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Research Article Assessment of Existing and Potential Feed Resources for Improving Livestock Productivity in Niger

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Abstract

Inadequate quantity and quality of feed resources are major factors limiting productivity of livestock systems in the Sahelian zone of West Africa. The possibilities of improving the livestock production systems by assessing potential feed resources and identifying points of intervention was investigated using feed assessment tool (FEAST) in two villages, Milli and Gourdjia in Maradi region of Niger. Results from focus group discussions and individual interviews indicated that mixed crop-livestock production systems are dominant in the study sites. Main livestock feed resources in the study sites were natural pastures, crop residues and agro-industrial byproducts particularly wheat bran. Purchased feed accounted for over 60% proportion of the livestock diets in Milli and Gourdjia in terms of Dry Matter (DM), Metabolizable Energy (ME) and Crude Protein (CP). Due to short supply fertile land and poor feed resource, more than 20% of the household income comes from off-farm businesses. Results further showed that farmers depended on purchased feed, which included crop residues, bush hay and cereal brans as major source of feed contributing more to the total diet of the livestock. Farmers were faced with low agricultural productivity due to declining soil fertility and declining grazing area principally due to expansion of cultivated land. Consequently off-farm businesses became a major strategy for sustaining their household. Provision of technical knowledge on how to improve the quality of existing feed resources and health management facilities will enhance productivity. The report also identified some potential feed resources that could be exploited for livestock nutrition.

Key words: Animal nutrition, farming systems, feed availability, feed scarcity, crude protein, DM

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Livestock contribute significantly to livelihoods of rural populations in West Africa. At least 100 million poor people in West Africa rely on livestock as part of their livelihood strategy (Williams and Okike, 2007). Livestock contribute significantly to the economies of the region, especially the Sahelian countries (SWAC-OECD/ECOWAS, 2008). In Niger republic, one of the Sahelian countries in West Africa, crop and livestock production are the mainstay of the national economy, (Geesing and Djibo, 2006). In the Sahelian and Sudanian zone of West Africa, nutrition of livestock in these regions are essentially based on the exploitation naturally occurring herbaceous grasses and dicotyledonous species, ligneous plants and crop residues (Teferedegne, 2000). The common problems with these resources are marked variation in availability and guality and seasonal shortage, which have been consistently reported as the major constraint to ruminant production (Devendra and Leng, 2011; FAO., 2012) in the developing countries. Low available forage is principally due to low biomass production from the rangelands (Penning de Vries and Djiteye, 1991) which is a reflection of poor soil fertility and inadequate and erratic rainfall. The proportion of crop residues in the animal's diet is related to annual rainfall, the intensity of cropping and the available forage during the dry season (Ayantunde et al., 2000). Qualitative and quantitative forage shortage, particularly in the dry season, has reduced the livestock productivity (Fernandez-Rivera et al., 2005) and addressing feed problem can significantly increase livestock productivity. Evaluation of the existing and potential feed resources are also important to develop strategies for efficient use of these resources by reducing waste. In addition, it is also necessary to promote proper management of natural resources and the adaptation of livestock systems to available feed resources (Corniaux et al., 2005; CIRAD., 2010; Dore et al., 2011). The objective of the study is to understand the present status of the farming systems in this area, collect up to date information on feeds resources and feeding strategies in order to guide appropriate research interventions that will improve livestock productivity and related livelihoods.

MATERIALS AND METHODS

Description of study site: This study was carried out in Maradi region of Niger, which is one of the seven regions in the country. It is located in the Southern part of the central Niger to the East of Tahoua region and West of Zinder region.

Maradi is divided into 6 administrative districts namely: Aguie, Dakoro, Guidan Roumdji, Madarounfa, Mayahi and Tessaoua departments. Maradi region falls within two agro ecological zones namely Sahelian in the North and Sahelo-Sudanian in the South with 300-600 mm/year of rainfall. The principal cereal crop in this region is pearl millet, which is grown either as a sole crop or intercropped with cowpea. Where the land quality permits, Sorghum and maize are also grown. Cereal production is principally geared toward household consumption, although periodic sales occur when money is needed to meet household obligations. Cowpea and groundnuts are considered as both cash and food crop. Two villages Milli and Gourdjia were selected for the study. These two villages are within Aguie administrative district of Maradi region and about 30 km to the border of Nigeria.

Methodologies and implementation of the survey: Focus group discussions and individual interviews were conducted between April and June, 2014 in the study communities to evaluate existing and potential feed resources using feed assessment tool (FEAST), which was developed by ILRI (Duncan et al., 2012). The FEAST comprises Participatory Rural Appraisal (PRA) using semi-structured guestionnaire for focus group discussions and individual interviews. Twenty farmers including women were selected to participate in group discussions PRA approach to provide an overview of the farming system and to identify constraints and opportunities for improving livestock production in the study sites. For the individual interviews, 12 farmers were selected from those who participated in the group discussions to represent 3 wealth endowment categories namely average, above average and below average in line with wealth ranking by the communities. Four farmers from each category were individually interviewed to collect quantitative information on feed resources and feeding practices. Samples of available feed resources offered to animal were collected and analyzed for nitrogen and ash content, fibre components (NDF, ADF and ADL) and in vitro organic matter digestibility.

Data analysis: The quantitative data collected from PRA surveys and individual interviews were entered into the FEAST excel template (www.ilri.org/feast) and analyzed. Results are presented in tables, graphs, pie and bar charts.

