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Characterization of Agropastoralist Production Systems and the Potential for Improving Livestock Productivity with Improved Feeding in Western Burkina Faso

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Abstract: The major constraint of livestock farming in Burkina Faso is the feed gap. This study aims to provide information on feed resources, availability, and uses in Bama's district. Feed Assessment Tool (FEAST) was used to evaluate feed resources and to generate possible interventions. Focus groups were held and took into account 140 farmers, of which 90 were recalled for individual surveys. We found that the Bama district was characterized by agropastoral production systems in which crop provides 65.1% of household income whereas 23.9% was from livestock. Livestock feeding throughout the year depended on natural grazing. Natural pastures contributed most often to dry matter, metabolizable energy, and crude protein in animals' total diet, respectively, with 65.4, 64.4, and 61.5%. In addition to grazing, crop residues were collected after harvest to form a dietary supplement for the animals. The study also revealed nutritional gaps, and farmers were purchasing concentrates to compensate and ensure the best livestock productivity. The dominant complement purchased was cotton cake at a rate of 623.1 kg/year/household. None of the agropastoralists grew fodder crops. Identified interventions able to improve productivity and production of animals were supplementations with: a high-energy supplement (molasses); protein byproducts; pruning products, aerial parts, and leaf-stripping without sacrificing grain/tuber yields; cereal byproducts (rice bran, corn, wheat); multi-nutritional blocks; and commercially balanced feed. Given the food shortage, especially in the dry season, better management of food resources through the collection and conservation of fodder and the adoption of forage crops could increase feed availability.

Keywords: Crop Residues, Grazing, FEAST, Intervention, Livestock Production, Feed Supplements

1. Introduction

In Burkina Faso, more than 80% of households are involved in agropastoral activities, whereas 92% reside in rural areas [1]. The livestock sub-sectors relative contribution to GDP is 18% and represents nearly 26% of exports [2]. Domestic ruminants (cattle, sheep, goats) raising the system is dominated by the extensive one, including the transhumant pastoral type, the sedentary agropastoral type, and the sedentary type of created rural zones [3]. Also, few intensive farming systems are developed for the meat and milk sectors. The extensive system produces 90% of meat and 95% of milk nation-wide [2], despite low per capita productivity. Livestock feed is based on pasture and crop residues [4, 5]. However, the scarcity of feed, especially in the dry season, remains the primary cause of the herd's low productivity. In the hot dry season, natural pastures produce poor feed that

have little nutritional value and are overgrazed [1, 6]. Also, climate change effects, expansion of cropping, urbanization, occupation of animal passageways, and water points' vicinity are detrimental to grazing land [7–10]. Therefore, it is to understand the spectrum of animal feed constraints to generate critical interventions that sustainably intensify animal production. International Livestock Research Institute (ILRI) has developed the Feed Assessment Tool (FEAST) that offers a systematic and rapid method for assessing feed resources [11–13] at the site level with a site-specific intervention strategy. This study aimed to characterize the agropastoralist production systems and inherent potentials for improving livestock productivity by better feeding practices in the Bama district using the Feed Assessment Tools.

2. Materials and Methods

The Bama district (Figure 1) is located about 30 Km northwest of Bobo-Dioulasso in the Hauts-Bassins region. It is a rural district of 1,300 km^2 located in the North-West by Dandé District, in the North by Padéma district, in the South by Bobo-Dioulasso district, in the East by Satiri district and in the West by Karangasso-Sambla district. Ten (10) out of a total of 21 villages in the district drawn randomly served as study sites. The selected villages were: Badara, Bama, Banakélédaga, Diarradougou, Natèma, Samandeni, Séguéré, Sangoulema, Souroukoudougou and Lanfiera. The area's climate is of the South Soudinian type with a rainfall that can reach 1000 mm and a rainy season that lasts from June to October. The district is crossed by important rivers such as Mouhoun, Kou, and Niamé. Within the last ten (10) years, rainfall varied between 700 mm and 1300 mm. The number of rainy days ranged from 65 to 95 days. The year 2018 was the rainiest year (1,300 mm). The quantities of rain water recorded were distributed from March to December over 70 rainy days. August was the rainiest month, with an amount of 375 mm spread over 14 days. Bama's district is dominated by vast alluvial plains (altitude: 320 m) with numerous mounds and hills (altitudes: 440 m to 480 m). The types of soils encountered are Loamy clay to clay, Gravelly, and Clayey-sandy. The plant community is very diverse, and the dominant species are *Bombax costatum, Isoberlinia doka, Detarium microcarpum, Anogeissus leiocarpus, Sclerocarya birrea, Parkia biglobosa, Vitellaria paradoxa*. The herbaceous stratus is very abundant and the dominant species are *Andropogon gayanus, Andropogon sp*, *Vetiveria nigritana, Loudetia togoensis* [14].

