Info Note

Managing local fodder species for a competitive gender-sensitive goat value chain: achievements and lessons learnt from climate-smart villages in northern Ghana

Franklin K. Avornyo, Robert B. Zougmoré, Samuel T. Partey

APRIL, 2020

Key messages

- Goat emerged as the animal of choice for poverty reduction, especially for women in Upper West Region (UWR) of Ghana, yet the goat value chain suffers from, among others, lack of feed particularly during the farming season, thereby negatively impacting on livelihoods
- UWR farmers as most prioritized, beneficial and nutritious for integrated tree-crop-livestock production systems have identified five local browse species (Faidherbia albida, Ficus sycomorus gnaphalocarpa, Afzelia africana, Annona senegalensis and Combretum mole). Also, lab analyses of palatability, nutritive value and digestibility indicate that feeding goats with these local browse species as whole or supplementary can be effective for production as daily crude protein requirement will be met
- These browse species are potentially available year-round but overly-exploited and exacerbated by climate change and variability
- A multi-storey multispecies fodder-bank system that concentrate preferred species on the same farm management unit alongside forbs, grasses and fast-growing fodder legumes was established and became fodder and propagule supply-source for farmers in Eremon-Bompare, Eremon-Dazuure and Doggoh CSVs
- With Leucaena leucocephala, Moringa oleifera, Cajanus cajan, Stylosanthes hamata, Sorghum almum, Andropogon gayanus, Sclerocarya birrea, Spondias mombin and Dichrostachys glomerata gone past the stage of harvesting, the fodder bank became operational at 12 months and planting materials could be obtained from them

In Ghana, women participation in the small ruminant value chain as a poverty reduction strategy is increasing. However, fodder of good nutritive value is relatively unavailable. Considering this need, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) has been using its Climate-Smart Village (CSV) approach to test and promote the adoption of climate-smart agricultural (CSA) interventions such as the management of useful fodder tree and shrub species. This research for development work was initiated in 2016 and implemented through various steps. We started with the analysis of ruminant production systems and identification of predominant feeding practices in order to identify and prioritize potential browse species for quality in terms of their nutrient profile, preference and digestibility by goats. This was followed by an evaluation of the goat value chain in the context of climate change and variability, with suggestions on improvement options for farmers especially women. We also investigated the potential availability of the prioritized browse species and interventions needed. The development of a multispecies fodder bank that concentrates preferred species on the same farm management unit alongside forbs, grasses and fast-growing fodder legumes was then identified and initiated for ensuring sustainable all-year-round fodder and propagule availability for small ruminant producers and traders against increased future demand for meat. A combination of desktop review, questionnaire interviews, direct field observations and experiments was therefore used between 2016 and 2019 to generate findings presented in this info note.

IFAD Investing in rural people · European Union · CSIR · ICRISAT · CGIAR · Research Program on Climate Change, Agriculture and Food Security · CCAFS

Local browse species for sustainable ruminant production

Ruminant production in Lawra and Jirapa districts was largely a male dominated enterprise. This notwithstanding, women participation in this enterprise seemed quite encouraging with about 21% of producers engaged in the sector being females (Avornyo et al., 2018). In South Western Nigeria however, Ogunlana et al (2006) reported that most small ruminants were owned by women. Since the sedentary type of rearing is practised in Ghana, goats may be more suited than sheep. In the dry season, ruminants were kept on free range. In the wet season, small ruminants particularly goats were tethered with or without feed supplementation.

In the study that researchers and agricultural staff conducted in 2016 at Climate-Smart Villages (CSVs), namely, Eremon-Bompare, Eremon-Dazuure and Doggoh, in order to identify and prioritize potential browse species, a total of 34 browse plants were identified and the most frequently browsed species were *Faidherbia albida, Ficus sycomorus gnaphalocarpa, Afzelia africana, Pterocarpus erinaceus, Annona senegalensis* and *Combretum molle.* Mokgologi et al. (2001) identified *F. albida* as highly preferred by farmers in West Africa.

