feed resources and values estimated as a factor of live weight

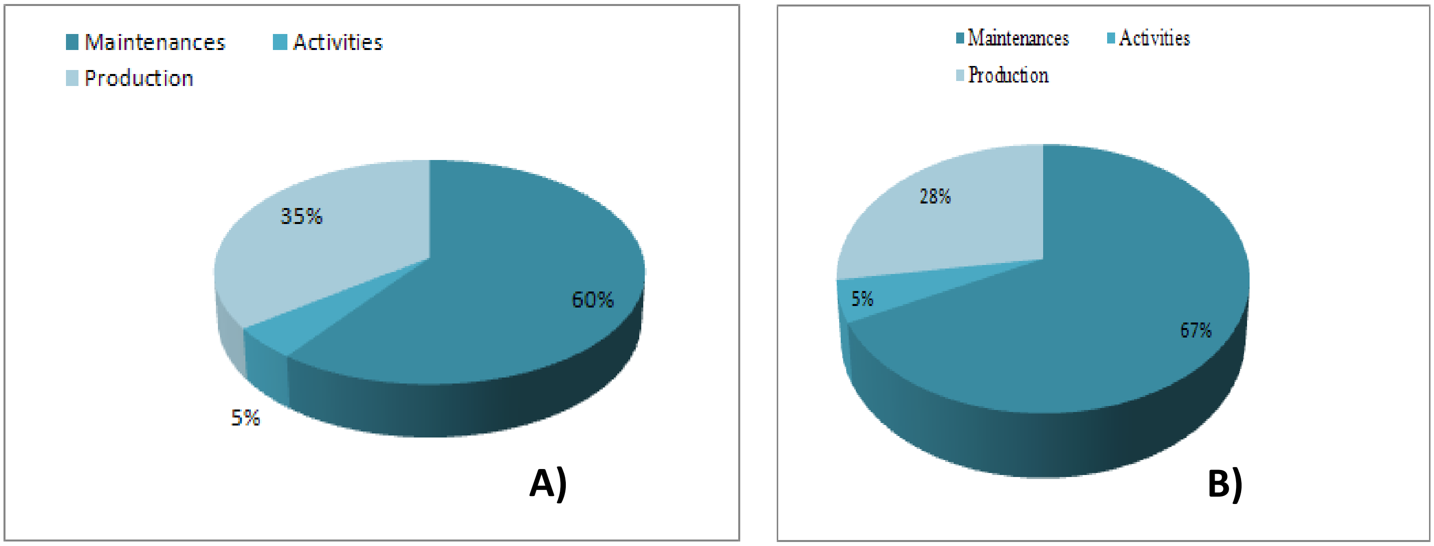


Figure 5A and B share of feed ME among maintenance; activities and production in Barley-Legume-Sheep (Fig 5A) and Cereals-Legumes and Livestock (Figure 5B) livelihood zones

One of the most interesting outcomes of the present study was also the estimates of the negative feed ME balances (Table 3). The magnitude of ME feed deficit estimated in the CLL is lower than the previous study (MoA 2002). This can be accounted for by to the relatively higher ME value used in the present study; improvement in crop yield and change in District boundary since 2002. The trend in the magnitude of feed deficient for BLS systems was apparently similar to the previous work (MoA 2002). Probably this can be ascribed to the relatively low crop yield improvement in this system and continues degradation of the grazing. Given two rain seasons in BLS systems and the fact that there can be double DM production in BLS systems (which we did not take into account in this estimation) may explain the huge feed demand supply gaps. Probably only long term and proper system monitoring will provide better insights on feed demand-supply balances.

Over all, the total feed supply barely exceeded the maintenance requirement. The CLL system is in much better position in this respect. Similar trend observed for a separate exercise for sheep. This, coupled with the low level of CP in commonly used feed in the study areas (as indicated earlier), suggests that the feed resources are under considerable pressure and sheep are not performing to their genetic merits. Scholars are increasingly concerned as to how livestock can survive and produce in states of negative feed ME balances (e.g. Thomas et al. 2002). Here we argue that demands might be overestimated and supplies underestimated due to inconsistencies in analytical methods. Systems are also not self-contained and there are feed trading. Although major share of feed sources come from own farm and communal grazing areas, CSA (2012) suggested that these traded or acquired informally constitute important fraction: green fodder (2.5%), CR (1.4%), improved [e.g. concentrates (22%)], hay (6%) and by products (30%). To consider these values in estimating feed supply, information as to whether these sources are within or outside the study District are not clear.

Farmers in mixed crop livestock systems are diverse (e.g. in terms of farmers' access to resources). In this respect a farm scale studies (e.g. Clement et al., 2011) suggest that farm households with less access to land and water are challenged by feed scarcity while the better off farmers (i.e. having better access to natural capital) have surplus feed and most often feed balance calculation neglect these diversity.