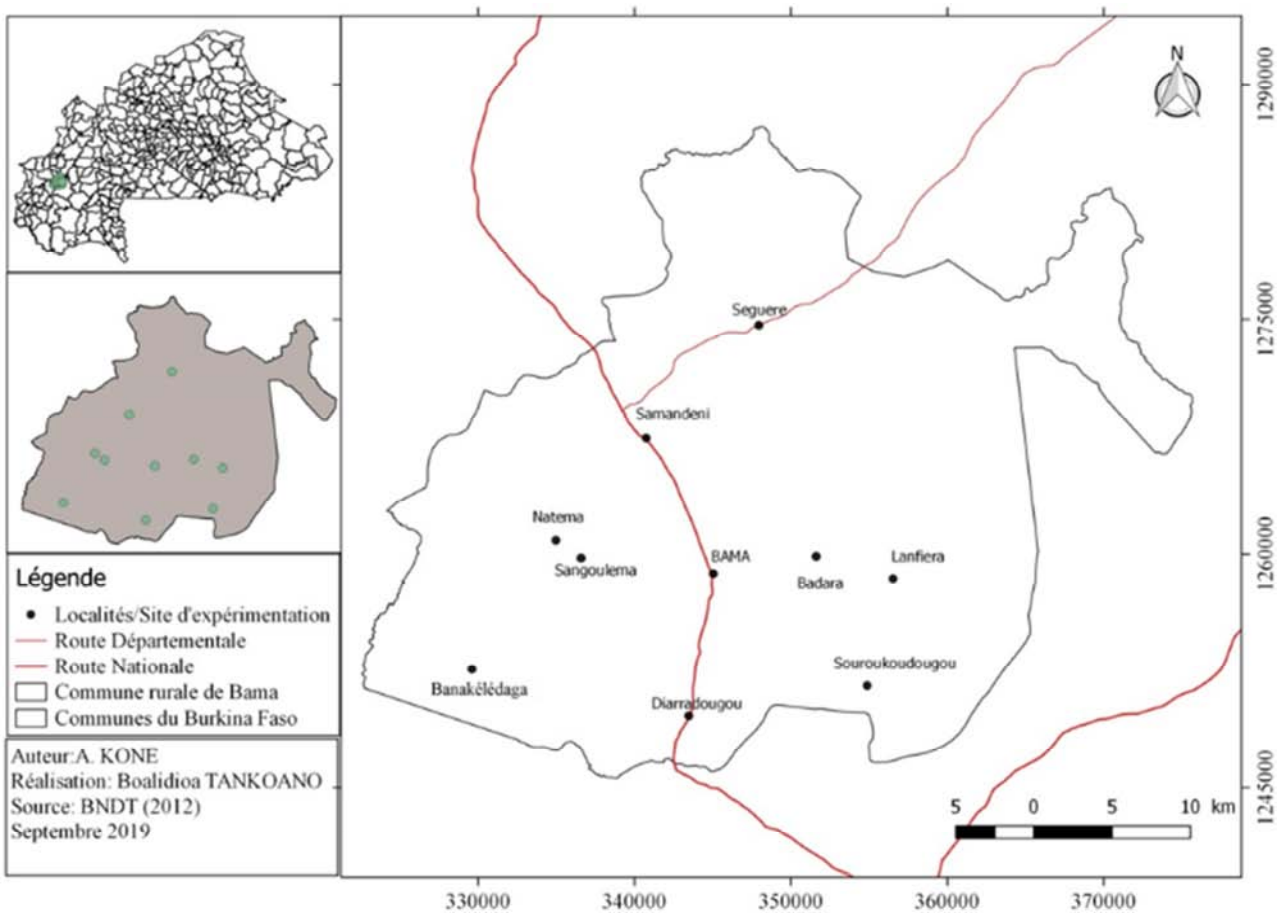


Figure 1. *Map of Bama's District.*

The district of Bama has 21 administrative villages and ten farming hamlets with a population according to the general population census of 2006 was estimated at 69,738 inhabitants, including 34,699 men and 35,039 women [15]. The ethnic

groups are Bobo, Mossi, Samo, Gourounsi, Peulh, Bwaba, Sénoufo. Agricultural production is dominated by cereals, cotton, fruit crops (bananas and papaya), and vegetable. Extensive livestock production is the second important activity. Agricultural products are sold in the nearest city of Bobo-Dioulasso (2nd largest city of Burkina Faso).

The FEAST Tool (Feed Resource Assessment Tool) is a systematic method for assessing the availability and use of local feed resources. It helps in the design of intervention strategies aimed at optimizing the use of feed and animal production. However, FEAST is available for free on the site: https://www.ilri.org/feast, which we used. The tool comprises two main elements: a) a focused PRA exercise that provides an overview of the farming system, emphasizing livestock feed aspects. b) A brief and straightforward quantitative questionnaire designed to be completed by experts under the Feast facilitator's guidance. Output from FEAST consists of a short report in a defined format and some quantitative information on overall feed availability, quality, and seasonality, helping inform intervention strategies.

Qualitative and quantitative surveys were carried out using the guides (focus group and individual survey). The information obtained allowed for a broad diagnosis of livestock production systems and identifying site-specific feeds and other constraints and opportunities. The first part of the FEAST activity was the focus group. Farmers were classified into three classes, i.e., small, medium, and large farmers according to farm field size. A total of 140 producers from the ten villages were selected for the focus group. In each town, 14 agropastoralists participated in the discussions. The focus group guide was used for this purpose. A facilitator posed these questions for focus group participants to give their opinion until consensus was reached and recorded. After the focus group, quantitative data was collected with the semi-structured questionnaire () through the individual interview of 90 producers in the ten villages. This covered all three classes of producers chosen in each village. Respondents were heads of households or representatives who had a good knowledge of household farming systems.

The information was entered into the FEAST database. The data analysis was carried out with the help of FEAST and made it possible to obtain socio-economic information on the availability and use of local food resources and to propose interventions likely to improve livestock productivity through to a better diet. Interventions were ranked on a scale of 0 to 20 with (0 indicating no potential improvement and 20 showing significant productivity improvement?) based on five key factors:

The capacity of the intervention to alleviate the fundamental constraints: global food scarcity, food quality, seasonal scarcity;

Relevance for essential products: to what extent the intervention is adapted to the main livestock product considered - dairy cattle, beef cattle, goats, pigs, etc.;

Relevance for the agricultural system, e.g., mixed intensive, agropastoral, pastoral, and landless farmers;

The relevance to local conditions: availability of land, labor, farmer skills, inputs, etc.

3. Results

The average household sizes (Table 1) were between 10 and 24 individuals. These households were made of several couples lead by a household head who organizes and coordinates household activities; several homes settled in the same yard. The main ethnic groups constituting the population are the Fulani, the Mossi, and the Bobo. Mossi and Bobo were animal owners under the guidance of salaried shepherds (mostly Fulanis). The majority of households (58%) were small farmers possessing less than 4.8 ha (Figure 2). Medium farmers had between 4.8 and 5.8 ha and represented 27% of households and 15% for large farmers owning more than 5.8 ha. Farmers noticed that years ago, they practiced fallowing. In recent years, labor was challenging to acquire due to youth immigration to the gold mines sites.

Table 1. *Average household size.*

Village	Household size
Diarradougou	16
Seguere	13
Badara	12
Lanfiera	13
Banakeledaga	18
Samandeni	12
Natema	12
Bama	24
Souroukoudougou	10
Sangoulema	10

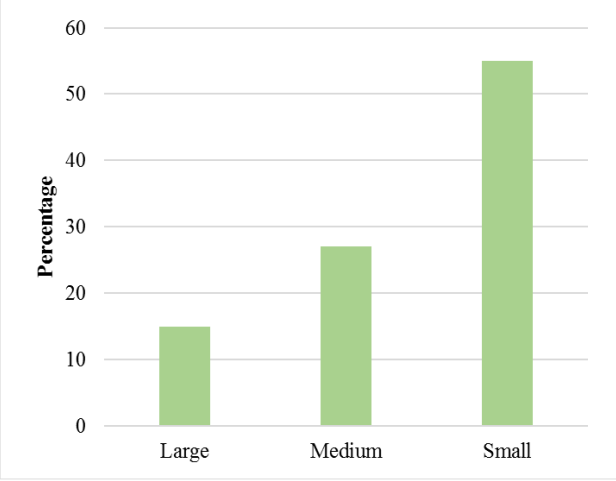


Figure 2. *Distribution of households' farm size. Small: less 4.8 ha; Medium: between 4.8 and 5.8 ha; Large: more than 5.8 ha.*

The main crop acreage (ha) ranked in descending order (Figure 3) were maize (2.55), cotton (1.88), rice (0.37), sorghum (0.36), cowpea (0.32), millet (0.24), bananas (0.21), groundnut (0.18), cabbage (0.09), eggplant (0.05), beans (0.01), cassava (0.01), tomato (0.01), sweet potato (0.01). Maize and cotton were the dominant crops in the district in term of acreage.

