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Improving livestock productivity: Assessment of feed resources and livestock management practices in Sudan-Savanna zones of West Africa

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Evaluation of existing and potential feed resources was conducted in Orodora district in the Southern region of Burkina Faso using Feed Assessment Tool (FEAST). The assessment was carried out through focus group discussions and individual interviews in Mahon and Sayaga communities in Orodara district. The study sites were characterized by mixed crop-livestock production systems. Seventy-percent of cropping activities were focused on fruit tree cultivation while food crop production accounted for the rest. Livestock species (predominantly local breeds) in the area included cattle sheep, goat, pig, poultry and donkey which are kept for different purposes. The main source of household income is crop production while livestock production contributed 35 and 45% to the household income in Mahon and Sayaga, respectively. In both study sites, natural grazing contributes highest (49 and 64% respectively) to the dry matter (DM) content of the total diet. Cultivated fodder contributed 1% of dry matter (DM), metabolizable energy and crude protein to the total diet of the existing feed resource in Mahon, while farmers in Sayaga depended more on purchased feed than in Mahon. Constraints to livestock production in the study sites included shortage of water in the dry season, insufficient quantity and quality of feed in the late dry season of the year and high cost of veterinary drugs and services. To mitigate these constraints farmers suggested an integrated approach to improve livestock production through: construction of small reservoir to provide water for human and animal consumption; training on the integration of forage legume into both tree and arable cropping, and efficient utilization of available feed resources; establishment of a veterinary service and drug centre in the village; better management of the existing water resources.

Key words: Animal nutrition, livestock productivity, feed resources, feed scarcity.

INTRODUCTION

Livestock sector is the second most important source of income in Burkina Faso, and its contribution to the country's gross domestic product (GDP) was estimated at 15% (Nianogo and Thomas, 2004) and varies between 18.3 and 19.5% over the period 2001 to 2008 (MRA, 2011). Nineteen percent of Burkina Faso's export

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products are from livestock production (MRA, 2004). The population of ruminant livestock species of Burkina Faso is estimated to be 8.7, 11.4 and 7.3 million heads of cattle, goats and sheep, respectively (FAO, 2005) and the annual growth rate was reported to be 4.7, 3.3 and 2.3% for goats, sheep and cattle, respectively (MRA, 2004). Most of these animals are found in the arid and semi-arid part of the country. However, the livestock numbers are growing faster in the sub-humid zone (LEAD, 2005), as a result of the recent pattern of transhumance in West Africa in which pastoralists and their livestock transited from the more arid Sahelian region in the north to the more humid Sudano-Guinean regions in the south (Ayantunde et al., 2014). The extensive production system using low inputs is common in the country (MRA, 2004), while the "mixed system" in which crop and livestock production are jointly practiced is the most dominant in the sub-humid zone (Seré and Steinfeld, 1996).

Nutrition of cattle, sheep and goats in the agro- pastoral systems of the Sahelian and Sudanian-Savanna zones of West Africa is essentially based on the exploitation of naturally occurring herbaceous and ligneous plant species, and crop residues. Qualitative and quantitative forage shortage, particularly in the dry season, is the major constraint in these farming systems (Breman and de Ridder, 1991). During periods of feed shortage (the dry season), livestock owners often use agricultural by-products such as cereal (maize, millet, sorghum, wheat) bran, cotton seed cake in the cotton producing zone, cowpea hay and groundnut haulm to supplement animal feed. Herders and others pastoral groups sometimes cut down branches from various tree species such as Acacia spp., *Balanites aegyptiaca, Pterocarpus lucens* and *Boscia angustifolia* to feed their animals during the dry season (Gautier et al., 2005).

Pastures in Burkina Faso are subject to seasonal variability. Generally, there is good availability of forages in terms of quantity as well as quality in the rainy season which lasts for about 6 months (May to October) in the sub-humid zone. This is followed by another 6 months of dry season (November to April) when there is a rapid decline in forage resources in both quantity and quantity. This has been considered as the major limitation to meeting the nutrient requirements of grazing livestock for most of the year (Kavana et al., 2007). With this constraint, animals that rely on natural pastures as basal diet cannot perform at high level without feed supplementation which may be expensive for low income farmers (Mohammed-Saleem, 1990).

Overcoming the constraint of feed scarcity requires a well-targeted assessment of available feed resources as to inform and guide interventions to address the problem. In this regard, a systematic and rapid methodology for assessing feed resources at site level with a view to developing a site-specific strategy for improving feed supply and utilization through technical and organizational interventions has been developed by International Livestock Research Institute (Duncan et al., 2012). The objective of this study was to evaluate existing and potential feed resources in the study sites to guide feed-related interventions to improve livestock productivity in the dryland areas of Burkina Faso.

MATERIALS AND METHODS

Description of study site

This study was conducted in Mahon and Sayaga communities in Orodara district in the southern part of Burkina Faso within latitude 11.3167°N and longitude 4.5667°W (Plate 1). Orodara district is in the South Sudan agro ecological zone of Burkina Faso with one rainy season per year and annual total rainfall ranging from about 900 to 1200 mm. The main textural classes are loamy sand, sandy loam, loam, sandy clay loam, clay and silty clay loam. These characteristics impose some limitations on crop production including restriction of plant rooting systems, high runoff, and low retention of water and nutrients (FAO, 2001). Mixed crop-livestock system is the dominant agricultural production system in the study site. The dominant crops grown in the study site include cotton, yams and cereals (sorghum, millet and maize). In addition, fruit trees such as mango, citrus and cashew are widely cultivated in the study area. Livestock are owned and managed under traditional production systems which are characterized by low productivity in terms of milk and meat (Figure 1).

Methodologies and implementation of the survey

Evaluation of existing and potential feed resources was conducted using Feed Assessment Tool (FEAST) developed by International Livestock Research Institute (ILRI) (Duncan et al., 2012). FEAST is a systematic method used to assess local feed resource availability and use. It helps in the design of intervention strategies aiming to optimize feed utilization and animal production. It comprises Participatory Rural Appraisal (PRA) using semi-structured questionnaire in a focus group discussion and individual interviews to collect both qualitative and quantitative data. The study was conducted from April to May 2014.

Twenty-six farmers which comprised 18 men and 8 women in Mahon and 20 farmers (15 men and 5 women) in Sayaga were selected as representatives of the community to participate in group discussions using the participatory rural appraisal (PRA) approach to provide an overview of the farming systems and to identify constraints and opportunities for improving livestock production in the 2 study communities. For the individual interview, twelve farmers were then selected representing 3 wealth categories within the community namely average, above average and below average in terms of land area owned and number of livestock possessed by the household. Four farmers from each wealth category were individually interviewed to collect quantitative and qualitative data on feed resources in the community. Through the use of a structured questionnaire, farmers were asked to identify and describe their perception of quality of the available feed resources and then rank them according to their indicators for feed quality. Samples of available feed resources offered to the animals were collected and analyzed for nitrogen, ash content, fibre components (NDF, ADF and ADL) and *in vitro* organic matter digestibility.

Data analysis

The quantitative data collected from individual key informant

Figure 1. Map of Burkina Faso showing the study site.

farmers were entered into the FEAST Excel template (www.ilri.org/feast) and analyzed. FEAST qualitative data collected were examined and summarized for each major topic and linked with FEAST individual interview output. Results are presented in tables and figures in the results and discussion of this work.

RESULTS AND DISCUSSION

Overview of the farming system

From the results of the survey, farming systems in both Mahon and Sayaga can be described as mixed crop-livestock production with fruit trees dominating the cropping systems. The major crops grown in both areas were maize, millet, sorghum, groundnut and cowpea which were mainly grown during the raining season. Other crops such as cabbage, carrots and other vegetables are planted in the dry season both for consumption and income. Farmers in both Mahon and Sayaga described two distinct cropping seasons based on the rainfall patterns and the time of crop harvest. The long rainfall season locally called 'Gnigboke' extends from May to October, while the dry season 'Gnigbeke' is from November to April.

Crop production in the study sites was dominated by fruit tree crop. Farmers confirmed that 70% of their cropping activities were focused on fruit tree cultivation (arboriculture) while food crop production accounted for the rest. The fruit tree crops were mango (which is 60% of the production), orange and cashew. Both fruit trees and arable crop production were rain-fed. According to Badini et al. (1997), 75% of the crop production in Burkina Faso which is the main source of food and income for the majority of people is rainfed. Maize was the dominant arable crop in both Mahon and Sayaga followed by sorghum (Figures 2 and 3). However, rice was considered as one of the arable crops in Mahon due to the presence of lowland areas which could support rice cultivation.