RESULTS AND DISCUSSION

Overview of the farming system: The results of the survey show that farming system in Milli and Gourdjia is a mixed crop-livestock production. Mixed crop-livestock farming form

the dominant farming system in the developing world (Herrero *et al.*, 2010). Particularly the Sahel areas, livestock keeping is a central livelihood element these mixed systems (McIntire *et al.*, 1992). Crop production was rainfed in Milli and Gourdjia and this limited the cropping season to only once in a year. This cropping season is called damane, which starts from June-October. Farmer also practiced off-season farming from November-January. Farmers reported that the month of May and June were used for land preparation for the planting season.

Crops grown in both sites and average land area cultivated per household were presented in Fig. 1 and 2. The major crops grown in the areas were millet, Sorghum, cowpea, groundnut and sesame, which were intercropped on the same farmland in succession due to shortage of fertile land. Pearl millet was the dominant crop in the area followed by Sorghum, while cowpea was the dominant leguminous crop in both study sites. Different authors have clearly underlined the importance of intercropping especially for small holder farmers in view of its profit maximization, risk minimization against total crop failure, soil conservation and improvement of soil fertility, weed control and yield (Shetty *et al.*, 1995; Mpairwe *et al.*, 2002). The most common associations of crops in this region have been reported by Bationo *et al.* (2005). Authors found that cereal/cowpea, cereal/groundnut and cereal/cereal, such as millet/Sorghum/maize and millet/Sorghum/cowpea are the combination of intercrops in Sudano-Sahelian region of West Africa. In these systems pearl millet is normally sown first and acts as the dominant crop (Bationo *et al.*, 2005). According to the farmers, during the main cropping season, pearl millet was planted first and then Sorghum in alternate rows, thereafter cowpea and groundnuts were sown.

Other crops grown in the study site included maize, Bambara nuts, sesame and potatoes. The cold dry season is characterized by dews and fogs with little or no rain. The major crops grown in this period were cabbage, tomato, lettuce, carrot, sweet pepper and onions. These off-season crops grown are mainly used as a means of income generation.



Fig. 1: Crops grown in Milli and average area of land cultivated per household



Fig. 2: Crops grown in Gourdjia and average area of land cultivated per household

Since all agricultural activities were land determined, farming is limited by lack of access to fertile land in the study sites. Farmers reported that lands were inherited from their parents and over each generation, the same land areas were shared among increasing number of family members, which often resulted in declining available land. Moreover, the limited available land was reported to low in fertility due to soil degradation resulting from continuous cropping. This major factor was reported to have led to reduction in crop productivity and income generally. It also contributed to low quantity of crop residues as major feed resources and consequently low livestock population. Besides rainfall, soil fertility appears to be more limiting to crop and fodder production in the Sahelian zone (Penning de Vries and Djiteye, 1991). The use of rotation systems, organic and inorganic nutrients combinations and water harvesting technologies and increasing the legume component for better integration of crop-livestock production systems has been suggested to mitigate the problem of soil fertility in the Sahel (Bationo et al., 2005). Identifying alternative nutrient sources, promoting efficient use of existing nutrient resources and settled livestock production for increasing manure production were recommended by Bidjokazo et al. (2012).

There were no irrigation facilities in Milli. Farmers only practiced traditional irrigation using buckets to water their small area of cabbage and other dry season vegetables. During the cold dry season cropping in Gourdjia, low land areas of about 3 ha were usually cultivated. This is known as fadama farming and 80% of the household in Gourdjia had at least about 0.02 ha. In this area of land there was a minor irrigation facility which comprises of a borehole and water pump. These were used to lift water from the borehole supply and distribute water to the area through channels and canals. This initiative was sponsored by the government of Niger. Farmers acknowledged that the fadama farming had contributed to their income especially in dry season. The role of irrigation in poverty reduction had been studied extensively in Northern Mali. It increased both household savings and informal social insurance in the form of transfers (Dillon, 2008).

According to the farmers, there was all-year round household labour for farming activities in both sites, which was mostly required shortly before and during rainy season for land preparation at 1000 CFA (\$2.2) per day for adult equivalent plus lunch.

On average, according to the farmers, about 2 people in a house hold normally leave the village for cities on yearly basis in search of better employment opportunities or for business. These people return to the village only during the festive period or at the end of each year, while some return during the raining season for cropping activities. This leads to seasonal or permanent migration of people especially men to pursue other means of livelihood. In Gourdjia, out-migration is mostly into cities in Nigeria across the border to seek other economic opportunities.

In Gourdjia, farmers described that farming activities, such as land preparation, planting and farm maintenance and herding have suffered greatly as a result of migration. Women and the remaining family members work harder and some even employ farm labourers as a result of out-migration of their family members. However, farmers in Milli viewed that out-migration did not result in decrease in agricultural output. They reported that remittances sent home by out-migrants are use to support agricultural activities by hiring more labourers and increasing agricultural output. Similar response was reported in East Gonja district of Northern Ghana (Kubon, 2004). Nyamieri (2011) also reported that migration was part of an income diversification strategy, where remittances are being sent to the farm household to help reduce the risks incurred in both subsistence and agriculture activities in Nyamira district of Kenya.