Extensive animal husbandry was practiced during the rainy season—most of the households surveyed produced milk. Housing and feeding practices varied for the different categories of animals raised. Cattle and donkeys were free-ranging. Collected crop residues and purchased concentrates were fed to milking dairy cows and convalescent animals. Treatment for the prevention of trypanosomiasis and pasteurellosis was at the beginning and the end of the rainy season. When disease occurred, farmers call on veterinarian service for care. The maintenance and follow-up tasks are assumed by a third person (herdsman, relatives). The local cattle breeds (zebu) were dominant in a herd, and the inherent potential milk yield was low. Reproduction was predominately by natural service. Extensive systems dominated the local dwarf sheep and goats farming. Women were the main actors in small ruminant production. The diet consisted mainly of natural pasture and little supplementation. During the rainy season, sheep and goats were housed near the farm. In the dry season, small ruminants were housed in the pens with large ruminants or free-ranged. Small ruminants did not benefit from health care except in cases of serious illness. In addition to herds of cattle and small ruminants (sheep, goats), farmers had donkeys and poultry (chickens and guinea fowl).

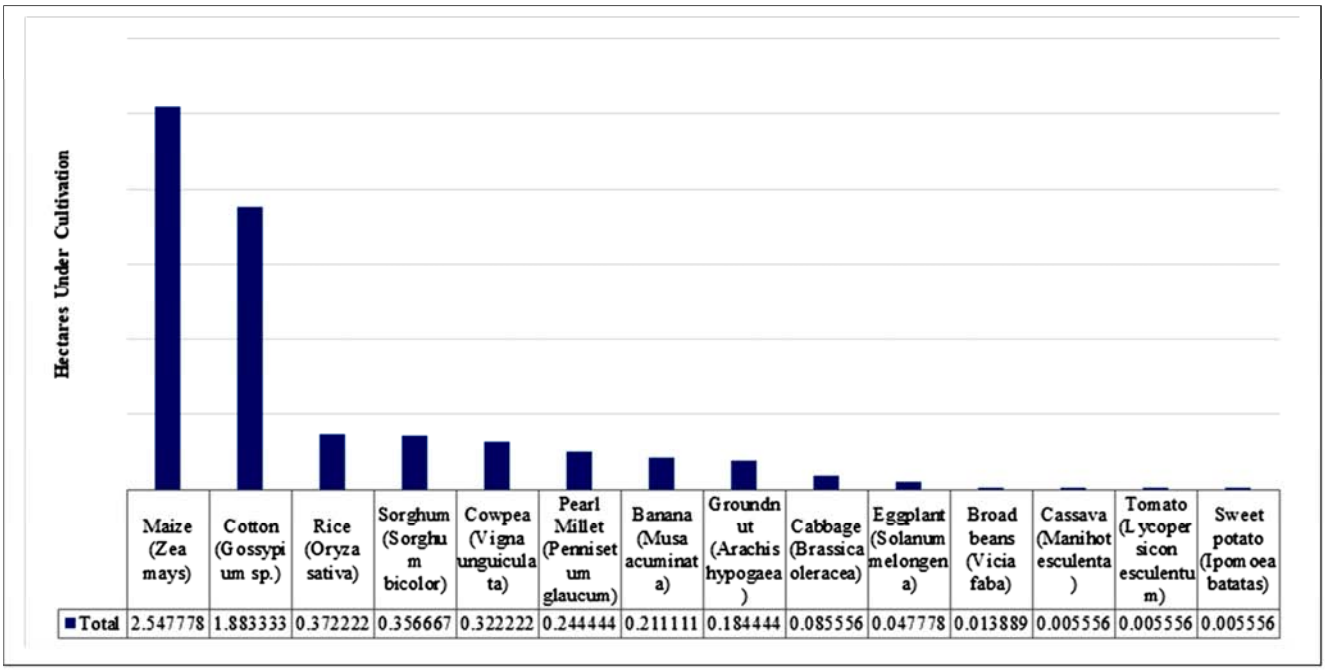


Figure 3. *Distribution of main crops acreage of per household.*

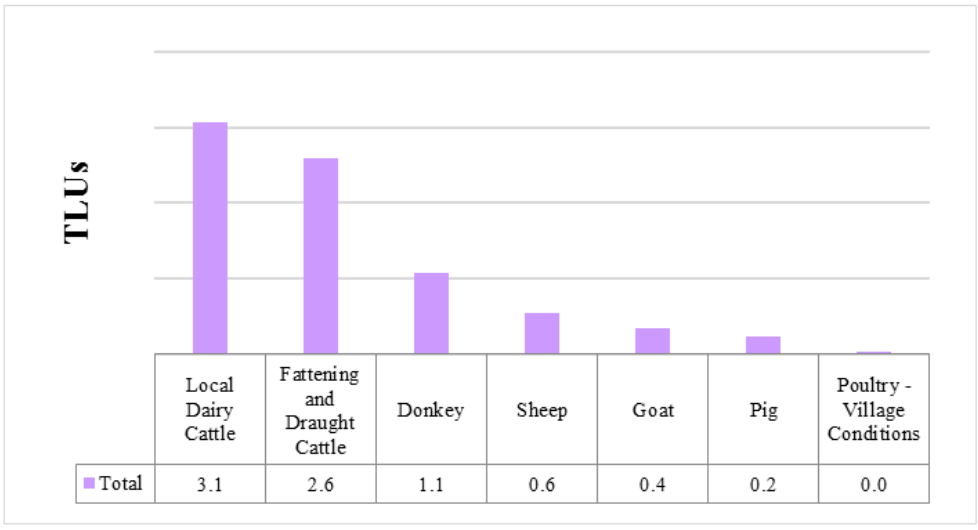


Figure 4. *Average livestock species holdings per household in Tropical Livestock Unit (TLU) in Bama.*

The main animal species encountered in the study area were cattle, donkey sheep, goats, pigs, and poultry (Figure 4). In a household, the dominant animals are locally bred cattle, whereas local dairy cattle were 3.06 TLUs, fattening and draught cattle were approximately 2.59 TLUs. Donkeys contributed with 1.07 TLUs. Sheep and goats contributed

poorly with 0.55 TLU and 0.35 TLU, respectively. All farmers' households possessed a donkey, small ruminants (sheep and goats), and local bulls and castrated male cattle and poultry even though large farms tended to raise more poultry (Figure 6). Large farm households raised local dairy (milking and non-milking cows, heifer, and calves). Medium farms households did not own dairy heifers and calves.