Results also showed that women mostly cultivated groundnut, maize, cowpea, bambara groundnuts, sorghum, millet and rice while men cultivated yam in addition. Twenty-eight (28) different tree/shrub species were identified on their farms. Ten most common ones were *Mangifera indica, Faidherbia albida, Vitellaria paradoxa, Parkia biglobosa, Ficus sycomorus gnaphalocarpa, Blighia sapida, Anacardium occidentale, Diospyros mespiliformis, A. africana* and *Moringa oleifera*. While twenty-two (22) of them served as animal feed sources, eighteen (18) served as human food sources such that fifteen (15) species were characterized as serving both needs. So just three (3) of them did not serve as fodder or food source. These species also served other purposes such as for soil fertility improvement, source of income, timber, making of xylophone, making of 'Oware' (a tool for playing a pit and pebble game), fuelwood, medicine, provision of shade, windbreaks, prevention of soil erosion and inducing rainfall. While these cultural practices may promote the availability and conservation of tree species on crop farms (Thapa et al 1997), leasing of lands may discourage the tending of economic trees on leased lands (Ogunlana et al., 2006).

The presence of anti-nutritive factors in these species confers the medicinal properties associated with them (Saganuwan, 2017). The leaves of *Annona senegalensis*, for instance, were used to bath newly born babies in the belief that it helps the baby develop strong bones and grow fat. It was also used to treat bone fractures. The presence of anti-nutritive factors could also contribute to a reduction in the production of methane and ammonia gas when the plants are consumed by ruminants (Estell et al., 2014).

Palatability, nutritive value and digestibility for goat production

Photo: Annona senegalensis.
Credit: Reiichi Miura

From the lab analyses we conducted (Avornyo et al., 2018), the crude protein (CP) values of the preferred browse species were higher than the minimum CP requirement for goats for maintenance. Therefore, feeding goats with these local browse species as whole or supplementary can be effective for production as daily CP requirement will be met (Machen, 2012). *Faidherbia albida* and *Ficus gnaphalocarpa* were found to have higher contents of phosphorus (P). Comparing the browse species, goats seemed to have preference for *A. senegalensis* and *A. africana* and this may be due to their low content of anti-nutritive factors and very good amino acid profile (Yisa *et al.,* 2010; Okunade *et al.,* 2014). On the other hand, Gidado *et al.* (2013) found a higher content of anti-nutritive factors in *P. erinaceus* compared to *A. senegalensis* and *A. africana*. They found the saponin level of *P. erinaceus* to be 4.42%, which was higher than the ruminant-tolerable level of 1.5 to 2% reported by Onwuka (1983) and would therefore impart a bitter taste and a lower preference. Feedstuffs with relatively high ash or fibre contents were also less preferred.

The amounts of feed intake were typical of most palatable fodder species with the exception of *P. erinaceus* which was lower ($P<0.05$). This suggests that *P. erinaceus* in particular should not be fed as the only feed for the animal otherwise the animal would starve. In fact, goats that were fed only *P. erinaceus* appeared to show visual signs of intoxication towards the latter stages of the experiment but none of them died. Meanwhile, *P. erinaceus* was a popular browse plant in northern Ghana, and it was the most common fodder species sold in Upper West Region. The apparent digestibility values were also typical of most fodder species. Nitrogen retention was also positive for all of them.