What we very often fail to understand are also seasonal variations in feed supply and farmers selective feeding of animal in state of production or service giving. Although lack of data is the major limiting factor to work out seasonal variation, discussion with farmers suggests that feed deficits built up rapidly from end of January, peaked in May and rapidly declined as pastures increased in DM, nutrient status and digestibility during the summer rain. Evidently, this is the time when animals are gaining weight and producing milk. Put differently seasonal/temporal disaggregation of feed demand supply estimation gives better clue as to the mechanisms how animal survive and produce under negative feed balances .

Generally farmers' perception of feed shortage is different: depending on their livelihood sources. During the field visits we had discussion with two groups of farms: i) these fully dependent on sheep for their livelihood (i.e. no land for cropping); ii) these rearing sheep as support to livelihood in time of risk associated with crop production. For the first group feed shortage is a concern but not the major issues. They are more concerned about the relation between increases in sheep and feed price and access to feed market. For farm households focusing on crop production the scenario is different: they are normally dependent on on-farm feed as illustrated above these feed sources are generally in short supply. This group is the one who is more vulnerable to seasonal feed shortage.

3.3. Implications and scopes for improvement: review of evidences

Getachew et al., (2010) suggested average market age of male and female Menz sheep are 11.3 (6.42 SD) and 11.9 (7.83 SD) months, respectively and yearlings are the first class of animals to be sold to cover immediate cash needs. Information from the same author and our discussions with farmers in both study areas revealed that most of the sale (80% of the total sheep sale) is concentrated to the months of major festive season. The major selling months were December to January (Ethiopian Christmas and Epiphany), August to September (Ethiopian New year) and April (Ethiopian Ester) accounted for 34.2%, 18.5% and 18.3% of the total sheep annual sell respectively. During these seasons the demand for meat becomes high and resulted in higher price of sheep. The remaining proportions of sheep sale occurs during the period October to November (20.3%) and June (8.8%).

Despite these, Negassa and Jabbar (2008) demonstrated that the bodies of ~55% of animal during sale, in Ethiopia, are not in good condition. Local field experimentation (personal communication, Tefera Mekonnen, Debre-Berhan Research Center) indicated that sole grazing based sheep daily live weight (LW) gain barley exceeds 16 grams. At yearling, under farm management condition, ~ 16 kg of LW is a norm. In contrast, supplementation of locally available feed with nuge-cake and oat grain showed a LW gain ranging between 50 and 73 g day^{-1}. Experiment also showed when within breed selection is combined with improved feed ~ 26 kg LW at yearling could be achieved. In a fattening experiment (for 123) days comparing yearlings of Menz and Horro sheep with initial LW of ~26 and 27 kg respectively suggested a weight gain of 8 kg for Menz at the end (Awgichew 2000). Put differently, the potential LW yield gap between farm practices and station is enormous (>60%). Value chain approaches may help to understand as to who is exploiting this potential and how can the majority of smallholder farmers benefited in long run? The issue here is also to understand as to whether sheep is a profitable business under intensive management system involving external inputs (e.g. concentrates). In this report, because of inadequate data on cost of feed, labor and price of sheep economic rate of return of sheep business under intensive feeding scenario is not considered. But certainly information from farm households who are involved in intensive sheep farming suggests that improved sheep feeding is a profitable business.

This being the supply side local data on the demand side is not available. As the major driver of the Menze sheep market is the Addis Ababa holiday market, it will be justifiable to use the national average. Number of studies suggests the current Ethiopian meet consumption per head at 11 kg per year (e.g. FAO 2009). Negassa and Jabbar (2008) estimated 18% of the meat in 2006 comes from sheep. FAO (2009) projection of the demand side to year 2050 indicates increase of the current consumption rate to 22 kg per head per year. In this view two key questions may emerge: i) how can farmers exploit this potential yield gaps or the underperforming supply side and ii) how they can be competent for quality and sufficient supply in the envisaged demand market without jeopardizing their environmental sustainability. It is most often argued that at some point these potential demand and supply gaps could be monopolized by the big investors and thus marginalizes the small holder farmers.

Meeting these goals primarily require closing the present feed ME demand supply and CP gaps. For example the productivity of recommended grass and herbaceous legume forage species is >100% higher that the indigenous species (Bediye and Feyissa 2007). Exploiting this potential will help closing the feed ME demand supply gaps. But this does not guarantee improved in productivity: unless the shortfall in feed quality addressed. Feed quality improvement is also relevant if we are to convert the feed ME spent for maintenance to production and to reduce the energy cost for activities like feed intake.