Availability of irrigation facility is a great constraint to crop production in the study sites due to the absence of perennial rivers. The only dam available is about 4 km to Mahon making it difficult to practice irrigation and this limits the productive ability of farmers in the dry season

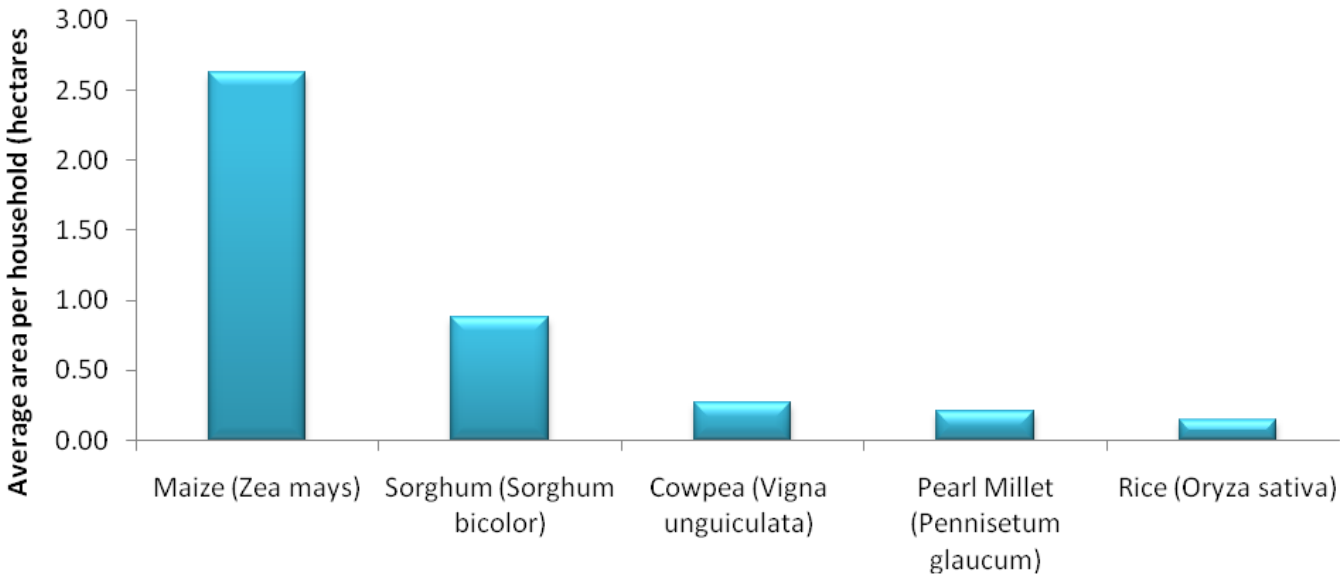

Figure 2. Average area (ha) cultivated per household of dominant arable crops in Mahon.

and animals often trekked long distance in search of water. Farming at this time of the year (dry season) in Mahon is also limited to vegetables, carrots, cabbage and tomatoes which are planted on small areas in lowland where the soil water is still available in sufficient amount to grow such crops. However, farmers reported that due to erratic rainfall pattern, there is reduction in the level of the water tables in the lowlands in the last 2 years as a result of low rainfall. There are no low land areas in Sayaga, therefore cropping activities were limited to the raining season.

Both household and hired labours for agricultural activities are available all year round in Mahon and Sayaga. Household members serve as labour force for certain farm activity such as fertilizer application. However, since most household members have their own farms to cultivate and may not always be available and adequate to undertake farm activities such as weeding and harvest, hired labours are therefore required at such times. In Mahon, there is an organized labour group where farmers can go and hire for the cropping activities. The cost of hiring group labour ranged from 10,000 to 25,000 CFA per day (21 to 53 USD as at the time of the study) which sometimes consisted of 15 to 20 men per group. A male farm labourer is hired for an average of 1500 CFA per day (3 USD) while female labourer could be less than 1000 CFA per day (2 USD) depending on the nature of work. Women are mostly needed during harvest and post-harvest operations. However in Sayaga, labour cost does not depend on the nature of farm activities.

Access to credit was described by the farmers as another constraint to agricultural production in the study areas. Although there is a local credit bank for farmers owned by the government (Caisse populaire), access to credit is quite difficult. Kuwornu et al. (2012) reported similar situation from a study conducted in Ghana. The main bottleneck as noted by the farmers in the study areas was the long process of applying for and receiving the credit. Farmers reported that it could take about 8 months before it is released. Sometimes, the loan is released after farming activities had ended for the cropping season. Apart from the problem of timing, farmers do not have the required collateral needed as guarantee to access credit. Another issue with access to credit according to the farmers interviewed was that available credit is mostly given for crop production for the purchase of farm inputs like fertilizer and improved seeds, and to pay hired labour which implies that it is difficult to access credit for livestock production. According to the respondents, there is no credit facility available for the farmers in Sayaga for both crop and animal production, although famers in the area were willing to organize their own cooperative if they could be trained on how to establish and run it.

Inputs such as fertilizers, improved seeds and tractor services are not readily available according to the respondents. Farmers also reported that some input such as fertilizer and seed are sometimes of low quality. At present, farmers in Mahon set up a community seed store where each farmer contributes his own grain seed which they later share during planting. Farmers in Sayaga reported that most agricultural inputs are not available in local markets, fertilizer prices were reported to be too high while other inputs are in short supply compared to Mahon. This could be attributed to the far distance of Sayaga to the major town in the region.

According to the farmers interviewed, an average of 8%

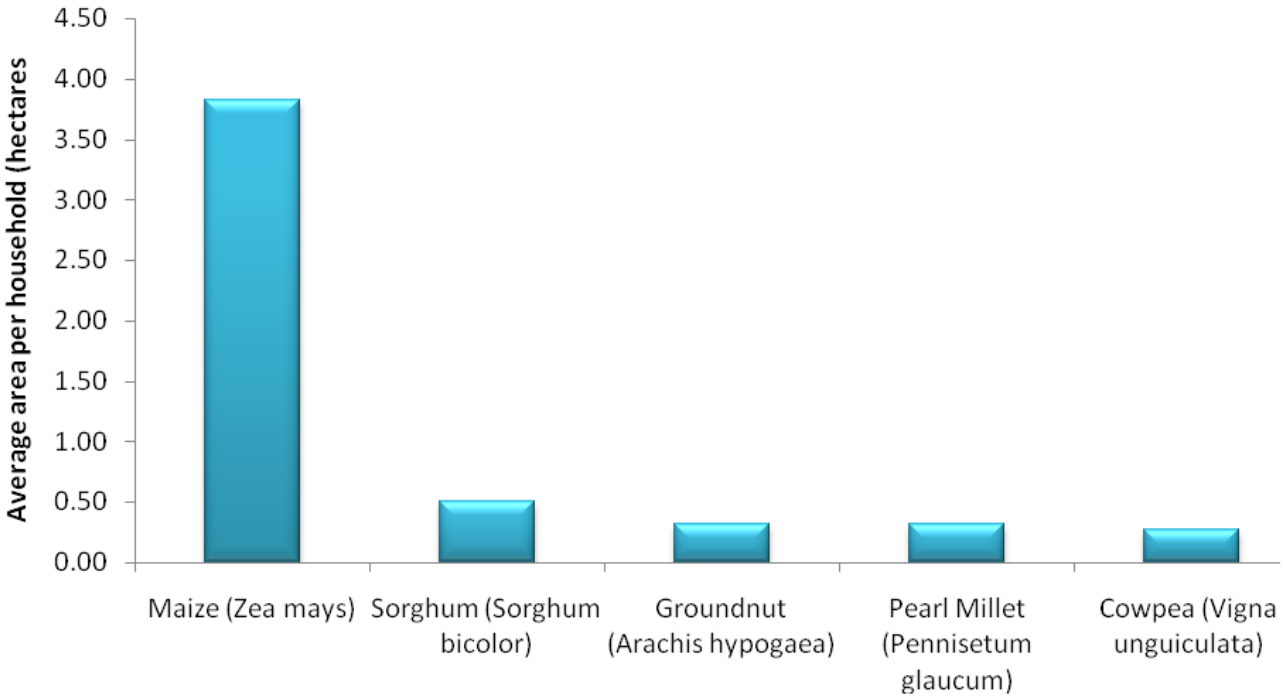

Figure 3. Average area (ha) cultivated per household of dominant arable crops in Sayaga.

of the people in every household migrated from Mahon to the cities and towns in search of better paid jobs. These groups of people are mostly youth and middle aged population. Few of them return to the village during the festive periods or at the end of each year. Migration out of Sayaga is quite high as about 25% of people from each household had moved out to cities and towns in search of better livelihood opportunities. Higher migration in Sayaga could be attributed to its remoteness. Deshingka (2010) reported higher incidence of migration among chronically poor people living in remote villages.

Household characteristics, land holding and land use pattern

Maholn is made up of approximately 180 households with an average of 20 to 25 people in each household. The average land holding in the study sites was between 5 to 10 ha for different wealth categories (Figure 3). The results indicated that the majority of the farming households are smallholders with land sizes less than 5 ha. Few households classified as medium and large farmers had few household size.

The farmers remarked that in the past, farm lands were jointly owned and cultivated by every member of the family; some 20 years ago, the lands were divided within the family to every member. As a result of land fragmentation, arable land is in short supply as the family size continues to increase and there is no more fallow practice in the communities. This fragmentation of limited farmland leads to shorter fallow periods and in some cases continuous cultivation (Bezuayehu et al., 2002). Continuous cropping significantly of the same land affects soil physical and chemical properties by increasing soil bulk density and reducing both macroporosity and macro-aggregates, resulting in less water and nutrient availability (Qin et al., 2007). Consequently, crop yields become unstable and tend to decline, especially in low rainfall years (Sainju et al., 2009). The 2% landless farmers in Mahon were the Fulani (pastoralist) migrants whose major livelihood strategy is animal production and do not have right to own land in the community.