Even though the goats showed preference for A. *senegalensis* and *A. africana*, yet in terms of digestibility and nitrogen retention, *Ficus gnaphalocarpa* appeared to be the overall best fodder species. This notwithstanding, in terms of enhancing the blood profile of the goats, it was found to be the least beneficial and the reason may be because of the presence of anti-nutritive substances causing an inhibition of the absorption of cobalt from the gut. It appears that when a particular feed is very palatable, the goat would eat a lot of it and much is eventually egested as faeces. If such a feed is rich in nutrients, a lot of the nutrients may be absorbed but appreciable amounts might also escape in the faeces. An example in this case was *A. africana*. On the other hand, if the palatable fodder species is not rich in nutrients, then very small amounts of nutrients would be absorbed and an appreciable amount may escape in the faeces. An example in this case was *A. senegalensis*. The consumption of unpalatable fodder species such as *P. erinaceus* is small and so very little faeces is passed out and the extent of absorption is to a large extent determined by the amount of anti-nutritive factor in the feed. Fodder species of fairly high palatability may give the overall best result because intake is not excessive and therefore faecal output is also not excessive thereby giving the gut of the goat more time to absorb the nutrients in the feed. The Organic Matter digestibility values of *A. senegalensis* and *A. hypogaea* appeared to be higher than that of *Medicago sativa* hay, which is considered to be of good nutritive value (Ramirez-Orduna et al, 2003). The digestibility values appeared similar to those obtained by Sabia et al, (2015) for berseem clover but higher than those obtained for barley by the same authors. Generally, about half of the N in these forage species was not utilized by goats but may rather be present in their urine and faeces. Bruinenberg et al, (2003) recovered about two-thirds of consumed N in the faeces and urine of dairy cows. Ruminant faeces and urine may therefore constitute valuable nutrient sources for crops.

After the analysis of their blood samples, the goats which were acquired for the experiment were suspected of having a condition like megaloblastic macrocytic anaemia in humans caused by vitamin B12 and folate deficiencies (Cafasso and Gotter 2017). Ikhimioya and Imasuen (2007) observed similar anaemic conditions in female West African Dwarf (WAD) goats of similar age to those used in this study. These animals, like those used in this study, were bought from the open market. Dietary tannic acid has the tendency to reduce the utilization of Co, which is a vital ingredient for the production of cyanocobalamin also known as vitamin B12 (Rubanza et al., 2005). The use of biochar as an additive at 1% (Sengsouly and Preston, 2016) or brewers' grains at 4% (Binh et al., 2017) has been found to neutralize the effects of most anti-nutritive substances in browse plants. After all our experimental goats were subjected to the various treatments including the consumption of the selected browse species, a second analysis of their blood samples suggested that there was noticeable improvement in their health.

Ranking	*Palatability (g DM consumed in 3 h/goat)	Nutritive value		*DM digestibility (g/kg DM)
		CP (g/kg DM)	P (g/kg DM)	
1st	*Annona senegalensis* (73[a])	*Faidherbia albida* (222[a])	*Faidherbia albida* (1.4[a])	*Annona senegalensis* (695[a])
2nd	*Afzelia Africana* (71[a])	*Afzelia africana* (137[b])	*Ficus gnaphalocarpa* (1.1[a])	*Ficus gnaphalocarpa* (691[a])
3rd	*Pterocarpus erinaceus* (56[b])	*Ficus gnaphalocarpa* (116[c])	*Pterocarpus erinaceus* (0.7[b])	*Pericopsis laxiflora* (628[a])
4th	*Pericopsis laxiflora* (42[c])	*Pterocarpus erinaceus* (105[c])	*Afzelia africana* (0.7[b])	*Afzelia africana* (533[ab])
5th	*Arachis hypogaea* (42[c])	*Annona senegalensis* (81[d])	*Annona senegalensis* (0.5[c])	*Pterocarpus erinaceus* (418[b])

***Table 1**. Ranking of the prioritized browse species according to their resource value for goat production*

**Faidherbia albida* was not in season during the time the palatability and digestibility studies were undertaken. *Ficus gnaphalocarpa* was withdrawn from the palatability studies. *Pericopsis laxiflora* was inadvertently included in the experiment because farmers had difficulty in distinguishing it from *P. erinaceus* and therefore selected it among the prioritized browse species.

Figures with different superscript letters in the same column are statistically different at (P<0.05).