The primary sources of income were crops (65%) and livestock (24%), both representing 88.95% of annual household income (Figure 5). Crop production was sufficient for household demand, and many farmers did not purchase food for the family. A few large producers sold part of their production. During the dry season, the farmers were engaged in vegetable production. All the farmers surveyed were agropastoralists. Households raised animals to collect manure as fertilizer in agricultural production. Most farmers preferred to raise cows for renewing the herd, followed by draft oxen. Milk and animal traction constitute important sources of household income. Aged draft oxen are sold by the household's head to buy calves, construct a house, purchase motorcycles or inputs (fertilizer, animal feed supplement). Small ruminants occupy an essential place in mixed agriculture-livestock farms. Small ruminants are reared in most households and are sold (at the start and end of the rainy seasons) to provide income to maintain large ruminants such as veterinary care and stockpile concentrate for milking, pregnant and sick cows.

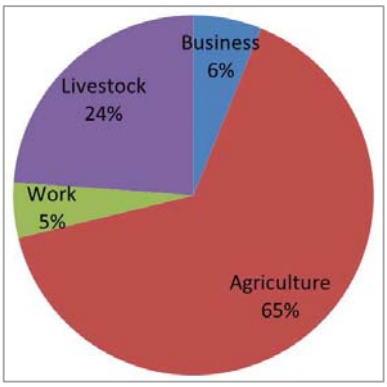


Figure 5. *Contribution of livelihood activities to household income.*

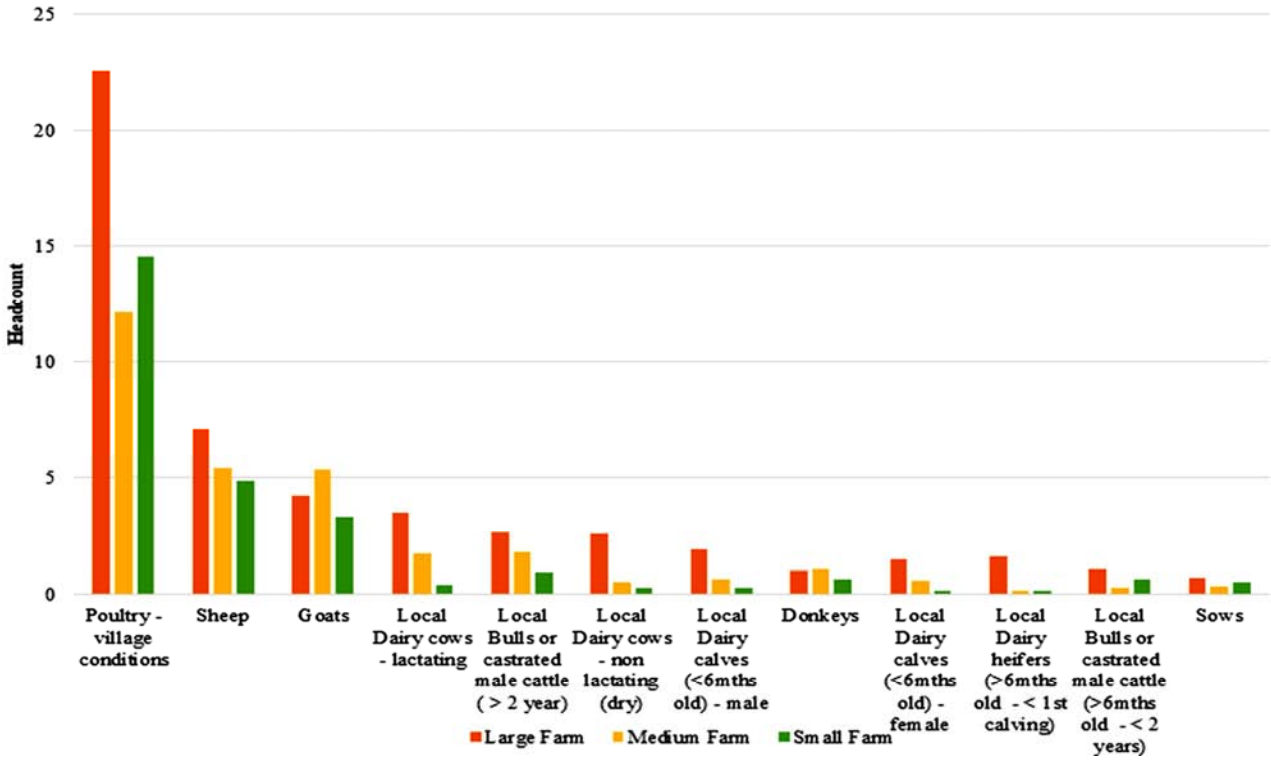


Figure 6. *Animals' headcount according to farm size.*

Non-agricultural activities such as business and labor represent 6.11 and 4.94%, respectively (Figure 5). These activities are carried out during the dry season by the heads of the family, and they allowed farmers to meet their secondary needs, such as clothing. For ruminants' prices, December and January were the moments that animal prices peaked with 426, 53 and 31 USD for cattle, sheep, and goats, respectively (Figure 7). The second peak of price is obtained for cattle (444 USD) in July and for sheep (49 USD) from August to September. October seemed to be the months where animals' prices were the lowest year-round with 339. 33 and 20 USD for cattle, sheep, and goats, respectively. Milk production phases were: 1) declining production starting from February to April with 9 to 7.6 L/day/household and 2) the maximum production phase forming a plateau-like curve from May to August where production varied between 22 and 24 L (Figure 8). Labor allowed males to generate 10.7 USD vs. 3 USD for females daily (Figure 9).