Sayaga consist of about 110 household with the average family size of 16 people per household. The farm land varied among the households but average farm size was about 5 ha. Majority of the households fell into the category of smallholder farmers with 1 to 5 ha of land (Figure 4), followed by the medium land holding and large land holding farmers. Namubiru-Mwaura and Place (2013) reported average size of 3 ha and above as land owned by smallholder farmers in West Africa countries namely Burkina Faso, Mali and Niger. There was no landless farmer in Sayaga (Figure 5).

Major sources of household income

As presented in Figure 6, the main sources of household income were crop farming, livestock production and other

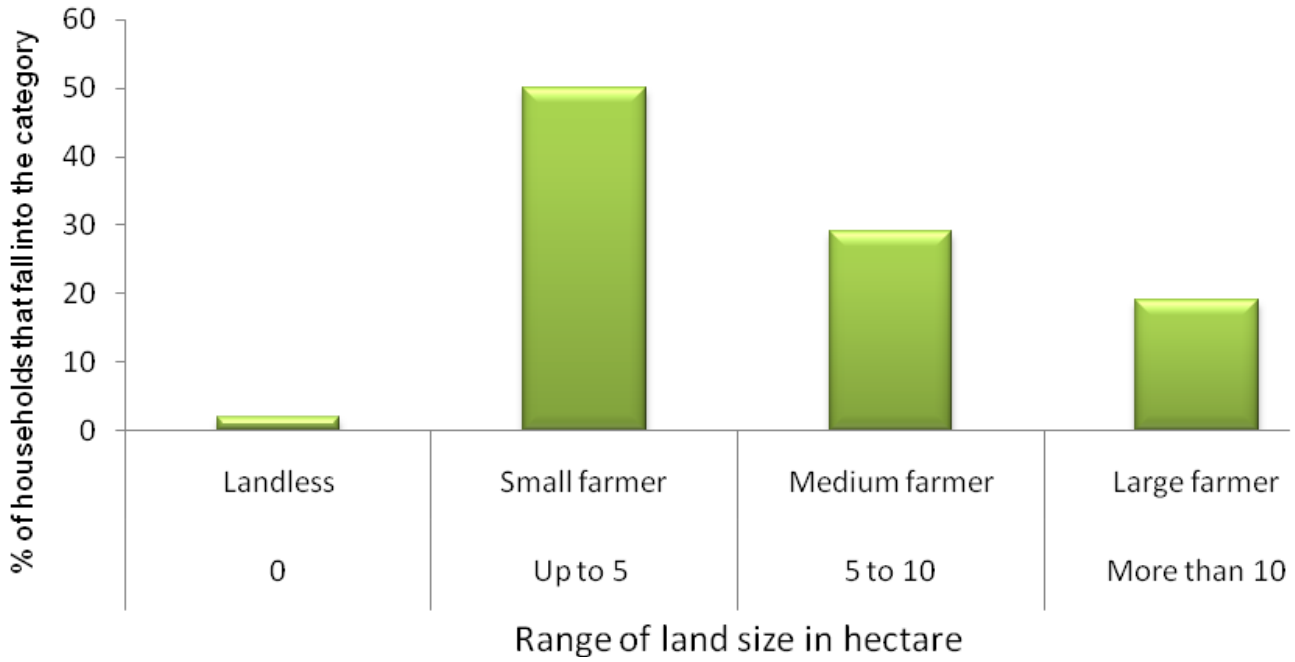

Figure 4. Distribution of land area cultivated for households in different wealth categories in Mahon.

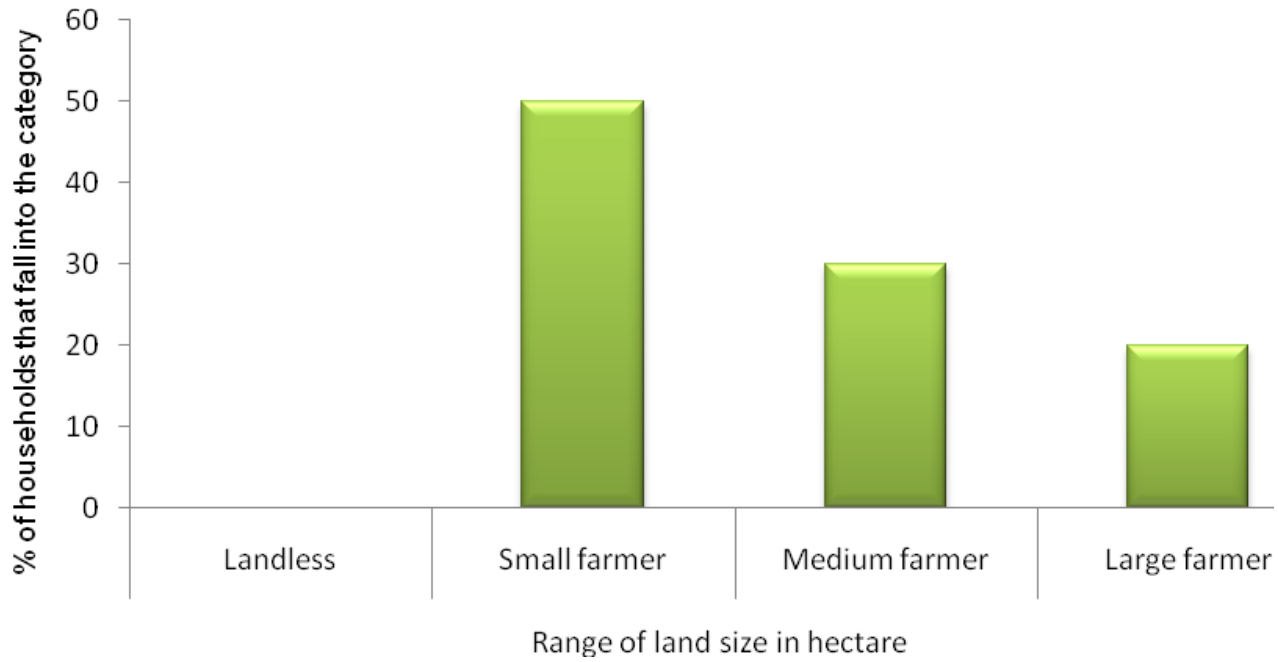

Figure 5. Distribution of land area cultivated for households in different wealth categories in Sayaga.

occasional businesses. Basically, income generated from crop production comes mainly from fruit trees and arable crops. Livestock production also contributed 35 and 45% to the household income in Mahon and Sayaga, respectively. This comes from sales of milk and live animals in general. This confirmed the report of Mabel et al. (2010) that livestock contributes a large proportion of the income of smallholder farmers in sub-Saharan Africa. The farmers' responses showed that non-farm businesses were also important sources of income in

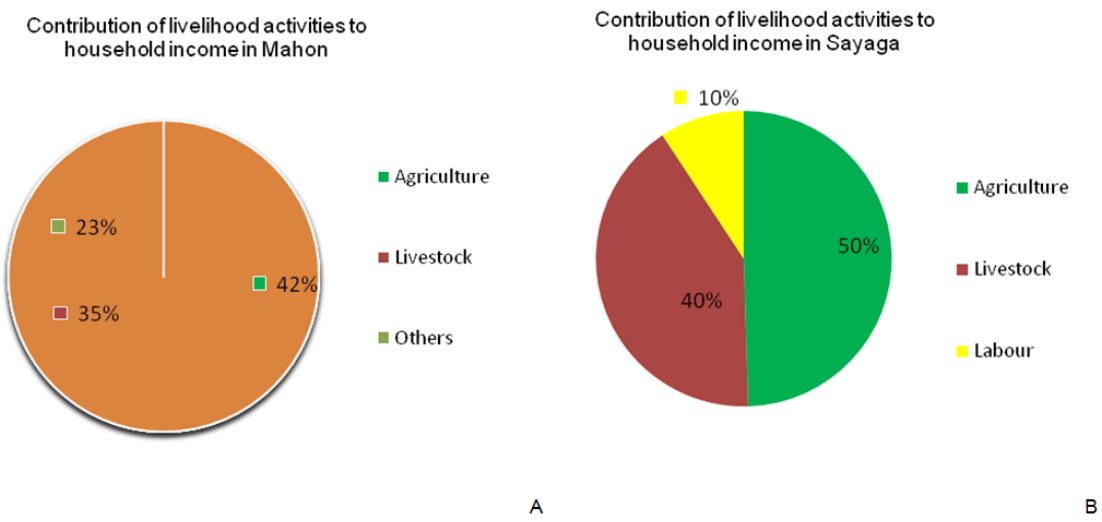

Figure 6. Contribution of livelihood activities to household income in Mahon and Sayaga.

Mahon and Sayaga. The result showed that crop and livestock production contribute more to household income in Sayaga than Mahon. On the other, household income derived from other sources such as off-farm businesses was higher in Mahon (23%) than (10%) in Sayaga. The distance and poor access road to nearby town may be responsible for this. Mahon is located 25 km from Orodara a semi-urban town with commercial activities which may influence the ease of engaging in off-farm businesses for farmers in Mahon.