Goat value chain and fodder availability in the context of climate change and variability: a gender lens

Photo: Goat.
Credit: C. Schubert (CCAFS)

A survey conducted by Avornyo et al. (unpublished) in the study zone revealed that women were strategically located in the livestock markets selling forage materials, food items and other items that goat traders patronized. No female respondents were recorded in the category of Traders, Transporters, Butchers, and Carcass Dressers (Figure 1). However, it appeared that women participation in small ruminant trade might be emerging in Upper East Region. There were also few women who provided veterinary service. The incidence of physical risk and strenuous activity makes it difficult for women to show interest and participate more fully in the small ruminant value chain. This contrasts with relatively high participation by women in the small ruminant value chain in some other West African countries. For example, women from Benin travel to Niger to buy small ruminants for Tabaski (CNFA, 2016). In Nigeria, an estimated 40% of traders in Oranyan market were women, while in Abeokuta, women outnumbered men in the small ruminant trade. In the southwestern city of Ibadan, one-third of the butchers in the abattoirs were women (CNFA, 2016). Women should be given priority in interventions aimed at increasing production and market participation to enhance their income levels and improve the food security in the region. This can be done by supporting women to increase the number of goats they rear. Even prized animals such as the red goat (Chevre rousse de Maradi) of Niger can be introduced to women in northern Ghana to fetch them premium prices. Ghanaian consumers prefer the chevon of male goats possibly because the meat of male goat is considered to be softer (CNFA, 2016). Women can participate in the production tasks and fattening of animals. A woman can organize other women in the form of a cooperative to achieve this initiative. Small ruminant producers need to aim at having more access to feed against future demand for meat as disposable income and human population increase. Women also produce leather products, specializing in certain items such as poofs.

Figure 1. *Gender distribution of actors in goat value chain in Upper West Region.*

Ghana has been experiencing increasing temperatures, frequent droughts particularly in August and erratic rainfall patterns, and Jirapa and Lawra districts are not an exception. Hotter temperatures are generally associated with reduced feed intake and increased water consumption (Hidosa and Guyo, 2017). Frequent storms also cause fodder trees to fall. Partly due to drought and bush fires, these fodder species are becoming more deciduous in character. Insect attack on fodder leaves is becoming common and this reduces feed quality sometimes posing danger to animals that ingest these insects. Fodder trees used to be common in community compounds. Adverse changes have been observed with slow tree growths and poorer quality of fodder (Rust and Rust, 2013) or fruits as well as reduced canopies. However, fodder trees are quite resilient to drought because of their deep rooting system. The incidence of fall army worm would reduce the amount of cereal crop residue available to ruminants. Low groundnut yields may discourage groundnut production which will affect the quantity and quality of fodder for livestock. According to Hidosa and Guyo (2017), climate change is contributing to increased lignification of plant tissues thereby decreasing the digestibility of forage by ruminants. There is a concurrent shift from C3 grass species to C4 grasses induced by increasing temperatures and this has adverse implications for forage quality and supply (Rust and Rust, 2013). Climate change also appears to cause a gradual transition leading to a reduction in tree cover and an increase in shrub cover that reduce the quantity and quality of forage and rangeland productivity available for livestock (Hidosa and Guyo, 2017).

Challenges along the goat value chain

Late outset of the rains causes delays in the emergence of vegetation thereby widening fodder scarcity period and accentuating the importance of supplementary feeding. Also, very little successful breeding occurs during the period of tethering because of reduced contact time between the sexes, undernourishment and general stress on the animals. Theft of goat was ranked by about 64% of respondents as a socioeconomic factor that had a high effect on production. Goats become easy targets for thieves when they stray in search of feed particularly under *F. albida* and *A. africana* trees during flowering. The traditional and formal structures of justice delivery did not seem to be effective. In terms of technical factors, about 64% of respondents reported that high incidence of disease was a major factor that was severely affecting their production. The disease was commonly referred to as the sheep and goat plague which respondents attributed to the changing climate. Another disease which was increasing in incidence was mange. The most worrying institutional factor reported by majority (61%) was the inadequate or no access to credit, which impeded expansion of the goat enterprise.

Other challenges reported to adversely affect the sector largely had to do with marketing, including unsatisfactory market prices (69%), high cost of transportation (38%),

poor market infrastructure (37%) and unavailable market information (37%). Respondents classified these as having very high effects on their production activities and addressing them would help improve their general wellbeing.