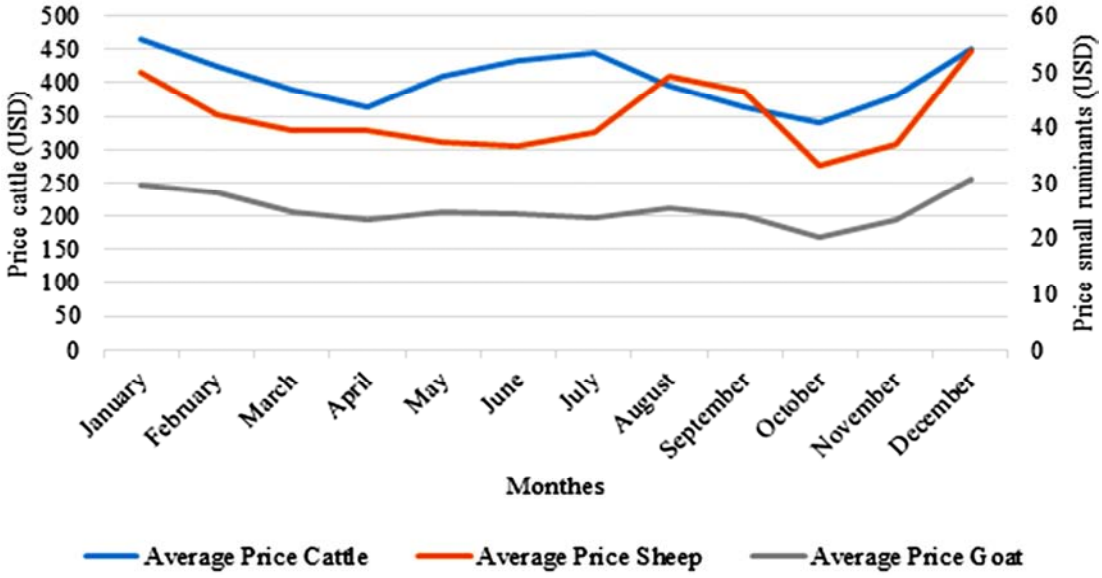


Figure 7. *Average Price of Major Livestock Species in USD by Month.*

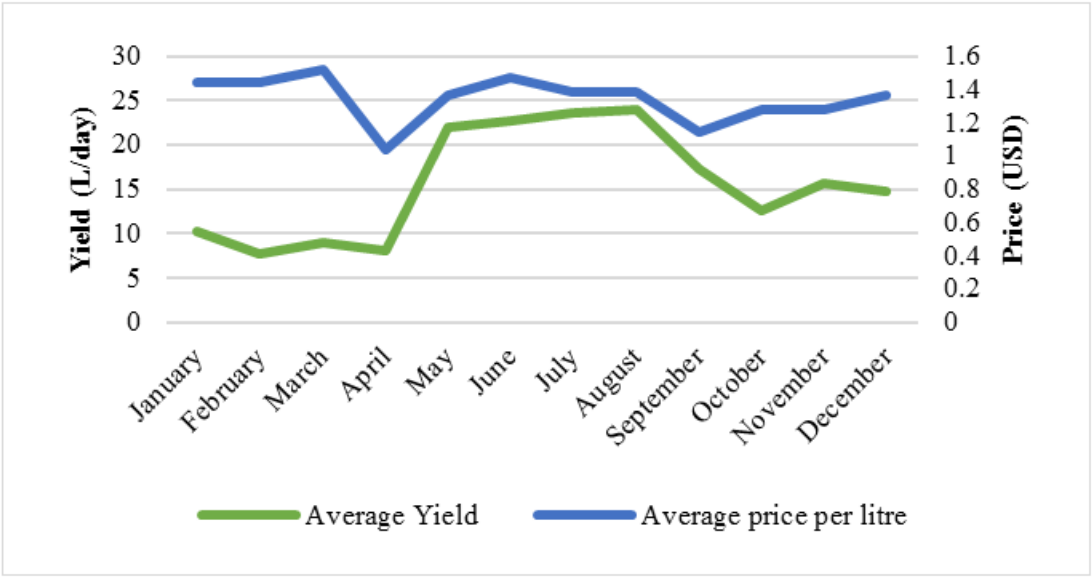


Figure 8. *Average daily Milk Yield (L) vs. price received per liter (USD).*

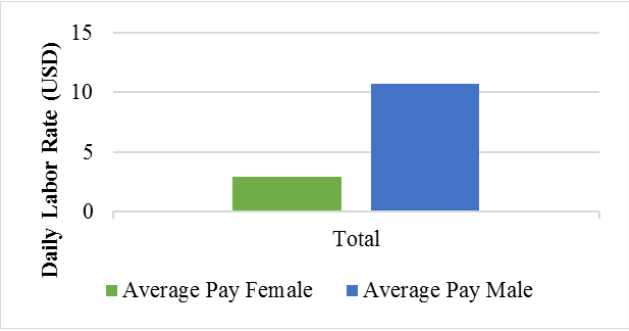
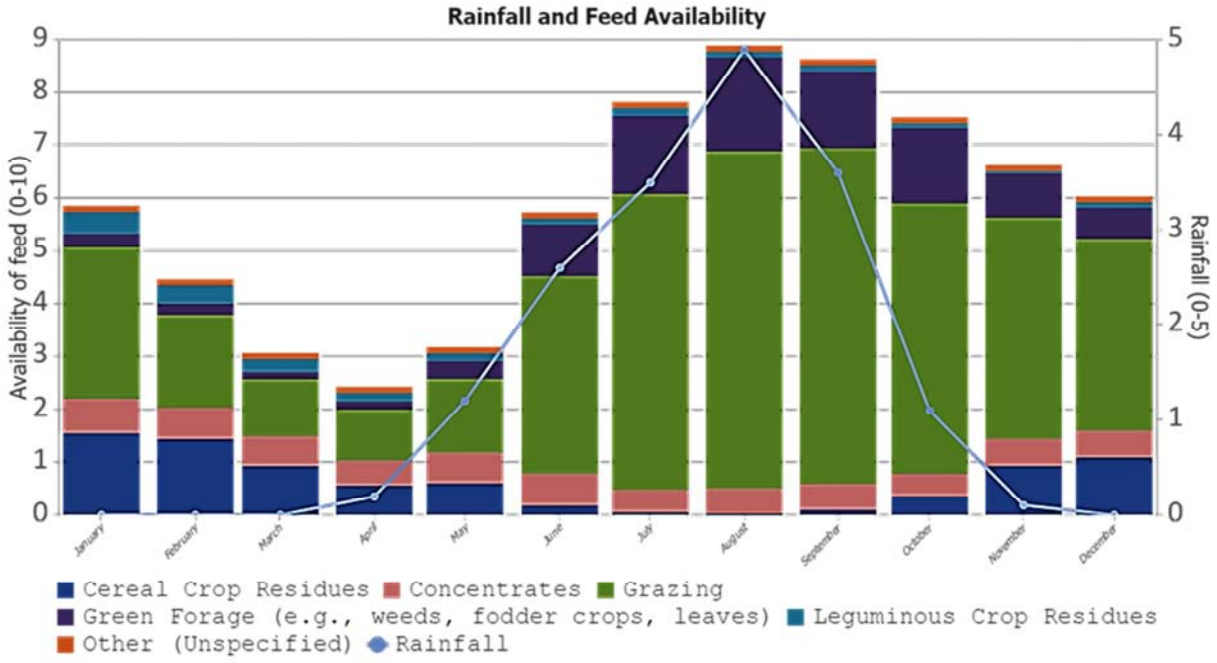