In general, the direct agricultural income of the poor is not enough to sustain their livelihoods, either because of landlessness or because the land they own or lease is insufficient. Furthermore, wage employment in agriculture is highly seasonal, therefore the poor farmer value non-farm sources as means of earning additional income (IFAD, 2002).

Livestock assets and roles

Livestock form an integral part of agriculture and almost every farming household keep ruminants and/or indigenous chicken and different livestock species were kept for various purposes. Livestock species in the area included cattle, sheep, goat, pig, poultry and donkey. There were no improved breed of cattle or other animals in both Sayaga and Mahon. The results of this study indicated that cattle are the dominant livestock species in the areas (Figures 7 and 8). Farmers reported that approximately 70 and 65% of the households keep local cattle breeds and draught cattle with an average number of six and four per household in Mahon and Sayaga, respectively. Generally, cattle are kept for the purpose of draft power, manure, milk and cash income. According to farmers, draft cattle are the most important animals because of their use for cultivating cropland, crop threshing and straw transportation. Peeling and Holden (2004) had stated that cattle in the communal areas have multiple uses that include acting as a source of draught power, transport, milk, manure and savings among others. About 90% of the households owned sheep with the average number of eleven per household. They are mostly used as source of cash and meat. From the survey, every household in Mahon reared at least 10 local chickens. These chickens are sold as need arises, and are also slaughtered for consumption during festivals or ceremonies but occasionally for food. Although the number of donkey per household is very few, about 80% of the households in Mahon have at least one donkey. The primary purpose is for transportation of goods, crop harvests, people and fetching of water.

Livestock housing and management systems

In the study sites, different housing and feeding management practices were used for different livestock species and different classes of animals. Cattle and donkeys were housed in the shed made of wooden poles and thatched roof. Due to their vulnerability to diseases, sheep and goats are provided better housing near the homestead during the raining season to protect them from diseases. During the rainy season, lactating cows are also housed in the shed and they are often released for grazing. No housing system is practiced for pigs and poultry. The primary feeding practice in the study areas was open grazing. Herding was done when the number of animals is about ten and above. When the number of animal is few, in particular one or two, they are

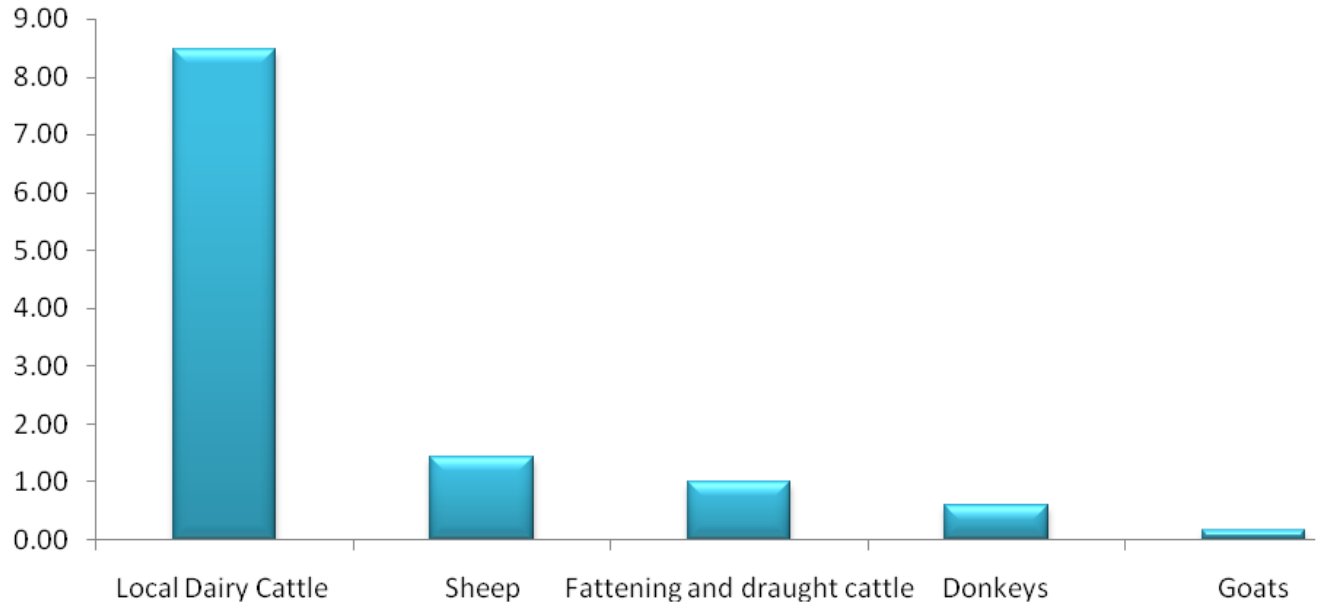

Figure 7. Average livestock holdings per household of dominant species (Tropical Livestock Unit) in Mahon.

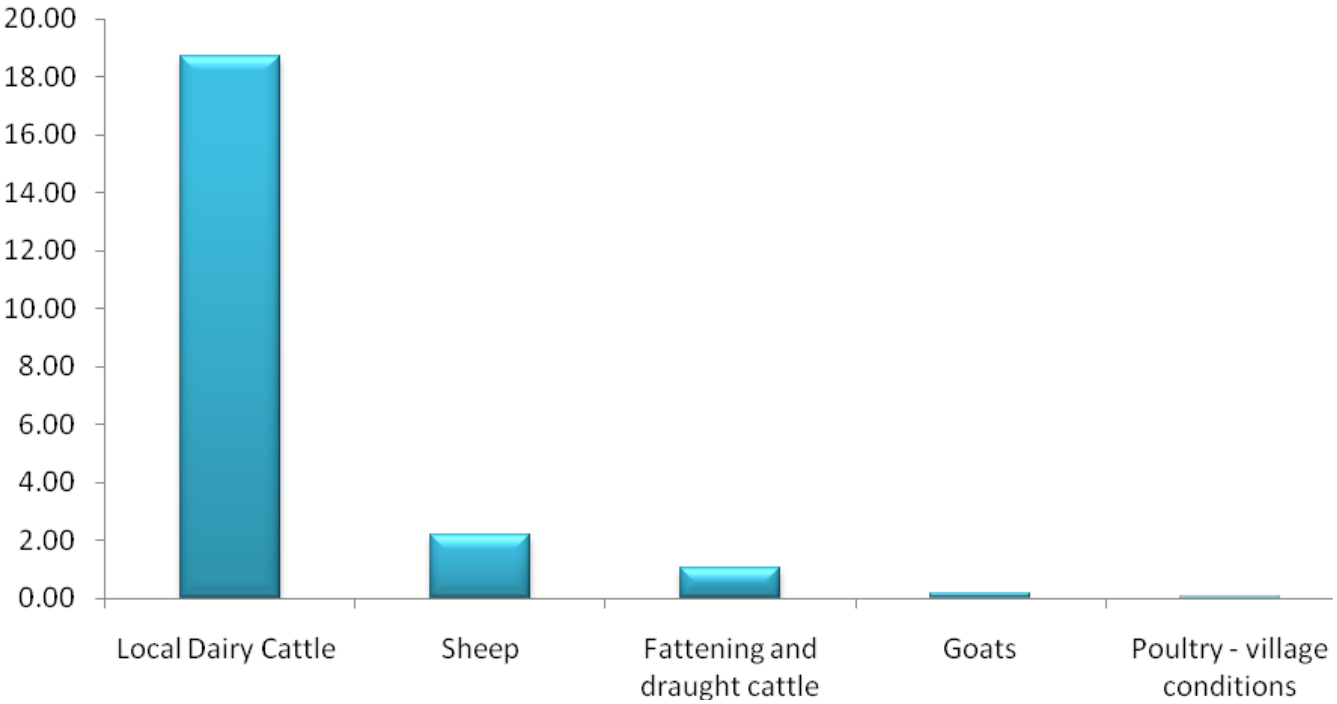

Figure 8. Average livestock holdings per household of dominant species (Tropical Livestock Unit) in Sayaga.

usually tethered.

Generally, farmers tethered their animals and feed them with crop residues. Occasionally, feed concentrate is offered during the dry season when there are limited feed resources. During the raining season, which is also the cropping time, open grazing is almost restricted to keep the animal from damaging crops. However, animals are allowed to graze near the homestead. According to the farmers, residues from cereals (maize, sorghum and millet) are chopped before being offered as feed, and

sometimes salt is sprinkled to add taste to some dry residues. One particular farmer in Mahon had practiced urea treatment and noticed a remarkable improvement in his animal performance over time. However, he discontinued for the fear of urea toxicity as a result of inappropriate dosage and financial constraint. Urea treatment of crop residues was not practiced in Sayaga due to cost. The farmers were aware of the potentials of such treatment to increase feed intake and animal performance, yet the costs of procuring it discouraged its use.

Results from another study in Zimbabwe revealed that labour availability, training, access to urea fertilizer and markets, and extension services are the main factors affecting adoption of urea treatment of maize stover technology (Mudzengi et al., 2014). Fodder production was not common in the study areas. Poor access to seeds, the problem of land rights and scarcity of land had been identified as major obstacles to adoption of fodder production in Burkina Faso (Kagone, 2006). However, one of the respondents in Mahon reported planting about 0.06 has of *Mucuna pruiens* over a period of 2 years and occasionally planted fodder maize but could no longer continue because of shortage of land and inability to harvest and conserve the seed of Mucuna.

Veterinary and artificial insemination (AI) services

Veterinary services were available to the farmers in both villages but not easily accessible. The veterinary clinic is located at about 8 km from Mahon and 15 km from Sayaga. The distance and the cost of transportation which is about 1500 FCFA (3 USD) make the service difficult to access. Farmers reported that about 2000 FCFA (4 USD) used to be spent to bring the veterinarian to Mahon for general treatments. In Sayaga, veterinary officers seldom visit the village but the farmers often invited them when it becomes inevitable which costs about 5000 FCFA (10 USD) due to long distance. Farmers described different symptoms of diseased condition in cattle such as fever, weakness and loss of appetite. Others are lameness and mange which cost 400 FCFA (0.8 USD) per cow to treat. The farmers also reported a disease condition in their cattle, whereby the animals are eating stones, sticks or plastic bags. Based on the symptoms described by farmer, this condition may probably be allotrophagia, although no clinical diagnosis was carried out. Allotrophagia had been reported as a diet-related disease of depraved or perverted appetite, whereby the animals start eating objects that they normally do not eat (Anderson, 1994; Akgul et al., 2000). This condition is probably due to mineral deficiency in the available feeds resources, natural pasture and crop residues, in the study sites. AI services were not available in the study sites. The practice is not common in the area according to the respondents. Uncontrolled mating with existing local bulls was the common practice in both study communities. In Sayaga, 20% of the farmers recalled being aware of AI but have never seen it practiced. However, they are willing to adopt AI if they can be trained and have access to it.

Major livestock feed resources and seasonal availability

The major feed resources were natural pasture and crop residues (Figures 9 and 10). Naturally occurring green fodder materials such as weeds from cropping areas, roadsides and grasses also served as sources of feeds particularly at the onset of rains. However, its availability was generally low in November to April to June which are the period of dry season. Crop residues become available in October after the crop harvest while availability of green forage declines. This may contribute to the increase in the quantity of commercially formulated ration purchased by the farmers as the dry season prolongs. Since the majority of the cultivated land area is allocated to cereal crops production, crop residues become the major feed resources during the dry season. In Sayaga, cereal crop residues (maize and sorghum stovers) and legumes (groundnut and cowpea haulms) formed parts of available feed resources (Figure 10). The collected residues are stacked in piles near homesteads and animals were given small quantities in the morning and evening.

The result showed that the quantity of collected crop residues used as livestock feed was higher in Sayaga than in Mahon. According to farmers, greater percentages of the crop residues were left on the field. These are also grazed along with naturally occurring forages which made grazing a major feeding method in both study sites. The result also showed that farmers in Mahon use commercially formulated ration as feed resource throughout the year while in Sayaga, farmers fed commercially formulated ration during the dry season till the onset of rains (Figures 9 and 10).

Purchased feed

The type, quantity and prices of purchased feed resources at the time of the study as described by the farmers were presented in Table 1. All the farmers interviewed in Mahon purchased supplementary feeds in the last 12 month to the time of the study. The available purchased feeds as reported by the farmers were maize bran, cotton seed cake, cowpea hay, *Parkia biglobosa* (pulp) leaves and commercially mixed ration (Table 1). *P. biglobosa* is one of the dominant tree species in study sites. The seed is used in making a local condiment. Ninety percent of the respondents purchased significant amounts of *P. biglobosa* pulp which was one of the

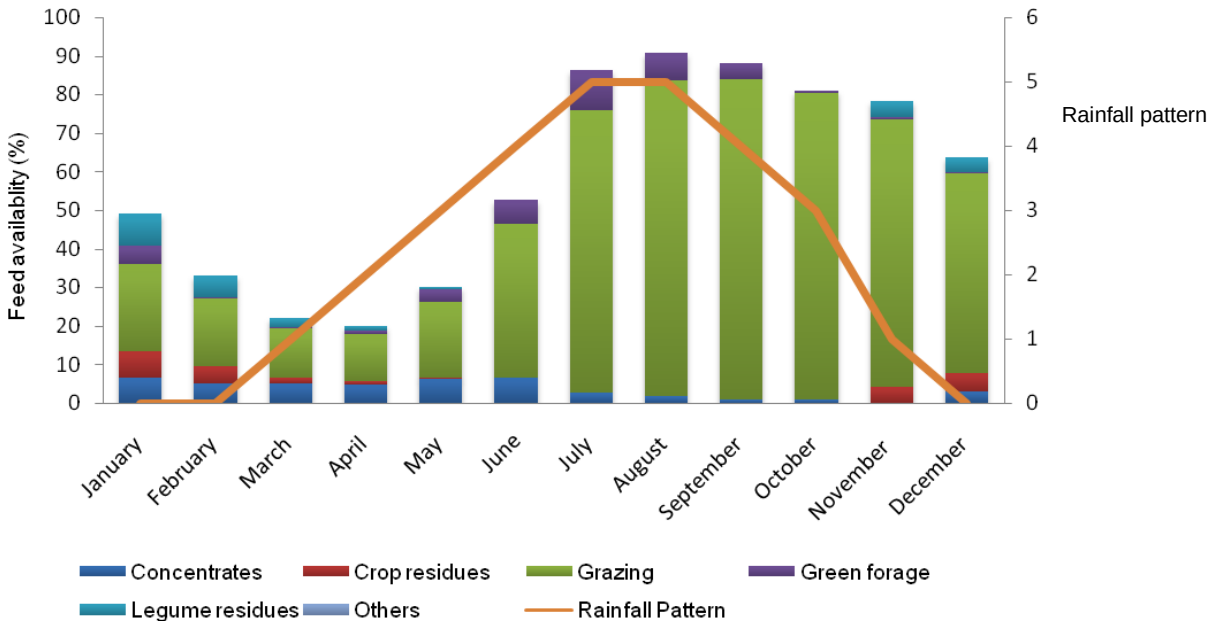

Figure 9. Available feed resources in Mahon. Rainfall pattern is on a scale of 0 to 5, where 5 = heavy rainfall and 0 = no rainfall.

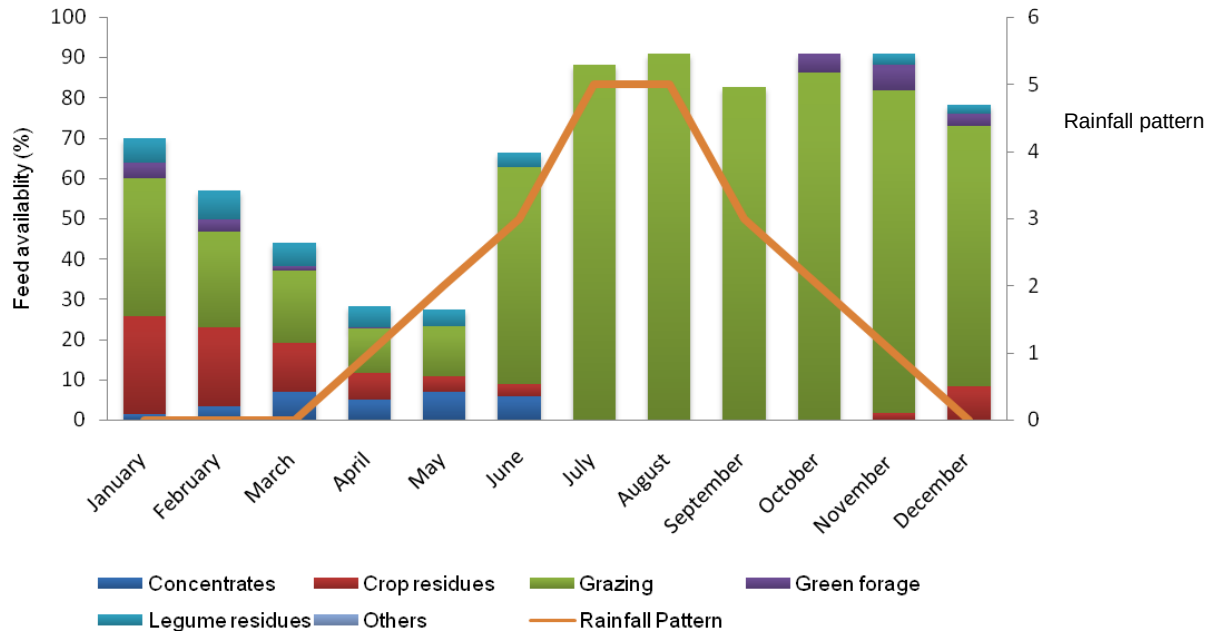

Figure 10. Available feed resources in Sayaga. Rainfall pattern is on a scale of 0-5, where 5 = heavy rainfall and 0.

wastes from its processing for making the local condiment. The pulp was mixed with chopped straw and feed to animals. This feed resource was the cheapest as at the time of the study and this may influence its choice and the quantity purchased. From the results, a total of 500 kg of *P. biglobosa* pulp was recorded as purchased by four of the respondents in Mahon at different intervals between May, 2013 and April, 2014. Maize bran and *P. biglobosa* (pulp) were commonly purchased in both sites, however, the quantity of each purchased feed was

Table 1. Quantity, prices and frequency of purchased feed in Mahon and Sayaga over the past 12 months.