Weaknesses and threats in the goat value chain:

- Improperly organized, fragmented and poorly-developed goat value chains;
- Difficulty with actors establishing their own linkages;
- Inappropriate transport, poor road conditions and network hampered the activities of Transporters, Traders and Producers;
- Infrastructure in the main markets were sub-standard (e.g. the slaughter houses had no slabs, hangers or even running water);
- Both the wet and long dry seasons posed a threat to animal health and safety;
- Cases of armed robbery during transit were reported;
- Unaffordable cost of veterinary treatment;
- High charges by the District Assembly and unapproved fees collected by police officers were leading to investment disenchantment;
- Gradual change of land tenure from communal to individual ownership

With regards to fodder production and trading, men and children assisted women in the harvesting of fodder. Women and girls participated in the sale of fodder. In smaller towns, only *F. albida* fruits were sold but in bigger towns and cities, there was more variety, and *P. erinaceus*, *F. gnaphalocarpa* and *A. africana* were among the fodder materials sold. Even though fodder traders at the CSVs did not organize themselves into groups, women fodder traders at Kong in Sissala East District belonged to a group which was named 'Fodder Marketing Group'. These women also participated in fodder markets in Burkina Faso. *Faidherbia albida* and *Ficus gnaphalocarpa* were mostly found within 1 km radius of the settlements of Eremon-Dazuure and Doggoh in Lawra and Jirapa Districts, respectively, while *A. senegalensis, Afzelia africana* and *Pterocarpus erinaceus* were found outside this radius. It was also observed that though seedling numbers were high, a large proportion of them were not tended to be recruited into the sapling and adult tree stages (Figure 2), a situation that did not favour natural regeneration and sustainability of stocks. Available fodder dry matter at Eremon-Dazuure was capable of providing feed for 1,642,260 goats for a day or 4,499 goats in a year while that at Doggoh was capable of feeding 1,027,080 goats in a day or 2,814 goats in a year assuming each goat was offered 500 g dry matter per day. Each goat farmer in the CSV had between 5 and 20 fodder trees on their farm.

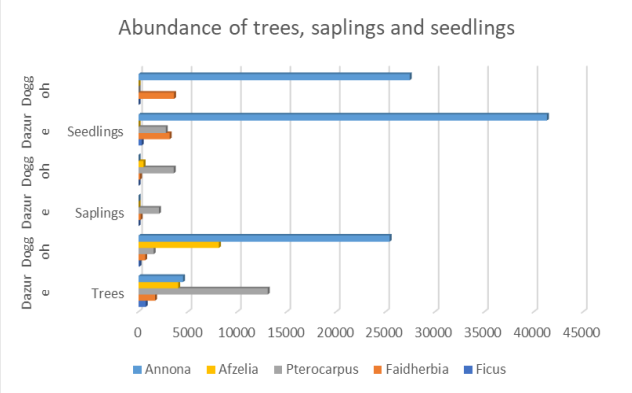

Figure 2. *Abundance of trees, saplings and seedlings of five preferred browse species in Eremon-Dazuure and Doggoh communities in Upper West Region.*

Climate-smart fodder bank development for income generation

In an effort to build capacity in the cultivation and management of fodder species with the aim of increasing small ruminant producers' access to feed against future demand for meat, one (1) ha site was planted with highly ranked fodder species, namely five browse tree species (*P. erinaceus*, *A. africana*, *F. albida*, *F. gnaphalocarpa* and *K. senegalensis*), three woody legume species (*Cajanus cajan*, *Moringa oleifera* and *Lucaena leucocephala*), two herbaceous legume species (*Lablab purpureus* and *Stylosanthes hamata*), one fodder grass (*Sorghum almum*) and two food-feed crops (sweet potato and cassava). Even though *K. senegalensis* had many uses, it was believed to have the potential to attract rainfall. Jatropha, which was used as the live fencing material would control termite infestation on the farm. The cost of establishing this fodder bank was estimated at GH₵18,528 (US$3,766). Planting materials alone constituted 35 to 45% of total cost of establishment. The fodder bank had the potential of serving as a source of planting materials for propagation of valuable species. Women substituted for their husbands and vice versa to provide labour in the fodder bank. When a woman substituted for her husband, the proceed was shared equally, but the men did not share their wages with their wives.