Farmers noted that besides land, another constraint to agricultural production was lack of access to credit or financial facilities. There was no available credit scheme either by the government or private sector in the community. The farmers therefore established a cooperative society in 2013, where each farmer contributes certain amount and then later can access loan. However, the available cash in the cooperative's account was very low to provide loan to all the members. Access to financial services by small scale farmers had been reported to have a potential to make a difference in agricultural productivity, food security and poverty reduction (Kalunda, 2014).

Lack of access to agricultural inputs such as fertilizers, improved seeds, tractor services or any other forms of inputs was another major problem in study sites. This is due both to distance to the city and lack of money to purchase the inputs when available. According to the report of Powell *et al.* (1996), lack of access to agricultural inputs is one of the common constraints to crop-livestock systems in the Sahelian region of West Africa.

Household characteristics, land holding and land use pattern: Majority of the households in Milli were in the category of small holder farmers with 1.5 ha of land on average (Fig. 3), while 10% of the households in Milli were landless farmers. Large land holding framers owned more than 3 ha of land. From the results of the surveys, approximately more than half of the farmers in Gourdjia were categorized as small land holder farmers cultivating about 1 ha of land



Fig. 3: Distribution of land area cultivated for households in different wealth categories in Milli



Fig. 4: Distribution of land area cultivated for households in different wealth categories in Gourdjia



Fig. 5(a-b): Contribution of livelihood activities to household income in (a) Milli and (b) Gourdjia (%)

(Fig. 4). About 30% of the farmers fell into medium land holder, while both landless and large land holding farmers accounted for 10% each in the village. Rainfed mixed cropping system combined with few numbers of animals was the main livelihood strategies of most households in the study site.

Major sources of household income: Crop production was the main sources of household income followed by livestock production in Milli. However, other businesses and off-farm labours contributed more to the household income than livestock production (Fig. 5a). Some of the businesses were trading, hired labour and trade within the country and across border in other places. Due to problem of inadequate land for farming and low number of livestock over the years, farmers in Gourdjia were increasingly engaged in off-farm activities, such as trading across the border with Nigeria and migration to urban centres in Niger and Nigeria for jobs. These have formed the major contributor to their livelihood income. Agriculture and livestock contributed 20 and 17%, respectively to the farmer's income (Fig. 5b). In contrast, result of other study in the sub-humid region of Burkina Faso indicated that livestock rearing accounted for 34% of rural household incomes (Zonon, 2004). Specific problems facing livestock production in the Sahel could be responsible for the low contribution from livestock in the study sites. These problems included: low and variable forage availability and poor quality water scarcity, low animal production, high mortality rates, low and declining soil fertility (Ayantunde *et al.*, 2008).

In Gourdjia, other business and labour work outside the village contributed 26 and 24% to the household income, respectively which is more than livestock production (Fig. 5b). In the rural Sahel, livelihoods are not only about cultivation of fields and securing a yield because farm work only takes place during the few months of the rainy season every year. Farmers are involved in all sorts of petty trading and non-agricultural rural employment is a substantial part of their income and living strategies (Bryceson, 1996). From the farmers responses, engagement in off-farm business increased due to increased population and the pressure on the available and degraded land. Similar increase in the number of off-farm business was reported in Maasailand, Kenya where income diversification and remittances accounted for more than 50% of the rural family's income (Nkedianye *et al.*, 2009).

Livestock assets and roles: Results of livestock ownership in Milli and Gourdjia as indicated in Table 1 suggested that cattle were the dominant livestock species with at least one per household. Milk from the cow was mostly sold for income, while some animals are used for farm operations and later fattened to be sold. The farmers noted that after use for traction, animals that have served for some years were fattened and sold. Sheep and goats are kept primarily for income with average of two per household while chickens were also sold as need arises and during festival by very low income farmers that could not afford ram. For religious reasons, pigs are not kept in Milli. Only local breeds of livestock species are kept by the farmers in Milli and Gourdjia.

The contribution of livestock to the poor resource farmers in the Sahel in providing income to the economy of pastoral households, ensuring a means for saving, insurance and legacies was reported by Wane *et al.* (2009). Their

contribution to soil fertility in mixed systems through organic matter transfer in form of manure has been intensively studied and has been reported to result in higher yields in cropland than in production systems without livestock (Manlay *et al.*, 2004).

During the focus group discussion in Milli, farmers reported that the number of animals per household had been reduced. Farmers explained that about 10 years ago, every household in Milli had at least 15-20 heads of cattle and other livestock species. However, as the population increased and land area for cultivation reduced, there was pressure on the livestock population in terms of feed availability and sale to generate income for the household. Coupled with this, there was an outbreak of poultry disease and very many household lost their birds.

Livestock housing and management systems: The livestock management system generally practiced in both Milli and Gourdjia is extensive system. Animals were kept on grazing most of the periods of the year. However, during raining season, farmers reported that all the animals are kept at home in the sheds. This was done to keep the animals from destroying the planted crops and at this time, animals were fed natural pastures and crop residues, which were either purchased or from the farmers farm. They also reported that there are local government officers who enforce the law of keeping the animals at home during the cropping season. Owners of strayed animals that damaged crops are made to pay fine. Majority of the farmers (80%) built sheds made of wooden pole and straws, where animals are kept at night. Sheds are also used to shelter the animal after grazing during the day or when it is raining and during the planting when the animals are kept normally indoors.