Purchased feed	Number of farmers	Prices* (FCFA/kg)	Quantity purchased (kg)	Number of farmers	Prices* (FCFA/kg)	Quantity purchased (kg)
	Mahon			Sayaga		
Commercially mixed ration	6	220.00	375	4	200.00	1250
Cotton (*Gossypium* sp.) - seed cake	1	500.00	25	-	-	-
Cowpea – hay	1	100.00	25	-	-	-
Maize - bran	4	120.00	225	3	120.00	750
Parkia biglobosa (pulp)	4	50.00	500	6	50.00	2625

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

higher in Sayaga than in Mahon.

Farmers in Sayaga depend more on livestock production than in Mahon as shown in the income generation from livestock. This might have influenced their decision for more purchased feed especially during feed shortage. There were slight variations in the prices of commercially mixed ration and *P. biglobosa* pulp in both study sites. Out of all the respondents in Mahon, 10% purchased cotton seed cake once in the last 12 months and no farmer in Sayaga purchased cotton seed cake which costs 500 FCFA per kilogram as at the time of the study. The low quantity and frequency of purchased feeds in both sites could be attributed to poor accessibility and the management practices in both Mahon and Sayaga. This suggests the need to improve the utilization of the available feed resources and to identify other potential feed resources and strengthening their use.

Feed quality

Grazing, including the natural pasture and crop residues left on the field, contributed the largest proportion to livestock diets in terms of DM, metabolizable energy (ME) and crude protein (CP) in the study sites followed by the naturally occurring green fodders which were collected for livestock feeding (Figures 11 and 12). While the percentage contribution of purchased feed to the DM, ME and CP in Mahon is less than 10%, purchased feed contributed 4, 18 and 8% of DM, ME and CP, respectively to the livestock total diet in Sayaga. This implies that farmers in Sayaga depend more on purchased feed than in Mahon. Trends in the contribution of collected crop residues to livestock feed were similar in both study sites. The percentage contribution of collected crop residues to the diets on the basis of DM, ME and CP was less than 3% in both study sites. It was noted that this percentage (3%) only accounted for the few collected quantity of crop residues. Farmers usually leave large percentage of crop residues on the farm for animal to graze which might have been mixed up or considered as grazing during the interview.

Generally, crop residues in both areas are mainly composed of cereals as the dominant crops. The feeding value of cereal stovers are very low while haulms of leguminous crop are very high owing to higher protein content (Carangal and Calub, 1987) but the quantities generated in these areas are generally low. This is owing to the fact that legumes are not commonly cultivated in the area. The quality of the collected crop residues become very low especially during the dry periods due to poor storage practices as residues are stockpiled on rafters outside where they are subjected to unfavorable weather and consequently, the quality diminishes as the residues lignify. Delayed harvesting can also lead to greater loss of leaves and leaf sheaths, the most digestible parts of cereal straws with a consequent reduction in nutritive value (Williams et al., 1997). Cultivated fodder, although not commonly practiced in Mahon, contributed about 1% of DM, ME and CP to the total diet of the existing feed resource. Although its contribution may be limited, it thus implies that cultivated pasture especially forage legume could improve the quality of livestock feed resources if integrated into arable cropping.

Farmers' knowledge of potential feed resources

In both study sites, farmers identified some potential feed resources and feed processing methods that they were aware of but are not currently practiced. They also mentioned few ways to strengthening the use of such resources (Table 2).

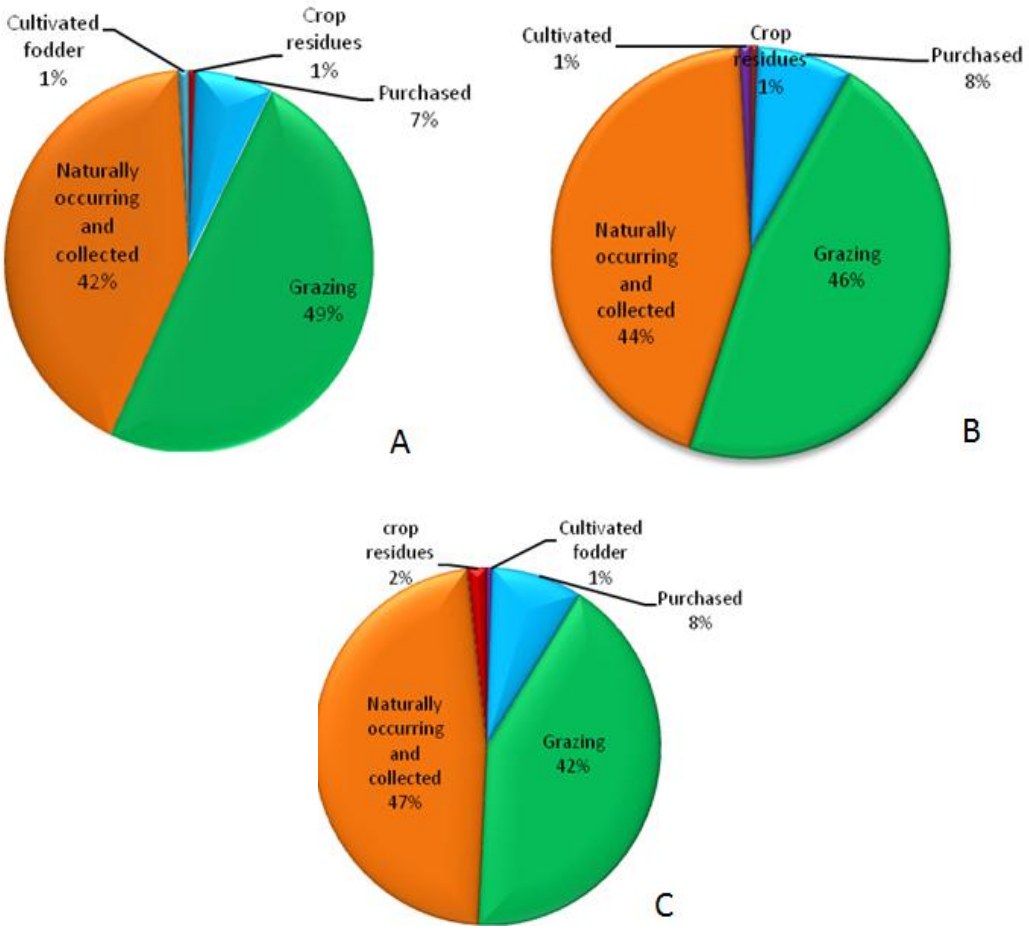

Figure 11. Contribution of various feed sources to the DM, ME and CP contents of total diet in Mahon respectively.

Composition of available feed resource during the dry season

In the dry season, available feed resources in both study sites ranged from herbaceous grasses (*Andropogon gayanus*) to browse trees, crop residues and crop by-products (maize bran, *P. biglobosa* pulp) (Tables 3 and 4). The species of browse trees found in the study areas were among the Sahelian and Sudanian browse species reported by Bognounou et al. (2008) and Sawadogo et al. (2010) as livestock feed. Schmidt et al. (2010) reported that the highest diversity of browse species was found in the Sudanian zone, where the vegetation consists of dry and sub-humid tree savannas and forests.

The study results indicated that a considerable number of browse species contributes to the ruminants' nutrition in the sub-Sahelian agro-ecological zone of Burkina Faso, particularly during the cool and hot dry season, which correspond to their fructification period (Heuzé and Tran, 2011). The mean value of crude protein (CP) concentration of the browse species available during the dry season in Mahon and Sayaga of 12.3 and 12.6% respectively doubled that of the crop residues and by-products of 6.12 and 4.12%, respectively. As discussed earlier, poor storage methods and leaving crop residues on the field, particularly for cereals reduced their feed values (Hiernaux et al., 2009). From the study results, the nutritional quality of legume residues and by-products need to be exploited as supplements particularly for lactating animals and animal fattening (Savadogo et al., 2000) by encouraging more intercropping with cereals. The use of browse as a source of protein could help livestock to cope with aggravated nutritional stress (Craine et al., 2010).

As the pastoralists and their livestock transited from the more arid Sahelian region in the north to the more humid Sudano-Guinean regions of the West Africa (Ayantunde et al., 2014), there is an anticipated increased pressure on forage resources in the region. In view of this, propagation and yield studies as well as fodder bank establishment and management should also be envisaged with other preferred browse species of high nutritional value that are drought tolerant and adapted to this regional. Species such as *Pterocarpus* which are

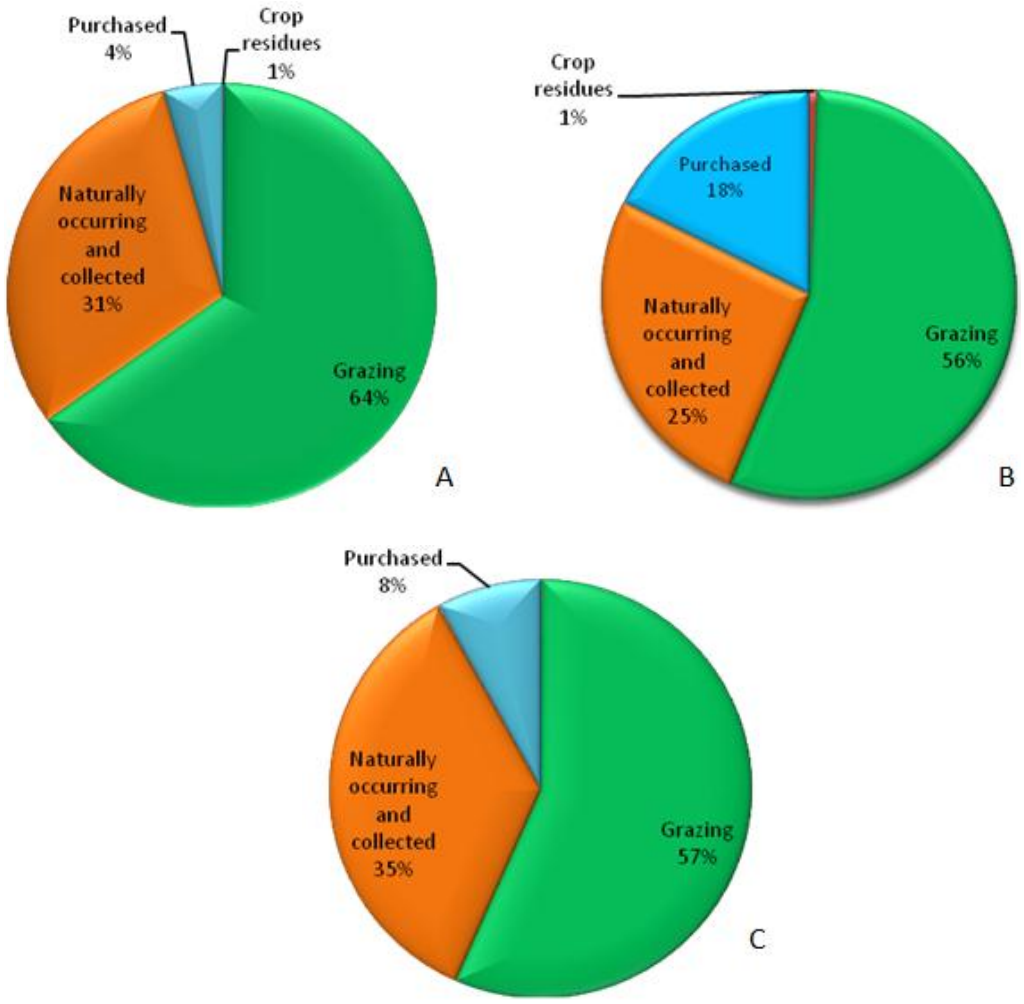

Figure 12. Contribution of various feed sources to the DM, ME and CP contents of total diet in Mahon respectively.

most frequently used by cattle, can be cultivated to yield a high amount of leaf biomass in Burkina Faso; they should therefore be introduced in local agroforestry systems to reduce dry season fodder scarcity (Ouédraogo-Koné, 2008).

Farmers' feed quality assessment indicators

In both Mahon and Sayaga, all the farmers interviewed confirmed the use of physical indicators to determine feed quality given to the animals (Table 5). All the farmers considered sick animals and pregnant female in that order as the priority animals that should be given quality feeds before other animals. Farmers reported that quality feeds are needed by sick animals for early recovery and for foetal development in pregnant females. Colouration, texture, odour, leaf to stem ratio, moistness, age at harvest and animal behaviour were listed as farmers'quality assessment indicators of livestock feed in both sites (Table 5).

In terms of colour as indicator, feeds generally have their own typical appearance, which the farmers are familiar with. Deviation from the typical appearance or colour was reported to have implication on quality. Farmers are able to assess the importance of feed quality as related to colour especially in the case of cereal residues. Berhanu et al. (2009) confirmed the use of visual observation and smell by farmers in Ethiopia to assess the quality of agro-industrial by-products as livestock feed and assessed black colouration of sorghum stover as poor quality and greenish colour hay good quality legume hay.

Another indicator for evaluation of feed quality reported by the farmers was texture. Soft and tender plant fraction and crop residues were considered high quality than the tough samples. For cereal stover, coarse texture of the stem residues with the presence of the sheath indicates

Table 2. Potential feed resource, feed processing methods and farmers' constraints in utilizing them.

Potential feed resources	Reason for not using the resource	How to strengthening the use of the feed resources
Mucuna pruiens	Knowledge gap is the major problem. Some of the farmers observed that when it was introduced to the village some years back, it's potential to add to feed quality and quantity was great. But they lacked the agronomic knowledge since it is an annual forage legume that should be planted yearly from the harvested seed.	Seed supply and knowledge of its annual propagation.
Leuceana leucocephala	Farmers reported lack of knowledge. One farmer watched it on the television once when he visited a relative in the city. Sharing with others, they are longing to know how to get access to the planting materials.	Supply of planting materials and training on how to be used properly.
Fodder maize and Forage grass	Lack of information and seed supply. The farmers remarked that they rarely see the extension service who will put them through and initiate any useful practice which they will then follow after.	Strengthening the capacity of the extension service. Adequate supply of the seed of fodder maize.
Methods of improving existing feed resources		
Conservation of crop residues	Lack of information and proper training on how to conserve the quality of crop residues.	Since maize is a major crop in the area and maize straw is of low nutritive value, convenient and affordable methods of improving maize straw quality should be sought.
Urea treatment of crop residues	Farmers reported that lack of knowledge was the predisposing factor for not exploiting the potential of urea treatment. The fear of losing the animal if the urea was not applied in the right quantity.	Awareness and training of farmers on the use of urea .

higher quality than smooth texture. Maize was ranked higher due to the presence of more sheaths which the farmers considered as an indication of quality as against sorghum and millet with lesser sheath. This confirmed a report that maize stover has a higher nutrient content than most straws (Suttie, 2000). Owen (1994) reported that animals are able to select for the more nutritious leaf and leaf-sheath components which contain more nitrogen against the less nutritious stem. As reported by the famers, coarse maize bran indicated high quality. Ground feeds with a large percentage of fine particles (<0.5 mm) are clearly less well accepted by cattle than coarse ground feeds (Morand-Fehr et al., 1994). The preference for coarse particles may be due to greater ease of prehension.

Leaf to stem ratio of forage crops is an important factor affecting diet selection, quality, and intake of forages (Smart et al., 2001), because leaves have usually higher nutrient quality (for example crude protein) than stems (Bakoglu et al., 1999). Farmers ranked higher in terms of quality the available sample of groundnut haulms with higher leaf to stem ratio than cowpea haulms. In an experiment, Savadogo (2000) reported groundnut haulms contained more leaves (48.1%) than cowpea haulms and both cowpea and groundnut haulms had been reported as high value supplement to poorer quality hay and stover to improve nutrient supply and growth of livestock (Savadogo et al., 2000; Bayala et al., 2014) with differing quality based on provenance, season and stages of maturity. This result underscores farmers' perception of quality based on leaf to stem ratio. Studies of the voluntary intake of sheep and cattle fed separated leaf and stem fractions of a range of tropical grasses have also indicated that leaf is eaten in much larger quantities than stem due to a shorter time the leaf is retained in the recticulo-rumen (Minson, 1980).

Farmers' perceived high moisture content relative to dryness as indicator for high feed quality as it reduces water intake by animals. Water intake (from all sources) had been reported to be related to the intake of dry matter (Forbes, 1985). The more moisture supplied in the feed, the lower the need for drinking water. Studies have also shown that the nutritive quality of forages varies as they grow towards maturity which agrees with farmers' assessment (Bilal et al., 2001). According to the farmers, animal behaviour is another indicator of feed quality assessment. Kalio et al. (2006) confirmed that the utilization of any feed resource is influenced by the animals' preference and acceptability of the feed, which is related to the animal's behavioral

Table 3. Nutrient composition (g/kg DM), metabolizable energy (MJ/kg) and *in vitro* organic matter digestibility (g/kg DM) of available feed resource in Mahon in dry season.

Type of feed	Ash	N	CP	NDF	ADF	ADL	ME	IVOMD
Grasses/Browse								
Khaya senegalensis (leaf)	127	24.0	149	425	34.7	74.2	71.7	522
Cassia sieberiana pods	47.8	12.9	80.5	325	31.6	107	90.9	610
Piliostigma tonenji pods	116	12.3	7.72	555	53.5	239	66.5	469
Cordia myxa (leaf)	141	24.1	151	595	67.2	279	55.4	423
Daniella oleifera (leaf)	63.7	30.3	18.9	569	42.2	137	102	705
Mangifera indica (leaf)	86.1	13.0	81.5	450	38.9	116	65.2	458
Cassia sieberiana (leaf)	42.9	21.2	133	665	55.4	249	71.5	501
Mean values	**89.2**	**19.7**	**123**	**512**	**46.2**	**172**	**74.7**	**527**
Crop residues/by-products								
Maize bran	11.9	11.7	72.9	389	8.62	13.6	119	776
Cowpea haulms	91.7	27.2	170	459	24.2	60.1	92.2	648
Groundnut haulms	239	18.7	117	452	44.7	152	72.6	539
Parkia biglobosa pulp	43.3	06.6	40.9	185	16.27	06.4	124	805
Millet stover	24.7	02.2	13.9	641	71.1	147	52.4	350
Maize stover	216	07.0	43.5	672	42.5	76.5	78.8	556
Maize husk	39.3	03.0	18.8	871	43.1	49.8	88.6	579
Sorghum bicolor stover	43.8	02.2	14.0	861	64.8	120	55.7	375
Mean values	**88.7**	**0.98**	**61.2**	**566**	**39.4**	**78.1**	**85.4**	**579**

Nitrogen (N), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), Metabolizable energy (ME) *in vitro* organic matter digestibility (IVOMD).

pattern. Similarly, the extent of preference and acceptability of a feed by the animals is one of the principal things to note when determining the best feed stuff (Ganskopp et al., 1997). The result suggests that there is significant complementarity between farmers' assessments of feed value of the available feed resources and relative assessment derived from laboratory analysis (Thorne et al., 1999).

Constraints to livestock production and proposed solutions

The livestock production constraints were identified in order of importance and farmers suggested solutions (Table 6). Shortage of water was described by the farmers as the first constraint in both communities. Inadequate quantity and quality feed throughout the year ranked next to shortage of water.

Opportunities for efficient conservation and utilization of available feed resources

The followings are potential interventions for both Mahon and Sayaga derived from farmers' proposed solutions and existing opportunities:

1. Farmers reported that lack of information on other feed resources was the predisposing factor for not exploiting the potential of the livestock sector to the fullest. Hence, training on ration formulation based on the locally available feed resources, fodder production, feed conservation and processing would be instrumental to enhance knowledge base and attitude/behaviour change of the farmers and livestock extension workers.
2. Improving the utilization of crop residue
a. Large quantities of crop residues are produced from cereals. However, only few are collected and properly used as animal feeds throughout the season due to poor storage facilities and strategies. Conservation of crop residues should be encouraged. Farmers need to be trained on how to conserve crop residues in a rain proof, well-ventilated barn to retain the quality of the crop residues throughout the period of storage.
b. Crop residue treatment and crop residue-based rations. In both villages, cattle showed symptoms of allotrophagia, a condition arising from mineral deficiency. On-farm training on ration formulation using cereals and legumes crop residues will increase the quality of livestock feed in the areas. Farmers could also be trained on the making of multinutrient feed block using local resources to improve animal feed intake.
3. Land was reported as one of the limiting factors inhibiting expansion of agricultural activities in the areas.

Table 4. Nutrient composition (g/kg DM), metabolizable energy (MJ/kg) and *in vitro* organic matter digestibility (g/kg DM) of available feed resource in Sayaga in dry season.

Type of feed	Ash	N	CP	NDF	ADF	ADL	ME	IVOMD
Grasses/Browse								
Andropogon gayanus (leaf)	147	05.7	35.7	743	529	109	53.5	385
Daniella oliveri (leaf)	69.9	31.6	198	609	475	189	67.7	498
Prosopis africana (leaf)	93.5	14.9	92.9	833	417	225	42.9	323
Pterocarpus microcarpa (leaf)	101	36.3	227	451	376	129	79.6	585
Vitellaria paradoxa (leaf)	48.7	15.1	94.1	506	469	198	50.9	365
Tectonia grandis (leaf)	86.2	40.5	253	421	338	141	72.2	542
Piliostigma tonenji pods	84.1	12.0	75.2	569	540	223	62.7	439
Dicrostachys cinera (leaf)	47.4	29.5	184	485	424	223	54.1	406
Cordia Africana (leaf)	99.5	17.4	109	503	422	198	61.0	440
Flugia virosa (leaf)	69.2	27.9	174	309	253	71.7	60.8	449
Cordia africana pods	135	16.4	102	395	404	178	45.4	348
Trichilia ematica (leaf)	69.5	17.8	111	502	421	128	93.1	635
Mean values	**79.4**	**20.2**	**126**	**516**	**422**	**149**	**76.1**	**535**
Crop residues/by-products								
Sorghum bicolor stover	80.0	03.8	23.5	654	437	60.8	75.0	503
Millet stover	106	02.5	15.6	721	524	83.4	74.0	499
Maize bran	146	13.5	844	351	99.0	16.9	78.6	552
Mean values	**111**	**06.6**	**4.12**	**57.5**	**354**	**53.7**	**75.9**	**518**

Nitrogen (N), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), Metabolizable energy (ME), *in vitro* organic matter digestibility (IVOMD).

Table 5. Farmers' indicators of feed quality assessment.

Parameters	Description
Colouration	Dark green colouration showed better quality than yellowish green. For cereal crop residues, no specific colour was mentioned, however, farmers noted that green colouration of cowpea and groundnut crop residues indicated good quality.
Texture	Farmers reported that coarse texture of maize gluten with bran due to the presence of crushed grains are of higher quality that the powdery maize gluten with bran. Coarse texture of the stem sorghum residues with the presence of the sheath indicated higher quality than smooth texture. Soft and tender plant fraction and crop residues were considered high quality than the tough samples.
Odour	Farmers described an offensive odour (pungent and rancid smell) in commercially formulated ration as poor quality while a pleasant smell of fresh coconut indicated high quality.
Leaf to stem ratio	Farmers considered high leaf to stem ratio as high quality feed for both fresh pasture and crop residues.
Moistness	From farmers' perspective, high moisture content indicated high quality. Some farmer reported that when animals take moist feed, their water intake will be reduced and this help to them manage the limited water source available because water supply was a major constraint.
Age at harvest	Farmers reported that younger plants are of higher quality than older plants.
Animal behaviour	Animals exhibited certain behaviour that indicated the quality of a feed. Wagging of tails when the food is served, competition for the feed, high intake rate and no left over are indicators of high quality as described by the farmers.

Therefore, planting of forage legume trees as fodder bank around the homestead and backyard as forage production is recommended. The legume trees are multipurpose and can provide feed, fuel, serve as live fences and shade. Backyard production of fodder trees is not land or labour demanding.

Table 6. Paired wise matrix ranking of major problems identified by the farmers facing livestock production in Mahon and Sayaga and suggested solutions.

Problems in order of importance	Problems identified	Proposed solution by the farmers
1	Shortage of water in the dry season for animals	- Construction of small dam for the animal. - Provision of water storage facilities in the village.
2	Inadequate quantity and quality feed throughout the year.	- Training and skill acquisition on how to improve the quality available feeds especially crop residues - Training on how to formulate animal feed ration using available feed resources. - Provision of forage legume and grass seed for cultivation - Training on proper storage methods for crop residues.
3	High cost of veterinary drugs and services	Establishment of a veterinary service and drug centre in the village.
4	Poor performance of their local breeds	Introduction of improved breed for cross breeding programme that can improve the genetic capacity of the local breed.
5	Poor housing provision	Provision of concrete, ventilated and protective housing for the animals. This will also facilitate the collection and utilization of animal dungs as manure.

a. Integrated crop farming with shade-tolerant forage grass and legumes planted in tree plantation. This practice encourages the effective utilization of same land resources where the tree biomass helps to enrich the soil and the animal dungs as well. Planting of fodder shrubs and tree as edge rows in arable crop land in form of alley-cropping will also restores nitrogen to the top layer of soil so that farmers can use the same piece of land year after year to grow their forage crops.
b. General health management and diseases prevention are the most important factors that affect ruminant production in the tropical environments. Losses because of ill health and diseases have not been quantified in the economic terms. Therefore, intervention must include proper animal healthcare. Provision of a veterinary center around these two villages is required.
c. Better management of the existing water resources, collecting rain water for dry periods, utilizing the existing limited water sources by making water reservoirs or ponds. Extracting the ground water with the assistance of government and non-government organizations.

CONCLUSION AND RECOMMENDATIONS

The farming system in both Mahon and Sayaga was characterized by mixed crop-livestock production system with fruit trees as major crops. Majority of the farmers are smallholder cultivating less than 5 has of land. Cattle are the most important livestock in these areas and are predominantly local breeds. Agricultural practices in both areas were characterized majorly by fruit trees cultivation and then arable crops. This contributes significantly to household's income generation. Livestock rearing contributes next to crop farming. Livestock production in these areas depends mostly on grazing of natural pastures. Crop residues, though available, had less contribution to the livestock diet in terms of DM, ME and CP, particularly when critically needed between March and April. This is as a result of poor storage facilities and continuous cropping on same land which affect the quality of the crop and residue. Although inadequate quantity and quality feed throughout the year was a problem facing livestock production in both Mahon and Sayaga, farmers viewed that shortage of water in the dry season for animals was the main constraint to livestock production in the areas. It is important to address the improvement of utilization of crop residues since it is available in both study sites. It is also important to encourage forage production to improve livestock productivity and farmers' livelihood.

Conflict of Interests

The authors have not declared any conflict of interests.

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