In all, eighteen (18) palatable fodder species were identified in the fodder bank, twelve (12) months after the cultivation of the fodder bank. Therefore, in addition to the thirteen (13) species which were planted to generate fodder for goats in the community, other valuable fodder species were also found in the fodder bank. They were *Sclerocarya birrea* (local name: kontie), *Andropogon gayanus* (local name: songmie), *Spondias mombin* (local name: bununa/busina) and *Dichrostachys glomerata* (local name: Susule). *Dichrostachys glomerata* in particular appeared to be a climate-smart fodder sp. as it appeared to be colonizing the area at a fast rate. However, *S. hamata* was the most successful of all the fodder species cultivated. Generally, the 18 fodder species in the fodder bank were fully established. In addition, some farmers who took some of the seedlings home and planted on their individual plots have additional feed as well as propagules. They had grown into a dense mass with numerous seeds. The biggest threat to the fodder bank was the incidence of bush fires despite the creation of a fire belt. Project farmers had

decided that in the rainy season, they would cultivate groundnut in the space demarcated as fire belt while serving as a fire belt in the dry season. The sale of the groundnuts planted in the 10 m wide fire belt (10 m x 440 m) would generate income to support the management of the fodder bank.

Lessons learned

The findings suggest that there is more potential for women in UWR to participate in the goat VC. Women are naturally adept at caring for small ruminants so greater efforts should be put into getting women participate in goat production, through the provision of start-up stock, input credits, and goat housing facilities. Women in goat trading and processing should be targeted for affirmative action with emphasis on grant provision, bookkeeping and business management training, and access to extension and veterinary services to boost their output and market margins.

The high incidence of theft can be reduced if local authorities strengthen and enforce their by-laws in dealing with vices. Security patrol needs to be intensified as is the case in Burkina Faso to deter theft of livestock. There was an indication that increasing fodder availability had the potential of reducing animal theft because the animals would not roam far. For effective combating of livestock diseases, there is the need to improve access to veterinary service and a search for alternatives to orthodox medicine such as the use of ethnoveterinary medicine and probiotics should be encouraged.

The risky nature of agriculture has made it relatively easy for profit-minded individuals and organizations to stay away from the sector. For those who are interested in supporting agriculture, their interest, which is rooted in traditional values, seems skewed to crops rather than livestock. There is lack of suitably developed places for livestock grazing. Livestock corridors should be defined and protected to reduce the intensity of transboundary infections and theft. Establishing a Livestock Development Fund at the Municipal/District level would help to boost domestic production and bridge the demand and supply gap.

Stakeholders should facilitate the formation of livestock producers' associations to enhance the bargaining power of producers so they can reap greater benefits from their efforts. Market tolls should be channeled into improving the infrastructure situation in the main markets and slaughterhouses. Affordable credit facilities should be made available to all interested actors to enhance their productivities. There should be awareness creation on tending of fodder tree seedlings on farmlands, rangelands, around homes and fallow lands. Bushfire prevention or management should therefore be encouraged in the communities and capacities built in chopping and baling of crop residue to improve intake and utilization. This can be achieved through the creation of fire volunteer squads and provision of rewards for well performing communities. The need to develop community nurseries to nurse seedlings of important fodder tree seedlings for enrichment planting is imminent.

Mining of gold and felling of trees for timber are activities taking place in some parts of Upper West Region including Wa East and Jirapa districts, and these activities pose a threat to the regeneration of tree resources and water bodies. *Pterocarpus erinaceus* and *A. africana* are among the trees being felled for timber.

Accurate climate information, livestock disease information and market price alert will inure to the benefit of actors and reduce their vulnerability position. Quality of fodder is likely to regress if efforts are not made to improve upon the quality of seed. Government therefore needs to facilitate and intensify the sale of fodder seeds and seedlings of useful multipurpose tree species such as *F. gnaphalocarpa*. Capacity also needs to be built in the cultivation and management of fodder species, as some species such as *F. gnaphalocarpa* are often difficult to cultivate and manage.