The scope for alleviating Menze sheep nutritional problems will depends very much on the characteristics of the system being studied. In BLS systems, where grazing land is the major source of feed and improvements of feed through CR based interventions is limited by low temperature and land degradation, improvements in animal nutrition may be virtually impossible without first addressing issues related to land tenure (communal grazing) and management (e.g. stocking rates and open grazing). While in CLL systems, where the CR constitute the major ingredients of livestock feed, technologies which increase the quantity and nutritive value of CR fed to animals might be applicable. This involves selection for crop varieties; changing crop combinations; changing the time of planting, physical and chemical treatments of CR.

4. Limitations of this study

This feed demand-supply analyses clearly demonstrated that the feed supply is in short of the demand and this fits well to farmers' perception of the problem and number of literature reviewed. However, during the review of the draft report, argument persisted among the expertise as to how livestock survived under feed deficit condition. Although most of the discussions presented in this report partly explain this, there is a consensus that the following can be major sources of error for feed demand supply balance estimation:

- Lack of up-to-date good quality data on area extent of different land use land/cover and their DM productivity and ME and CP values;
- Considering agricultural production system as a closed system and households as an independent system-component of a system usually lead to ignoring material flow among systems and within system (among the farm households). Such approaches limit the supply side only to on farm feed sources; which is not in reality;
- Farmers feed sourcing and feeding strategies are diverse and depends on the objectives of livestock production. Lack of capturing these diversity can be one of the major sources of error in estimating feed supply side;
- Conversion factors such as: feed use factors and harvest index are most often used to fill data gaps and are literature based. The fact that harvest index varies across varieties and use factor changes overtime may also introduce some error;
- The demand side estimation involves different livestock data including the herd structure, activity, and productivity. In open grazing systems parameters like slope, distances and speed of walking are hard to quantify. The open grazing practices further complicated the exercises of feed demand supply estimation. District level data normally lacks these details and the gaps are filled through estimate and literature.

Addressing these gaps are important, particularly, if the purposes of the feed balance outputs is for planning and research purpose. To do so sufficient resources and time needs to be allocated.

5. Key messages

This snapshot study targets policy makers (for awareness creation on status of feed resources) and researchers (for future research planning). The overarching objectives of this study were to: i) diagnose the meso-scale feed demand, availability and management; ii) to synthesize potential implications for feed based interventions. In view of the results, the following key messages can be drawn:

- The present livestock feed ingredients in BLS system primarily constitute green fodder from grazing, dry fodder from CR, standing hay and conserved hay. Similar feed ingredients were identified for CLL system with CR playing the major role. Supplementation is limited mainly to residues of local brewery which is limited in volume and farmers are selectively feeding to large ruminants. Despite slight deviation in type of feed ingredients, sheep in both systems suffers from nutritional deficiencies (CP) and thus this may account for the current low levels of productivity.
- The feed ME demand is dominated by the maintenance requirement followed by activities. ME for production is insignificant particularly when the contribution of service is deducted. This, partly, substantiates the above conclusion and at the same time suggests the need to convert maintenance feed ME investment to production through proper supplementation. The question as to whether intensive sheep feeding, through supplementation, is economically and environmentally feasible is an issue for future research.
- The demand-supply balance indicates that the available feed is hardly sufficient for maintenance. Farmers selective feeding and targeting of marketing at better feed availability time are major coping strategies. But as selective feeding hardly include sheep, particularly in CLL system, the weight gain potential and festive season market opportunities for sheep are not well exploited. Coping or adaptations to the field realities of systems in which few purchased inputs were the norm (low-input, low-output systems) but which now may be responding to increased demand for slaughter sheep through increased purchases; smart feeding and increased feed production are likely to emerge if institutional changes can be achieved: i.e. more effective input markets and knowledge systems.
- Apparently the gap between farmers practice and potential weight gain of sheep under station condition shows the potential for intervention. Projected demand side is also very promising. In view of the above low feed quantity and quality a simultaneous interventions addressing these shortfalls are important to exploit these potential. This includes both technical (crop selection, CR treatment, nutritious and high yielding fodder crops) and policy measures (e.g. open grazing, CPR management input and output market). For such attempts to be realistic a unique role, context and optimum

combination of different feed ingredient must be recognized and linked to input costs and output benefit.

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Annex: Photo plates

Photo plate 1: Typical mixed herding (left) and crop production moving into grazing land in CLL system (right)

Photo plate 2: Typical locations of grazing areas in CLL and BLS systems (note the landscape positions)

Photo plate 3: Typical bare land in BLS system (note the cultivated steep slopes, rock outcrops)

Photo plate 4: Examples of standing hay in BLS system. Note selective feeding (left) and deteriorating standing hay (right) and note also fresh grass growing

Photo plate 5: Degraded grazing lands (left) and typical herding in BLS system (right)