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Livestock species	Use	Household that owns the species (%)	Average number of animals per household
Milli (%)			
Local dairy cows	Milk, breeding and manure	35	1
Draught cattle	Draught and means of transporting manure, crop	10	1
	residues, harvest and a new wife on the wedding day		
Sheep	Fattened for sale, manure production	40	2
Goats	Income and food	30	2
Poultry-village	Income, gifts, festival and ceremonies,	20	3
Donkeys	Transporting goods and fetching water	3	2
Gourdjia (%)			
Local dairy cows	Milk, breeding and manure	20	2
Draught cattle	Draught and means of transporting manure, crop	30	1
	residues, harvest and a new wife on the wedding day		
Sheep	Fattened for sale, manure production	40	3
Goats	Income and food	30	5
Poultry-village	Income, gifts, festival and ceremonies,	70	10
Donkeys	Transporting goods and fetching water	1	1

Keeping the animals in the shed near homestead during the wet season as reported by the farmer was contrary to some previous reports. Thebaud and Batterbury (2001) stated that during the wet season, the common practice in the region is to send the animals on transhumance to pastoral zones in the Northern Sahel, where the animals remain until harvest of crops in the Southern Sahel. However, over time, due to a number of factors, such as the drought in the Northern Sahel, the seasonal transhumance from Southern Sahel is gradually disappearing giving way to the process of sedentarization (Daodu et al., 2009). According to the survey conducted in Fakara in South-Western Niger in 1998 on the practice of wet season transhumance, about 43% of the households managing herds of cattle, sheep and goats did not practice transhumance (Hiernaux and Ayantunde, 2004). From the results on the number of animal per household (Table 1), farmers may not practice transhumance during the cropping season because the number of animals are very few.

Feed resources are not commonly processed in the study sites according to the respondents. According to farmers in Milli, the local extension agents came and trained about 12 farmers in the village on the use of urea treatment of crop residues. However, since the training ended, no one has practiced the method in the village owing to lack of cash to purchase urea and the few number of animals owned. Such training on urea treatment was not reported in Gourdjia as farmers claimed to have never heard of urea treatment.

From the response of the farmers interviewed, major feed resources in both study sites were natural pasture and crop residues. Naturally occurring green fodder species identified included: *Andropogon gayanus, Eragrostic tremula, Pennisetum pedicelatum* and *Digitaria ciliaris.* These forage grasses were harvested as hay and sold in market along with some crop residues (Plate 1 and 2). At harvest, most crop residues were harvested and stockpiled on the farm, on the animal shed (Plate 3) or trees (Plate 4) beside the homestead from where they are brought to the animal in the evening after grazing.

Veterinary and AI services: According to the farmers, veterinary services were provided in Milli by the regional government. The farmers normally contact livestock services whenever there is any need and the veterinarian often responded almost immediately. This service was made available by the government at no cost. However, farmers paid the cost of drugs as the case may arise. This cost varies depending on the nature of the treatment. Contrarily, there were no veterinary services either in or near Gourdjia. The veterinary service provided by the government for Milli, only



Plate 1: Crop residues in fodder market near Gourdjia



Plate 2: Busy hay in fodder market near Gourdjia



Plate 3: Methods of storing crop residues in the areas

comes to Gourdjia once in a year to vaccinate the animals. This poor veterinary service might have contributed to high animal mortality in the community as described by the farmers and could have discouraged many farmers from investing in



Plate 4: Methods of storing crop residues in the areas



Fig. 6: Available feed resources in Milli



Fig. 7: Availability of feed resources during the year in Gourdjia

livestock production. According to Masikati (2011), the major constraint for cattle production in the smallholder farming systems is the high animal mortality through diseases. Poor farmers have few animals and few reserves on which to survive during lean times and use for recovery, consequently, loss of individual animals has a proportionally greater impact. From farmers response, Artificial Insemination (AI) services were not available in the study sites.

Major livestock feed resources and seasonal availability:

Figure 6 and 7 showed the composition of feedstuffs

available throughout the year in relation to the rainfall patterns in Milli and Gourdjia, respectively. At the peak of wet season, livestock relied mainly on the available green forage resources, which were cut-and-carried to the animals, where they were confined to prevent damage of crop farm. Although, there seems to be more forage availability during this time, farmers reported that performance of animals in terms of weight gain was low and this affect the selling price. This reduction in weight gain of grazing ruminants in the wet season, when grazing resources were of the best quality was as a result of under-nutrition due to restricted access to grazing (Ayantunde *et al.*, 2008). The authors indicated that the common practice of tethering sedentary cattle in the wet season in the southern Sahel in West Africa reduces forage intake and consequently average daily gain. Other reported cause of the problem of access to pastures in the wet season, especially in agro-pastoral zone in the Southern Sahel is fragmentation of cultivated fields (Turner and Hiernaux, 2002).

From this results, crop residues remain the main feed resources at the end of the wet season, which also coincided with the harvest period (Fig. 6 and 7). Similar result by Fernandez-Rivera *et al.* (2005) in Fakara, Southwestern Niger showed that the end of growing season for herbage also coincided with peak of availability of millet stover. Moderate to high amounts of millet stover were available in all villages from harvest time to February (middle of the dry season) but the last 3 months (April-June) of dry season were characterised by a remarkable feed scarcity.