Conclusions and recommendations

The preferred fodder tree and shrub species were *F. albida, F. sycomorus gnaphalocarpa, A. africana, P. erinaceus, A. senegalensis and C. molle.* Comparing these browse species, goats seemed to have preference for *A. senegalensis* and *A. africana* due to their low content of anti-nutritive factors and very good amino acid profile. However, in terms of absorption of dry matter and nitrogen, *Ficus gnaphalocarpa* appeared to be the overall best fodder species. To effectively combat livestock diseases, there is the need to improve access to veterinary service and to embark on a search for alternatives to orthodox medicine such as the use of ethnoveterinary medicine. Stakeholders should facilitate the formation of livestock producers' associations to enhance the bargaining power of producers so they can reap greater benefits from their efforts. Women should be given priority in interventions aimed at increasing participation in the goat value chain. Effort is needed to procure more fodder seeds for the establishment of fodder nurseries to help reduce the cost of establishing fodder banks since planting materials alone constituted about 35 to 45% of the total cost. The biggest threat to the fodder bank is the incidence of bush fires despite the creation of a fire belt.

Photo: Afzelia Africana.
Credit: Warren McCleland (westafricanplants, 2020)

References

- Avornyo, F. K., Zougmore R, Partey S and Tengan K (2018). Local fodder trees and shrubs for sustainable ruminant production in northern Ghana. *Livestock Research for Rural Development*. Volume 30, Article #154. Retrieved September 4, 2018, from http://www.lrrd.org/lrrd30/9/favor30154.html.
- Binh, P.L.T., Preston, T.R., Duong, K.N. and Leng, R.A. 2017. A low concentration (4% in diet dry matter) of brewers' grains improves the growth rate and reduces thiocyanate excretion of cattle fed cassava pulp-urea and "bitter" cassava foliage, Livestock Research for Rural Development, 29: #104, Retrieved August 09, 2018 from http://www.lrrd.org/lrrd29/5/phuo29104.html.
- Bruinenberg, M.H., Valk, H. and Struik, P.C. 2003. Voluntary intake and in vivo digestibility of forages from semi-natural grasslands in dairy cows, Netherlands Journal of Agricultural Science, 51(3): 219 – 235.
- Cafasso, J. and Gotter, A. 2017. Red blood cell count (RBC), Retrieved on August 16, 2018 from healthline.com/health/rbc-count.
- CNFA (2016). Resilience and Economic Growth in the Sahel – Accelerated Growth (REGIS-AG) Project: Value chain and end market assessment – small ruminants. USAID Contract #AID-625-C-14-00001.74 pp.
- Estell R.E., Haystad K.M., Cibils A.F., Anderson D.M., Scott T. 2014. The changing role of shrubs in rangeland-based livestock production systems: Can shrubs increase our forage supply? Rangelands, 36(2): 25-31.
- Gidado, O.G., A. Kibon, Z.A. Gwargwor, P. Mbaya and M.J. Baba. 2013. Assessment of anti-nutritive factors and nutrient composition of some selected browse plants use as livestock feeds in Taraba State. Inter. J. Appl. Sci. Engr. 1:5-9.
- Hidosa D, and M. Guyo 2017. Climate Change Effects on Livestock Feed Resources: A Review. J Fisheries Livest Prod 5: 259. doi: 10.4172/2332-2608.1000259
- Ikhimioya, I. and Imasuen, J.A. 2007. Blood Profile of West African Dwarf Goats Fed Panicum maximum Supplemented with Afzelia africana and Newbouldia laevis, Pakistan Journal of Nutrition, 6 (1): 79-84, ISSN 1680-5194 © Asian Network for Scientific Information.
- Machen, R. 2012. Goat nutrition-protein. Small Ruminant Series. Texas Agri. Ext. Serv.
- Mokgolodi, N.C., Setshogo, M.P., Shi, L. *et al.,* 2011. Achieving food and nutritional security through agroforestry: a case of *Faidherbia albida* in sub-Saharan Africa. *For. Stud. China* **13,** 123–131 (2011). https://doi.org/10.1007/s11632-011-0202-y