Figure 9. *Average daily labor Rates by gender (in USD).*

The feed resources were natural pasture, crop residues (cereal and leguminous), green fodder, concentrates, and other such as brewery grain (Figure 8). The contribution of these feed resources varied year-round. The primary sources of feed were natural pasture and cereal crop residues. Green fodder, including weeds from cultivation areas, was collected served as feed sources, especially at the rains' onset. However, its availability was generally low from January to May, a period corresponding to the dry season. Cereal crop residues were used starting from October after crop harvest when the green fodder is declining until June. Feed availability has been strongly linked to rainfall patterns, with great scarcity during the dry season from March to May. Year-round, grazing constituted a major part of the diet. Rains began in March and gradually increased in intensity until August when the greatest precipitation was recorded before decreasing and finally ceasing in December. In terms of animal feed availability, March to May recorded the lowest quantity of feed available. Feed was abundant from July to November.



Legend: 10 = excess food available, 5 = adequate food available and 0 = no food available

Figure 10. *Rainfall and feed resources available on the site.*

All farmers interviewed purchased additional feed in the past 12 months (Figure 11). The dominant purchased feed was cotton seed meal (623.1 kg), maize bran (591.67 kg), and rice bran (400.11 kg) yearly basis. The rest of the feed is purchased in a small quantity (< less than 15 kg/year/farmer).

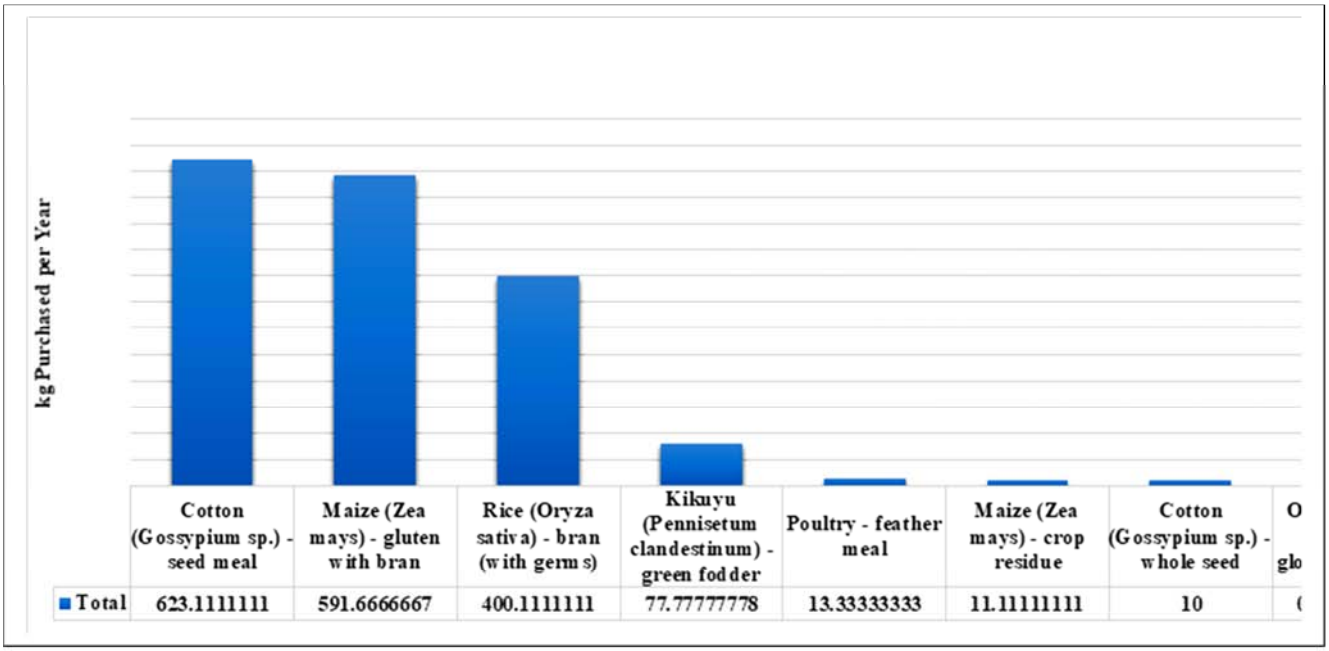


Figure 11. *Dominant purchased feed types.*

Natural pasture remained the primary source of feed, providing the highest dry matter content (65.4%), followed by crop residues (21.1%). Collected fodder and meal purchased provided (9.2%) and (4.3%) respectively (Figure 12). Nome of the farmers practiced fodder cultivation in Bama's district. Regarding the crude protein, natural pasture provided the highest crude protein rate (61.5%), followed by purchased feed (15.2%) and crop residues (15.0%). The collected fodder contributed 8.1%. In terms of metabolizable energy, grazing contribution was 64.8%, crop residues for 20%, fodder 9.5%, and the purchased feed contributed 5.8%.

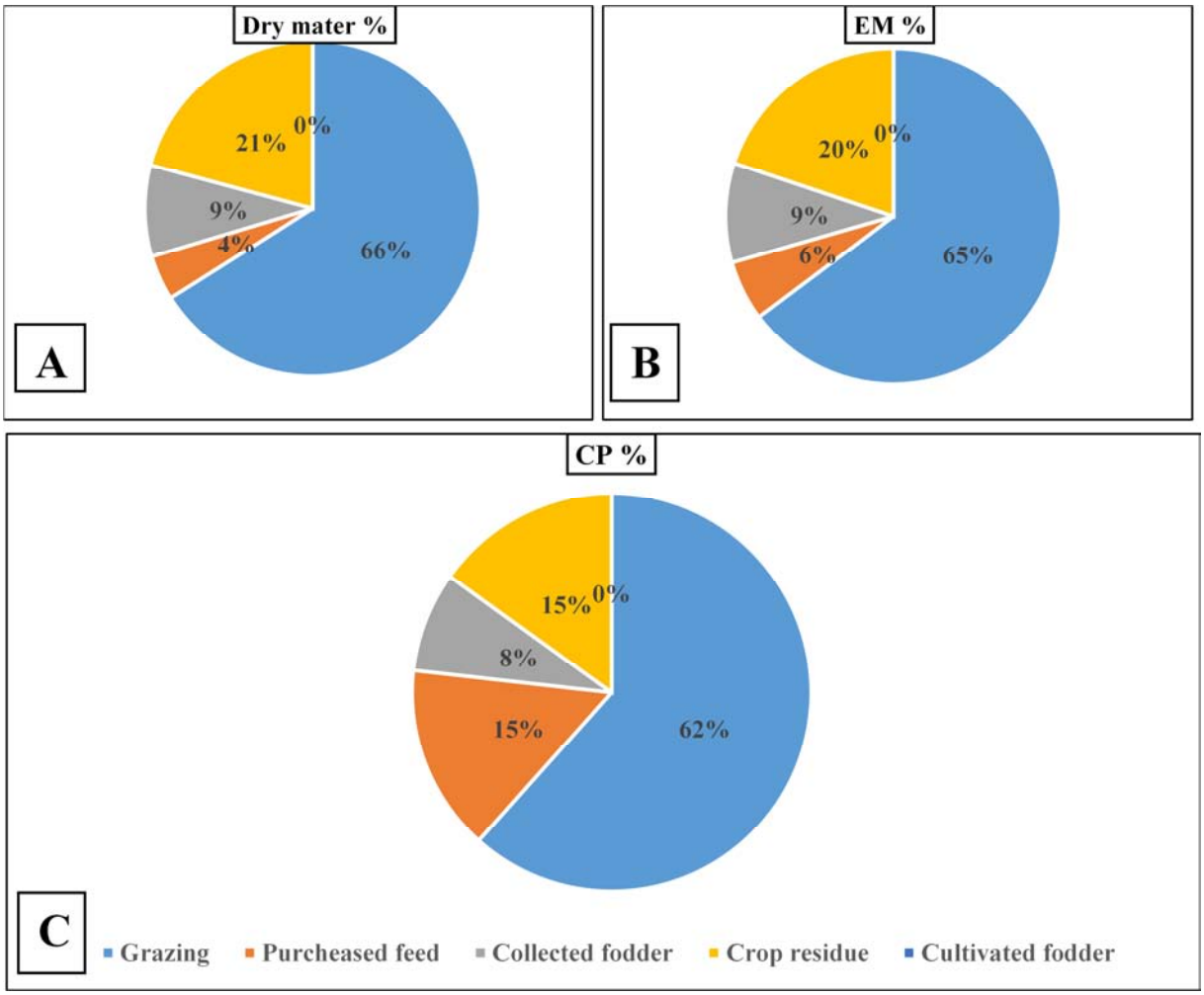


Figure 12. *Proportion of livestock feed in terms of dry matter, metabolizable energy, and crude protein: A) Dry matter content by feed sources; B) Metabolizable energy by feed sources; C) Crude protein by feed sources.*

The main constraints and the inherent solutions to animal production in Bama's district obtained from the respondents are presented in Table 2. In general, the high incidence of diseases associated with mortality and poor housing conditions were common constraints in most villages. Another critical constraint mentioned by respondents is the feed gap in the dry season. Others were the lack of potable water for livestock due to the use of chemicals (fertilizers, pesticides, and herbicides) on irrigated fields, the lack of access to finance, and the marketing of agriculture products.

Table 2. *The major constraints that hinder the development of livestock farming and the solutions recommended by farmers.*

Constraints	Solutions
Death of animals due to a recurrent streak of diseases	a. Construction of a vaccination park b. Availability of veterinarians and pharmaceuticals.
Animal feeding problem	a. Provision of shredders for cereals crop residues b. Subsidizing cotton cake c. Training on mowing techniques and fodder conservation (silage, tedding, etc.) and fodder crops production.
Lack of potable water for watering	a. Provision of wells for cattle
Access to finance	a. Improve access to micro-finance structures at affordable interest rates.
Marketing problems	a. Develop a marketing strategy selling cattle at better prices b. Connection of farmers to buyers and the establishment of a weight-price system.

These animal feed interventions were expected to have a very high impact on animal productivity and production. Altogether, six keys' interventions (Table 3) were generated, and the top five were recommended to the village farmers. They were: 1) energy-rich supplements, 2) supplementation with protein byproducts, 3) feed cereal byproducts, 4) provide multi-nutrient supplement blocks, 5) commercially balanced compound feeds, 6) thinning tops, leaf strips without sacrificing grain/tuber yields.

Table 3. *Intervention analysis report.*

Bama's district village names	Top 5 Interventions that can impact animal production				
	1st	2nd	3rd	4th	5th
Diarradougou	Supplementation with energy-rich supplements, e.g., molasses	Use of commercially balanced feed	Supplementation using protein byproducts	Cereal byproducts	Thinnings, tops, leaf strips without sacrificing grain/tuber yields
Seguere	Supplementation with energy-rich supplements, e.g., molasses	Multi nutrients supplement block	Supplementation using protein byproducts	Cereal byproducts	Use of commercially balanced feed
Badara	Supplementation with energy-rich supplements, e.g., molasses	Supplementation using protein byproducts	Cereal byproducts	Multi nutrients supplement block	Use of commercial balanced compound feed
Lanfiera	Supplementation with energy-rich supplements, e.g., molasses	Supplementation using protein byproducts	Thinnings, tops, leaf strips without sacrificing grain/tuber yields	Cereal byproducts	Multi nutrients supplement block
Banakeledaga	Supplementation with energy-rich supplements, e.g., molasses	Supplementation using protein byproducts	Thinnings, tops, leaf strips without sacrificing grain/tuber yields	Cereal byproducts	Multi nutrients supplement block
Samandeni	Use of commercial balanced compound feed	Cereal byproducts	Supplementation with energy-rich supplements, e.g., molasses	Supplementation using protein byproducts	Thinnings, tops, leaf strips without sacrificing grain/tuber yields
Natema	Use of commercial balanced compound feed	Supplementation with energy-rich supplements, e.g., molasses	Supplementation using protein byproducts	Cereal byproducts	Thinnings, tops, leaf strips without sacrificing grain/tuber yields
Bama	Supplementation with energy-rich supplements, e.g., molasses	Use of commercial balanced compound f	Supplementation using protein byproducts	Cereal byproducts	Thinnings, tops, leaf strips without sacrificing grain/tuber yields
Souroukoudougou	Supplementation with energy-rich supplements, e.g., molasses	Use of commercial balanced compound f	Supplementation using protein byproducts	Cereal byproducts	Thinnings, tops, leaf strips without sacrificing grain/tuber yields
Sangoulema	Supplementation with energy-rich supplements, e.g., molasses	Supplementation using protein byproducts	Cereal byproducts	Multi nutrients supplement block	Use of commercial balanced compound feed

4. Discussion

The surveyed households consisted of multiple families and were large (10 to 24 people). The high number of people per household on some farms could be explained by the need for abundant labor in agricultural activities [5]. In the Hauts-Bassins region of Burkina Faso, a household may reach 85 persons [16]. Also, the patriarchal system forces young people to remain under parental care for a long time, contributing to relatively large households' makeup [17]. Agriculture is the primary source of household income (65.1%) FAO [18]. Agriculture remains the main contributor to household revenue, particularly in sub-Saharan regions [18, 19]. The household's surveyed yearly yield was sufficient to cover the family needs of cereal. Since most cultivated areas are used for the production of cereal crops, crop residues become significant fodder resources during the dry season. Previous studies noticed the systematic use of crop residues to feed animals during the dry season [4, 20, 21]. Livestock (animals and animal products) was the second source of income for households (24%). In the Bama district, farmers were all agropastoralists, and therefore animal husbandry is the second revenue source. A shift of income source is observed closer to Bobo-Dioulasso city. In the peri-urban areas of Bobo-Dioulasso, animal husbandry represented the main activity for 18.2% and secondary for 81.8% of respondents [22].

All animals' price peaks in December, and only sheep price peak during Muslims' celebration (Aïd el-Kebir). The farmers should fatten the animals targeting these periods to increase revenue. Milk prices seemed to be stable, but production was related to feed availability, low in dry season and abundant in the rainy season. Livestock constituted an essential source of smallholder farmers' income in sub-Saharan Africa [23, 24]. However, our results differed from those of Amole and Ayantunde [11] who reported that livestock was ranked ahead of crop production in subsistence activities to household income in Hauts- Basins. Generally, the agricultural income of smallholder households is insufficient to maintain their livelihoods. Farmers were engaged in off-farm activities as a complementary source of income. IFAD [25] noticed that wage employment in the agricultural sector is seasonal, which leads producers to engage in non-agricultural activities as sources of additional income where we see a huge gap between men and women's daily pay (3 vs. 11 USD). According to the respondents, domestic ruminants (cattle, sheep, and goats) represented a real economic value. The dominance of cattle was due to the high demand for oxen for agricultural activities. We observed that small farm households didn't raise dairy cows nor calves, so they depended on large farmers who owned oxen. The smallholder

farms could not fully benefit from cattle advantages such as traction force, transportation, milk, manure, savings [26], and natural renewal of herds. All households possessed 1 to 2 donkeys showing a wide use of the animal in agricultural activities. FAO [27] stated that livestock is an essential factor for improving the populations' living conditions both for its economic, food, and nutritional importance.

Natural pastures and crop residues were necessary feed resources for livestock. Previous studies found similar results [4, 5, 11, 28, 29]. However, the quality of natural pastures is deficient to meet the animals' nutritional needs during the dry season, requiring food supplementation. During the rainy season, except for sick animals and small ones who cannot graze, there is no collection of fodder for the animals. Crop residues were available starting from October after harvesting. Crop residues became a significant fodder resource during the dry season.

Comprehensive use of purchased byproducts made of cottonseed meal (623.1 kg), maize bran (591.6 kg), and rice bran (400.1 kg) throughout the year is needed to meet the needs of animals. The same animal feed management strategy was observed in previous studies [4, 30–32] constitute essential supplements to pasture, crop residues, and almost all fattening, dairy, and convalescents animal rations. Nevertheless, these agro-industrial byproducts constitute a promising way of sustainably improve the productivity of domestic ruminants. The purchased feed contributed to 4.3% of dry matter, 5.8% metabolizable energy, and 15% crude protein, meaning that farmers tend to buy high energy and protein content feed to supplement their animals. Through the year, animals seemed to be dependent on grazing.

The availability and abundance of natural pasture resources depend on rainfall. At the start of the dry season (October), crop residues were available, which coincides with the peak of stover availability that remained the primary food resource. Similar results were reported by Fernandez-Rivera et al [33] and Amole and Ayantunde [11]. In addition to feed resources. Farmers identified others solutions that can positively impact animal productivity. These were: 1) construction of a vaccination park, 2) greater access to veterinarians and pharmaceuticals, 3) wells for fresh, clean water, 4) access to micro-finance, 5) marketing strategies for selling cattle at better prices, 6) connecting farmers and buyers with the establishment of a weight-price system.

5. Conclusion

In the Bama district, most farmers were agropastoralists. The animal feeding systems relied on natural pastures, crop residues, and purchased feeds (cottonseed meal, maize bran, and rice bran). These purchased feeds can balance the metabolizable energy, crude protein, and other essential nutrients. Technologies such as fodder crop production, mowing, and natural fodder conservation are not practiced in the study area. The adoption of these practices would be an essential step in improving the productivity of livestock and farmers' livelihoods. In that line, making hay, haylage and silage are optional processes for conservation and storing available feed resources during the rainy season. There is a need for a supply network to improve animal productivity with energy-rich supplements such as commercially balanced feeds, protein byproducts (meat, blood and bone, fish, meal from leguminous leaves, industrial byproducts, oilseeds, poultry litter, etc.), and cereal byproducts (rice bran, corn, wheat). We believe that the FEAST software tool can be used successfully to improve livestock production by identifying critical opportunities to crop and livestock management. Therefore, we recommend its use nationwide at district level to capture the existing different agropastoralist production systems and providing means for improving livestock productivity through improved feeding in Burkina Faso.

Competing Interests

All the authors do not have any possible conflicts of interest.

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