Farmers from Milli and Gourdjia also noted that cereal crop residues are more in abundance than legumes. Hence, they were normally fed to the animal first, while legumes are fed at critical times when the feeds are scarce or as supplement. In a similar report from the Gambia, farmers fed their livestock mostly with Sorghum, millet and maize stover as basal diet, while cowpea and groundnut haulms are fed as protein supplement (Russo, 1990). In addition, crop residues are also stored for feeding during in the dry season to selected animals and or sold (Powell *et al.*, 1996). As the dry season advances and the cereal residues declined in quantity, legumes residues, concentrate and open grazing formed the major livestock feed resources in the study sites.

Purchased feed: Some feed resources purchased by farmers in Milli to supplement animals particularly during the cropping season when the animals are kept in the shed included; millet bran, bush hay (Eragrostic tremula and Andropogon gayanus), wheat bran, groundnut haulms, cowpea hay and cowpea husk (Table 2). The need for purchased feed was inevitable in the region due to extremely variable and generally low yields of millet and Sorghum caused by declining soil fertility and consequently low quantity of crop residues. Many farmers do not produce enough cereals to meet their domestic requirements and residues needed to feed their animals. Reduction in the quantity of available cereal residues per animal has been observed in recent years (FAO., 2014). About 58% of smallholder dairy farmers in Kenya also ranked purchase of fodder from other farmers as the second most important coping strategy against feed shortage in dry season (Njarui et al., 2011). Kayouli (1996) also reported that most cereal crop residues are of poor quality with low nitrogen, energy and mineral contents, while the edible proportion rarely exceeds one-third of the biomass, which necessitates purchase of more feeds.

Purchased feeds available from the feed market in Madaou, a peri-urban village, where famers purchase feeds are: Wheat bran, millet bran and Sorghum bran. Others are residues of pearl millet, Sorghum, groundnut, cowpea and its husk (Table 3). Bush hays were mainly from *Eragrostic tremula* and *Andropogon gayanus. Eragrostic tremula* has been reported to be a highly palatable annual forage grass species in South-Western part of Niger (Ayantunde *et al.*, 2009).

Table 2: Purchased feeds, prices and quantity in Milli and Gourdjia in the past 12 months					
Feeds purchased	Quantity (kg)	No. of farmers	Price FCFA kg ⁻¹		
Milli					
Wheat (<i>Triticum aestivum</i>) bran	2656	10	400.00		
Pearl millet (<i>Pennisetum glaucum</i>) bran	336	2	80.00		
Groundnut (Arachis hypogea) crop residue	546	4	100.00		
Naturally occurring pasture-hay (tropical)	1155	2	30.00		
Cowpea (<i>Vigna unguculata</i>) husk	184	3	120.00		
Pearl millet (<i>Pennisetum glaucum</i>) crop residue	28	2	40.00		
Sorghum (<i>Sorghum bicolor</i>) bran	-	-	-		
Sorghum (<i>Sorghum bicolor</i>) crop residue	-	-	-		
Gourdjia					
Wheat (<i>Triticum aestivum</i>) bran	2268	11	360.00		
Pearl millet (<i>Pennisetum glaucum</i>) bran	16	1	60.00		
Groundnut (Arachis hypogea) crop residue	5	1	100.00		
Naturally occurring pasture-hay (tropical)	5664	8	20.00		
Cowpea (<i>Vigna unguculata</i>) husk	15	1	150.00		
Pearl millet (<i>Pennisetum glaucum</i>) crop residue	220	3	42.00		
Sorghum (<i>Sorghum bicolor</i>) bran	64	2	25.00		
Sorghum (<i>Sorghum bicolor</i>) crop residue	3	1	100.00		

Prices as at the time of the survey (500 FCFA = 1 USD)

Table 3: Nutrient composition (g kg ⁻	¹ DM), metabolizable energy (MJ kg ⁻	¹) and <i>in vitro</i> organic matter	⁻ digestibility (g kg ⁻¹	DM) of available feed resource in Mil	li in
dry season					

Type of feed	Ash	Ν	СР	NDF	ADF	ADL	ME	IVOMD
Grasses/broadleaves/browse								
Piliostigma reticulate (leaf)	73.40	18.90	118.00	694.0	694.0	373.00	55.30	402.0
<i>Eragrostis tremula</i> (fresh)	62.20	11.90	74.20	724.0	361.0	59.20	69.80	480.0
Andropogon gayanus (hay)	66.40	04.30	26.80	710.0	463.0	91.70	64.60	437.0
<i>Hypheanea thebaica</i> (fresh)	64.40	12.10	75.60	749.0	579.0	155.00	66.10	458.0
<i>Acacia albida</i> (pods)	43.80	12.60	78.70	308.0	285.0	77.00	101.00	673.0
Mean values	6.20	1.19	7.47	63.7	47.6	15.10	7.14	49.0
Crop residues/by-products								
Sorghum bicolor (stover)	107.0	01.30	07.90	736.0	482.0	81.70	69.00	467.0
Millet stover	207.0	05.80	35.90	597.0	399.0	62.90	60.70	441.0
Rice stover	198.0	07.70	47.90	489.0	339.0	56.60	62.00	449.0
Cowpea stover (green*)	84.2	26.30	165.00	479.0	238.0	59.00	92.00	644.0
Millet bran	125.0	08.90	55.50	628.0	338.0	46.00	88.40	602.0
Wheat bran	54.2	29.90	187.00	367.0	131.0	40.00	89.20	626.0
Groundnut haulms	109.0	20.70	129.00	355.0	302.0	49.70	93.80	651.0
Cowpea haulms	200.0	16.00	100.00	456.0	726.0	393.00	76.80	555.0
Mean values	13.6	1.46	9.10	51.3	36.4	9.86	7.90	55.4

N: Nitrogen, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ME: Metabolizable energy, INVOMD: *In vitro* organic matter digestibility, *Newly harvested cowpea pea stover

According to the authors, herbaceous plants are commonly harvested dry as bush hay in to fatten sheep or to sell at feed market to other livestock farmers. The report of Lamers and Ermhard (1995) also confirmed that fodder weeds such as, *Alysicarpus ovalifolius, Commelina forskalaei, Zornia glochidiata* and *Eragrostis tremula* are traded at rural and urban markets in Niger. They revealed that laboratory analysis of these fodder weeds are two times higher crude protein content than low quality roughages such as millet stover. This may account for the wide used of hay in this region, beside the low price per kilogram.

According to the farmers, large quantities of pearl millet and Sorghum bran were produced daily from the household food processing, which are used directly to feed animals and often sold at the market. In Milli, wheat bran was purchased more than other available feed stuffs in the feed market (Table 2). The demand for wheat bran was also reported to be generally high throughout the year in feed market in Southern Ethiopia particularly during the fattening period (Berhanu *et al.*, 2009). Results showed that bush hay contributed 70% of the feed purchased in the past 12 months in Gourdjia (Table 2).

Farmers in Milli reported that there was a government grazing reserve about 13.5 km from the village, which was established years ago but had been invaded with low quality forage species due to poor management. In addition, a large proportion of the grazing reserve had been turned into farmland. Declining grazing area, which is principally due to expansion of cultivated land has been reported as one of the problems facing livestock production in the Sahel region (Ayantunde, 1998). This contributed to the reduction in the available natural pasture and increase in the quantity of feed purchased in the region.

Feed quality: Purchased feed accounted for the highest proportion of the livestock diets in Milli and Gourdjia in terms of Dry Matter (DM), Metabolizable Energy (ME) and Crude Protein (CP) (Fig. 8 and 9). These purchased feeds are combination of brans, crop residues and hay of Eragrostic tremula and Andropogon gayanus. Crop residues contributed next to purchased feeds in terms of DM, ME and CP of livestock diets. Although, in terms of guantity and availability during the dry season, crop residue provided the major bulk of feed resources in these sites. However, its contribution to dietary DM and ME and CP was guite low. This probably resulted from the poor guality of the crop residues due to time at harvest, poor storage methods and a generally low nutritional status of cereal straws. Seasonality in supply, low nutrient content, poor digestibility and low voluntary intake by animals are factors limiting the effective utilization of crop residues as animal feed (Tolera et al., 2000). The total contribution of crop residues to livestock diets are higher in Gourdjia than in Milli. Legume crop residues (cowpeas and groundnut) can serve as supplement to cereal stovers given their relatively high crude protein (about 10% or more) (Tolera et al., 2000). However, the quantities of legume crop residues available in these sites are very low (Fig. 8).

Nutrient composition of available feed resource during the

dry season: This result indicated different available ruminant



Fig. 8: Contribution of various feed sources to the DM, ME and CP contents of total diet in Milli, respectively, DM: Dry matter, ME: Metabolized energy and CP: Crude protein



Fig. 9: Contribution of various feed sources to the DM, ME and CP contents of total diet in Gourdjia, respectively, DM: Dry matter, ME: Metabolized energy and CP: Crude protein

Table 4: Nutrient composition (g kg⁻¹ DM), metabolizable energy (MJ kg⁻¹) and *in vitro* organic matter digestibility (g kg⁻¹ DM) of available feed resource in Gourdjia in dry season

in ury season									
Type of feed	Ash	OM	Ν	CP	NDF	ADF	ADL	ME	IVOMD
Grasses/broadleave									
<i>Andropogon gayanus</i> (hay)	90.1	909	04.3	27.0	699	466	83.1	59.0	407
Eragrostis tremula (fresh)	55.6	944	12.4	77.7	712	386	63.4	64.5	447
<i>Merremia tridentata</i> (fresh)	115	885	24.1	150	473	368	78.5	75.8	545
Commelina bengalensis (hay)	63.1	937	07.8	48.9	97.6	65.4	14.9	62.3	428
<i>Boerhavia erecta</i> (fresh)	174	826	28.9	181	421	335	78.7	101	717
<i>Digitaria ciliaris</i> (fresh)	226	774	20.3	127	456	374	63.6	114	795
Cyperus pulchellus (fresh)	285	715	16.1	101	469	319	69.8	72.0	541
Tribulus terrestris (fresh)	151	849	25.4	159	456	476	83.6	89.2	637
Sporobolus festivus (fresh)	197	804	18.3	115	585	374	64.8	80.2	579
Achyranthes argentea (fresh)	157	843	14.8	92.4	477	403	52.5	95.6	662
Mean values	15.2	84.9	1.72	10.8	48.5	35.7	6.53	8.14	57.6
Crop residues/by-products									
Millet stover	86.5	914	03.5	22.0	769	548	88.4	71.1	479
Millet bran	53.7	946	22.3	139	345	82.4	11.6	87.9	607
Wheat bran	55.0	945	27.1	169	425	144	35.9	97.1	671
Millet husk	100	899	09.8	61.5	765	438	68.2	64.7	452
Cowpea haulms	115	885	11.5	72.1	506	473	102	89.3	610
Groundnut haulms	129	870	17.4	109	391	392	78.6	85.6	599
Mean values	8.99	90.9	1.53	9.54	53.4	34.6	6.42	8.26	56.9

N; Nitrogen, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ME: Metabolizable energy, INVOMD: In vitro organic matter digestibility

feed resources in both sites. Available feed resources in both Milli and Gourdjia during the time of the study include: Browse trees (*Acacia albida*), crop residues (cereal stovers), and crop by-products (brans) and the natural pasture of different plant families: Poaceae, Commenlinaceae, Convolvulaceae and Cyperaceae (Table 3 and 4). As discussed above, most of these feeds are sourced from the well-developed fodder market in the area. Feed scarcity during the dry season and the limited access to grazing areas in West Africa's Sahel region, has made most livestock keepers

depend on purchased feeds, often at high prices and influenced by seasonal variations (Bayala et al., 2014). And as livestock population increases and the associated growth in the demand for feeds, feed markets have sprung up in many cities and towns in the region, which has played a key role in the household economy of rural farmers. Bayala et al. (2014) concluded that if people tend to remain in this sale of fodder for very long time, it can be envisaged to encourage them to establish fodder banks. This may promote the greening of the Sahelian and mitigate desertification. The nutrient analysis revealed that wheat bran ranked highest in Crude Protein (CP) amongst other feed resources in Milli, which could explain why famers to purchase more quantity as reflected in the quantity purchased above. Farmers who engage in animal fattening invest in quality feed in order to promote rapid growth and good condition required within a short time (Savadogo, 2000).

The nutritive quality of the browse plants and legume crop residues at the time of the study in terms of CP could provide 11-13% CP known to be capable of supplying adequate protein for maintenance and moderate growth ruminant goat and sheep (NRC., 1981) but a minimum requirements for lactation (120 g CP kg⁻¹ DM) and growth (113 g CP kg⁻¹ DM) in cattle (ARC., 1984). However, seasonal fluctuation in guantity supply has been associated with low rainfall and poor soil fertility in the Sahel (Fernandez-Rivera et al., 2005). The analysis of the feed value confirm previous results on the poor quality of crop cereal crop residue in the region and the need to supplement them with bran of millet, Sorghum and maize (Ayantunde et al., 2008; Abdou et al., 2011). The species of browse plants found in the study areas were among those reported by several authors cited by Bayala et al. (2014) as commonly found species fed to livestock in the Sahel. Browse species make an important contribution to the diet of cattle, goats and sheep, especially during the dry season and farmers are familiar with the species consumed by ruminant animals. Geesing and Diibo (2006) also reported similar naturally occurring herbaceous fodder species Commelina forskalaei (Commelinaceae) and Eragrostis tremula (Poaceae) are sold

at rural markets and their laboratory analysis revealed a crude protein content twice that of low quality roughages, such as millet stover.

Complementarity of farmers feed quality assessment and laboratory analysis: Farmers described 5 different physical parameters used in determining feed quality both at the point of purchase or when given to the animals. The physical parameters included: Colouration, texture, odour, age at harvest and animal behaviour (Table 5). According to farmers ranking in terms of colour green colouration in fresh pasture was ranked higher than others (Table 5).

Although, color alone is not a good indicator of forage quality but it can be an indicator of time of harvest and storage conditions (Ball et al., 2001). Matile et al. (1999) reported that as plant mature the chlorophyll is degraded, which is accompanied decolouration of the green pigment to yellow and thus reduced nutritive quality of the plant leads to a period of senescence, in which protein and carbohydrate are remobilized for transport to other organs. Farmers ranked groundnut haulms higher than cowpea in terms of texture (Table 5). They concluded that the leaves and stem of groundnut haulms are smaller and finer than the cowpea haulm and this influenced the texture and animals preference. In a laboratory result, Grings et al. (2012) reported that there is lower nitrogen intake and retention and dry matter digestibility of cowpea haulms compared to the groundnut haulms. According to farmers ranking, wheat offal was considered more palatable than other feed material judging from animal preference when served. High-quality forages are generally highly palatable (Ball et al., 2001) and are consume first by the animal when fed along with other feeds. Fuller (2004) reported that wheat bran is suitable for livestock feeding and very palatable to most classes of animals. Wheat bran is more expensive than other available feed material in the fodder market in this region (Table 2), however, farmers perception of its quality accounted for the high proportion purchased in the study areas.

From the results, it was cleared that farmers possessed indigenous knowledge concerning the nutritional quality of the feed resources they used. These indicators had been

t

Parameters	Description by the farmers
Colouration	Green colouration of cowpea and groundnut crop residues indicated good quality while a uniform brown colour of millet bran also
	indicated quality
Texture	Farmers described fluffy texture of millet bran as quality while moldy and crusty texture will indicate poor quality
Odour	According to the farmers, fresh smell odour of millet bran is considered as quality and rancid or decayed smell confirms as poor quality
Age at harvest	Farmers reported that younger plants are of higher quality than older plants
Animal behaviour	Eating rate at the beginning of the meal, high intake rate and no left over are indicators of high quality as described by the farmers

derived empirically from observing the outcomes of feeding different feed resources over the years. An observation from Nepal suggested that there is significant complementarity between farmers assessments of tree fodder feeding values and relative assessments derived from laboratory information (Thorne *et al.*, 1999). In a similar report from Uganda, indigenous criteria used were mostly based on the perceived effects of the feed resources on health, appetite and performance of the animal in question. Hence, a feed resource of good nutritional quality was said to enhance disease resistance, satisfy appetite (animals ingest much of it) and enhance good animal performance (animals gain weight with well-filled bodies and produce more milk during lactation (Lumu *et al.*, 2013).

Potential feed resources from farmers knowledge: From the

interview, farmers identified some potential feed resources and feed processing methods that they were aware of but are not being used at present in both study sites. They highlighted reasons for not using such resources and also mentioned few ways to strengthening the use of such resources (Table 6).

Constraints to livestock production and proposed solutions:

The livestock production constraints were identified in Milli and Gourdjia in order of importance and farmers suggested solutions are presented in Table 7 and 8.

Potential interventions derived from farmers proposed solutions and existing opportunities in Milli and Gourdjia:

• Financial constraint is one of the major problems mentioned by farmers in Milli relating to farming and livestock production. Proper training and empowerment on income oriented livestock production, such as sheep fattening could be a better way of improving farmer's livelihood and household income

Table 6: Potential feed and processing methods identified by farmers and ways of strengthening their use

	, , , , ,	
Potential feed resources/processing methods	Reason for not using the resource	How to strengthening the use of the feed resources
Mixture of <i>Piliostigma reticulatum</i> pods and	Few farmers reported they have heard of the feed	More technical information in feeds production,
groundriat nadims	and groundnut haulms but lack the training on how to mix the ration	
Chopped millet stover mixed with salt	Lack of information, training and the cost of procuring a forage chopper since manual chopping will be laborious and time consuming	Farmers are more keen for knowledge on livestock feed. Farmers requested for training of few selected ones and are willing to contribute to procure a forage chopper if it's available
Cotton seed cake	According to the farmers, lack of cash and consistent sources of supply hindered the use of cotton seed cake	Establishment of farmers cooperative association that will be responsible to bulk purchase of cotton seed cake for contributing members
Methods of improving existing feed resources		
Treated crop residues with urea and salt	Farmers acknowledge the potentials of treated crop residues especially the cereals. However, among other reasons for not harnessing the potentials of this method is inadequate cash. They would rather use the cash for other purpose than to buy urea. Other limitations include low quantity of residue turn out from the limited and poor land area	Organize training sessions and on-farm practical on urea treatment

Table 7: Paired wise matrix ranking major problems identified by the farmers facing livestock production in Milli and suggested solutions

Problems in order of importance	Problems identified	Proposed solution by the farmers
1	High cost of veterinary drugs	Although the veterinary service is free, farmers considered the cost of
		drug higher than their income. They suggest a subsidy in the price of the
		drug by the government or low cost drug centre in the village
2	Absence of credit and loan facilities	Farmer suggested community credit and loan facilities. They also request
		for training on the production of marketable farm produce, such as local
		egg production, all year round pepper production with irrigation
		facilities. This can serve as source of income for them
3	Shortage of feed in quantity and quality	Provision of grazing areas. Farmers noted that if the existing grazing
		reserves could be renovated and managed properly, it will encourage
		them to embark on livestock production again
4	Shortage of water in the dry season for animals	Construction of bole-holes with storage facilities in the village
5	Animal theft	Provision of good housing for the animals.

Table 8: Major identified problems facing livestock production in Gourdjia and suggested solutions by farmers

Problems in order of importance	Problems identified	Proposed solution by the farmers		
1	Poor performance of their local breeds	Introduction of improved breed for cross breeding programme that can		
		improve the genetic potential of the local breed		
2	Shortage of water in the dry season for animals	Construction of bole-holes with storage facilities in the village		
3	Shortage of feed in quantity and quality	Provision of grazing areas. Farmers noted that if the existing grazing		
		reserves could be renovated and managed properly, it will encourage		
		them to embark on livestock production again		
4	Lack of veterinary services	Government veterinary service should endeavor to visit the village		
		regularly as they do in Milli, which is just 46 km away. They suggest		
		a subsidy in the price of the drugs by the government or low cost		
		drug centre in the village		
5	Inadequate technical knowledge on fodder,	More technical knowledge in feeds production, processing and		
	feeding management and livestock production	feeding through training and tours. Training in livestock improvement		
		related topics is required		

- There is a need for regular health treatments of flocks by the veterinary services of the region, which will reduce the rate of disease outbreak. These could include preventive strategies through effective disease control and vaccination campaigns
- Better management of the existing water resources, collecting rainwater for dry periods, such as construction of small reservoirs
- Farmers reported that lack of technical knowledge was the predisposing factor for not exploiting the potential of the livestock sector. Hence, training would be instrumental to enhance knowledge base and attitude/behaviour change of the farmers and livestock extension workers

CONCLUSION

From the results of the study, the farming system in both Mill and Gourdjia is characterised by mixed crop-livestock production system and majority of the farmers are categorized as small land holders. Livestock production depends on natural pasture and crop residues, which are both harvested by the farmers or purchased. Animals were kept on grazing most of the periods of the year except during the wet season when cropping activities commenced till harvest. Since the main crops are millet, Sorghum, cowpea and groundnuts, crop residues constitute a major source of livestock feed after natural pastures especially during the dry season. Generally, livestock production in both sites are characterised by very low level of productivity that results from feed related constraints arising from low and variable forage availability and poor quality. In other to address the constraints to livestock production as described by the farmers, potential intervention could be providing technical knowledge to improve the existing feed resources and health management facilities using an on-farm experiment approach.

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