- Ogunlana E A, Salokhe V and Lund R. 2006 Alley farming: A sustainable technology for crops and livestock production. Journal of Sustainable Agriculture, Volume 29, Article# 1: 131–144
- Okunade, S.A., O.A. Olafadehan and O.A. Isah. 2014. Fodder Potential and Acceptability of Selected Tree Leaves by Goats. J. Anim. Nutr. Feed Techn. 14:489-498.
- Onwuka, F.C. 1983. Nutritional evaluation of some Nigerian Browse Plants in the humid tropics. Ph.D. diss, Coll. Med., Univ. Ibadan. Ibadan, Nigeria.
- Ramirez-Orduna, R., Ramirez, R. G., Gomez-Meza, M. V., Armenta-Quintana J. A., Ramirez-Orduna', J. M., Cepeda-Palacios, R. and Avila-Sandoval, J. M. (2003). Seasonal Dynamics of Organic Matter Digestion in Browse Species from Baja California Sur, Mexico. J. Appl. Anim. Res. 24: 65-78.
- Rubanza, C.D.K., Shem, M.N., Otsyina, E.R. and Fujihara, T. 2005. Performance of zebu steers grazing on western Tanzania native forages supplemented with Leucaena leucocephala leaf meal, Agroforestry Systems, 65: 165-174
- Rust, J.M. and T. Rust, 2013. Climate change and livestock production: A review with emphasis on Africa. South African Journal of Animal Science 2013, 43 (No. 3) URL: http://www.sasas.co.za. ISSN 222-4062 (online), http://dx.doi.org/10.4314/sajas.v43i3.3
- Sabia, E., Claps, S., Napolitano, F., Annicchiarico, G., Bruno, A., Francaviglia, R., Sepe, L. and Aleandri, R. 2015. In vivo digestibility of two forage species inoculated by arbuscular mycorrhiza in Mediterranean red goats, Small Ruminant Research, 123: 83-87
- Saganuwan AS. 2017. Ethnoveterinary values of Nigerian medicinal plants: An overview. Eur J Med Plants 18(4): 1-35, 2017; Article no. EJMP.29321 ISSN: 2231-0894, NLM ID: 101583475
- Sengsouly, P. and Preston, T.R. 2016. Effect of rice-wine distillers' byproduct and biochar on growth performance and methane emissions in local "Yellow" cattle fed ensiled cassava root, urea, cassava foliage and rice straw, Livestock Research for Rural Development, 28: #178, Retrieved August 7, 2018, from http://www.lrrd.org/lrrd28/10/seng28178.html
- Thapa B, Walker DH, Sinclair FL. 1997. Indigenous knowledge of the feeding value of tree fodder. Anim Feed Sci Technol, 67: 97-114.
- Yisa, J., J.N. Egila and A.O. Darlinton. 2010. Chemical composition of *Annona senegalensis* from Nupe land, Nigeria. Afr. J. Biotechnol. 9:4106-4109.

Acknowledgment

This brief summarizes findings of a project entitled, "Managing local fodder species for a competitive gender-sensitive goat value chain: achievements and lessons learnt from climate-smart villages in northern Ghana'" undertaken by researchers from the Council for Scientific and Industrial Research – Animal Research Institute (CSIR – ARI) and the CCAFS West Africa Program based at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Mali. This brief focuses on the medium-term impact of CGIAR Climate-Smart livestock interventions in CSVs in northern Ghana.

"Funding for the research work in this report was provided by the European Union, as part of the European Commission's support to AR4D for the year 2019. The funds are administered by the International Fund for Agricultural Development (IFAD), Rome Italy while the project is implemented by Alliance Bioversity-CIAT.

''The authors accept full responsibility for the contents of this report. The report does not necessarily reflect the views of the European Commission or IFAD."

***Franklin K. Avornyo** (favornyo@yahoo.com) is the Principal Investigator of the project which is implemented through CSIR-ARI.*

***Robert B. Zougmore** (r.zougmore@cgiar.org) is the Africa Program Leader for CCAFS*

***Samuel T. Partey** (s.partey@cgiar.org) is the Science Officer for CCAFS West Africa*

Research led by: