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Feed inventory and feed balance of Ethiopia: salient findings and way forward

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Introduction

Livestock are vital for the food security and the livelihoods of millions of people in Ethiopia and will remain important in the coming decades. A large segment of the children suffers from malnutrition leading to stunting. Food of animal origin, even in small amounts, can play an important role in improving the nutritional status of children and pregnant and lactating women by mitigating micro- and macro-nutrient deficiencies. Meat and milk are good sources of vitamin B12, riboflavin and vitamin A. Meat also provides zinc, and milk provides calcium. Adding a small amount of animal source food to the diets of malnourished children can increase their energy and cognitive ability.

Recurrent droughts in pastoral Ethiopia have exposed the critical feed shortage that prevails in the country. Between 2000 and 2017, six drought episodes have been registered in the country, of which the latest two (in 2011 and 2016/17) had devastating effects on pastoral and agro-pastoral livelihoods. Available evidence indicates that pastoral destitution in Ethiopia is principally driven by feed and water scarcity, as the natural resource base in the rangelands is shrinking fast. Feed resources ought to be considered in the broader perspective and not predominantly during emergency as is the case now. Institutionalization of a feed security system is therefore requisite such that the country is aware of its needs, resource availability, gaps, implications and how the gap can be filled within the country, the region or beyond. This will make feed interventions in the country effective in the immediate, medium and long term as well as provide solutions for replication in the region.

There is a management quote: 'If you cannot measure it, you cannot manage it'. A pre-requisite for making the best use of available feed resources is to accurately assess their availability at national level along with their nutritive value. The assessments of current and future supplies and demands for livestock feed are also needed for national food security policy and planning, as well as for the setting of environmentally sustainable stocking rates. Feed resources properly assessed and monitored will provide information for the development and implementation of policies that will contribute to the sustainable growth of the national livestock sector. Information provided by livestock feed inventories would be of immense use for policy makers, government agencies, NGOs, intergovernmental agencies and development agencies in formulating and implementing sustainable livestock-development activities and for preparing and coping with climatic variations, such as droughts, floods, severe winter weather events and global climatic change. Spatial

and temporal assessments of current and forecasted feed resources, including forages, will assist in disaster management (e.g. in situations such as floods and droughts). Feed assessments will also inform decisions related to the nature and quantities of commodities, the feed resources that could be traded locally, potential areas for feed markets, and feed resources that are imported and exported. Although livestock-feed shortages have clearly constrained productivity in many countries, the impacts of feed shortages at national levels have been poorly characterised due to the lack of national-scale feed assessments. In addition, information on availability of feed ingredients at a country level will enhance efficiency and profitability of the animal feed industry and assist researchers to formulate sustainable feeding strategies. The estimation of feed resources at national level will also improve the accuracy of estimates of the environmental impacts of livestock, not only through land-use transformations, but also in the estimation of greenhouse gas emissions associated with livestock production. It would also be of use for determining potential for carbon sequestration. Generation of feed balance at country level will be possible with the feed-inventory information, which will assist in proper planning of the livestock industry; for example, the number of animal heads that can be raised with the existing feed resources and determining what feed resources should be made available to achieve the set targets. Such efforts will, in turn, translate into enhanced food security.

The feed inventory entails information and data on what, how much and where various feed resources exist. Feed balance is the balance between availability and demand. This short paper presents feed inventory and feed balance of Ethiopia in terms of dry matter (DM), metabolizable energy (ME) and crude protein (CP) for each of the 10 regions of Ethiopia and for the nation. It is expected that the findings reported in this study would help informed decisions making in meeting feed shortages in drought-prone areas and in building sustainable livestock production systems on sound footings in Ethiopia. This would also guide donors to prioritise their funding in the animal production sector and within this sector, on which aspects in the animal feed and feeding area.

The under-developed animal feed sector is one of the major bottlenecks for a sustainable and more efficient livestock sector development in Ethiopia. Accordingly, this paper highlights the importance of developing this sector in an informed and evidence based manner. The newly generated feed-related data given here together with the innovations reported that pay strong attention to the environment, could create the basis to support the implementation of the ambitious Ethiopian Livestock Master Plan (Shapiro et al., 2015) while creating new job opportunities, especially for the increasing young population, along a potentially well organised feed supply chain.

National Feed inventory

Four major cultivated crop-based forage (crop residues such as straw, stover, haulm; stubbles; and feeds derived from permanent crops) production regions in Ethiopia are Oromia, Amhara, Southern Nation, Nationalities and People Regional (SNNPR) and Tigray. In this group of feed resources, in Oromia, maize stover availability is highest (39%), followed by straws of sorghum (22%), wheat (16%) and teff (15%). In Amhara, availability of sorghum straw is highest (29%), followed by those of maize (25%) and teff (18%). In SNNPR, availability of straws of maize, sorghum and teff are 61, 13 and 11% respectively. In Tigray, sorghum straw availability is highest (55%). The pattern of availability of pulse straw is the same as of cereal straws/stovers; highest being in Oromia followed by Amhara. In Oromia, the availability of horse bean straw is highest, followed by those of haricot and chickpea; and in Amhara availability of horse bean straw is also highest (33%), followed by chickpeas and grass peas straws. In Oromia, noug straw availability is highest (53%) and those of groundnut and linseed are 18% and 16% respectively; while in Amhara, sesame and noug are the main straws available. Crop-based forages in Oromia, Amhara and SNNPR contribute 47, 30 and 13% respectively of the total metabolizable energy (ME). Same is the trend for crude protein (CP) availability from the crop-based forages. In Ethiopia, total annual contribution of crop-based forages is 52.7 million tonnes, which include 5.8 million tonnes of stubble

biomass and 1.72 million tonnes from permanent crops. The biomass contribution of grazing pastures is 57.09 million tonnes, which is 1.08-fold higher than that of crop-based forages.

Oil seeds cakes of about 567 thousand tonnes are potentially available in Ethiopia in a year; of which noug cake potential is highest at 34.2%, followed by sesame at 26.2%. Currently, almost all sesame seeds are exported and hence contribution of its seed cake for animal feeding is non-existent. Oromia and Amhara regions produce almost 79.1% of the total oilseed cake production, each contributing 43.7% and 35.4% respectively. In Amhara, potential production of sesame cake is highest (40%), followed by noug cake (24.5%); while in Oromia noug cake availability is highest (54.5%) and then is of linseed cake. The production of oilseed cakes in Somali, Harari, Gambela and Afar is negligible.

A total of 2.041 million tonnes of cereal brans are potentially available in Ethiopia in a year (almost 3.6 times higher than of oilseed cakes and 25.8-fold lower than of crop-based forages). The highest production is in Oromia (50.0%), followed by Amhara (30.9%), SNNPR (10.2%) and Tigray (6.4%). In other regions the potential availability is low. Oromia, Amhara, SNNPR and Tigray are the main regions for CP availability from concentrates, contributing respectively 49, 31, 10 and 7% of the total. Potential annual pulse milling by-products (bran/bulule) availability is approximately 488 000 tonnes (almost 4.2-fold lower than that of cereal brans). Oromia followed by Amhara and SNNPR contribute almost 97% of the total ME and CP production from pulse milling by-products. Annual availability of sugarcane tops and sugarcane bagasse in SNNPR is 110.2 and 123.4 (both $x10^3$ tonnes) respectively; while these values for Amhara are 22.9 and 25.5 (both $x10^3$ tonnes) and for Oromia 42.9 and 48.1 (both $x10^3$ tonnes) respectively. For enhancing livestock production, decreasing cost of transport and storage, and increasing shelf-life, densified forage-based total mixed ration (DFB-TMR) is an appropriate technology for establishment of strategic feed reserves in the form of feed bank or for use of forage-based total mixed ration during droughts (FAO, 2012). Other feed resources such as oilseed cakes, brans and molasses, required for production of the DFB-TMR, are also available in the regions of forage availability. Availability of all ingredients for producing DFB-TMR in these regions opens new avenues to establish units for their production. Also a large amount of biomass is produced in these regions, suggesting that these regions have high potential for establishing other agro-based industries.

Total annual potential biomass available for animal feeding in Ethiopia is 144.48 million tonnes, with embedded ME and CP respectively of 890 x 10^9MJ and 7.49 million tonnes. The contribution of forages is 96.6% and 93% towards total ME and CP availability in Ethiopia. Poultry, aqua and pig feeds require energy and protein dense feed resources, which are highly scares in Ethiopia. Efficient use of agro-industrial and food processing by-products and of lesser-utilized feed resources could bridge the gap between supply and demand to some extent. Concerted efforts are needed to enhance the availability and efficient and more effective utilization of good quality feeds in Ethiopia.

National Feed Balance

A large sub-national difference exists in terms of feed surpluses and deficits. Eight out of ten regions are deficit in feed resources. The contributions of cattle, sheep and goats towards total ME requirements are 83%, 4.7% and 4.7%, while these figures for CP requirement are 79.5%, 6.1% and 5.5%. The difference between availability of feed resources as dry matter (DM), ME and CP and the requirements of all animal species (i.e. feed balance) showed that feed deficiency in Ethiopia is 9% as DM, while ME and CP deficiencies are 45% and 42% respectively, again suggesting lack of good quality feeds in the country. Two regions, Benishangul-Gemuz and Gambela have positive feed balance which could be attributed to relatively low livestock population (due to presence of tsetse fly) in these regions. A large amount of grasses is available in these two regions which is currently not being efficiently utilized. These mature and get burnt when dry, causing pollution. Efforts are needed to harvest and densify them for use in other regions. Similarly, other biomass available in other regions is being wasted and not properly utilized mainly due to unavailability of agriculture equipment such as

mowers, harvesters, choppers and mixers, among all. Developments in the agricultural equipment manufacturing sector would help utilization of biomass for feed production.

After considering the competitive uses of crop residues and export of oilseeds, the feed deficiency increased to 21.6% as DM, and 51.7% and 48.2% as ME and CP respectively (Table 1). There is a need to consider ways to meet these deficiencies. Some possible ways to achieve this are listed in the 'Way Forward' section.

The analyses for Afar and Somali Regional States are based on the data availability for only 2 and 3 zones respectively (CSA, 2016-2017). Further resources and investments are required to gather reliable data on livestock number and crop production for all zones in these two predominantly pastoral regions.

In another FAO study (FAO, 2019), a total of 7.58 million tonnes (DM) of agro-industrial by-products with embedded crude protein (CP) and metabolizable energy (ME) of 762846 tonnes and 73.34×10^9 MJ were recorded. Out of these, the use of the by-products as animal feed was 5.1 million tonnes containing 639 559 tonnes of CP and 52.15×10^9 MJ of ME. Slaughterhouse offal, brewery by-products, food industry by-product (mainly biscuit waste) and molasses could not be included in the feed inventory and feed balance conducted for Ethiopia (FAO, 2018). These additional feed resources would add an additional 1 084 770 tonnes of DM, 213 389 tonnes of CP and 11.28×10^9 MJ of ME to the national feed inventory. Their contribution to the total actual feed DM, CP and ME availability in Ethiopia is only 1.08%, 3.08% and 1.42%respectively. This would lead to a reduction in national feed balance of DM, CP and ME to -20.07%, -45.06% and -50.26% from -21.16%, -48.24% and -51.70% respectively. Currently, the contribution of these by-products to the total feed use is negligible.

Implications

The feed inventory presented in this paper also maps the availability of an array of biomasses (Figure 1),

Table 1. Feed balance as dry matter, crude protein and metabolizable energy after taking into account competitive uses of resources

Regional State	Feed dry matter balance (%)	Feed metabolizable energy balance (%)	Feed crude protein balance (%)
Tigray	-21.07	-53.06	-51.87
Afar*	-35.14	-51.30	-48.10
Amhara	-16.88	-50.68	-47.04
Oromia	-24.03	-53.93	-50.87
Somali*	+29.39	-5.02	+0.57
B-G	+142.98	+47.16	+73.37
SNNPR	-40.31	-62.62	-57.89
Gambela	+280.36	+139.05	+163.52
Harari	-70.98	-81.28	-84.09
Dire Dawa	-55.53	-69.34	-74.49
Total	**-21.16**	**-51.70**	**-48.24**

*Areas and biomass correspond to three zones of Somali, and to two zones of Afar, as per CSA (2016–2017)

which could form the basis for development of agro-based industries. The information generated through this study would assist the government, donors, entrepreneurs and the private sector in formulating investment strategies for development of the agro-based sector. Ethiopia is actively developing Integrated Agro-Industrial Parks. The information generated could also be used by both public and private sectors that wish to benefit from the Agro-Industrial Parks. Also the data generated would assist in better understanding of the value chains linked to use and misuse of the biomass, and in developing strategies for their efficient use including following the concept of circular economy and wastage reduction. This would also open new avenues and opportunities for green economy development, job creation and environment protection.

To overcome the feed shortages in droughts and for their effective management, the common biomass required to produce feeds are: crop residues including straws, stovers, sugarcane tops, bagasse, grass hay, pulse and cereal milling by-products (brans), and oilseed cakes.

Figure 1 pictorially shows their availability in Ethiopia. In Benishangul-Gemuz and Gambela (the regions with positive feed balance), the availability of crop residues is 931.6 and 44.3 (both: $x10^3$ tonnes) respectively; while that of pasture grasses is much higher: 2 874.9 and 1 820.5 (both: $x10^3$ tonnes) respectively.

Other biomasses that could be used for feed production are sugarcane tops and sugarcane bagasse, which are available in high amounts in SNNPR, Amhara and Oromia. There is a substantial availability of sugarcane tops and sugarcane bagasse in SNNPR, Oromia and Amhara. These biomasses, in particular a mix of bagasse, sugarcane tops, grass hay and cereal straws (in different proportions, depending on their availability) can be used to prepare densified complete feed blocks for

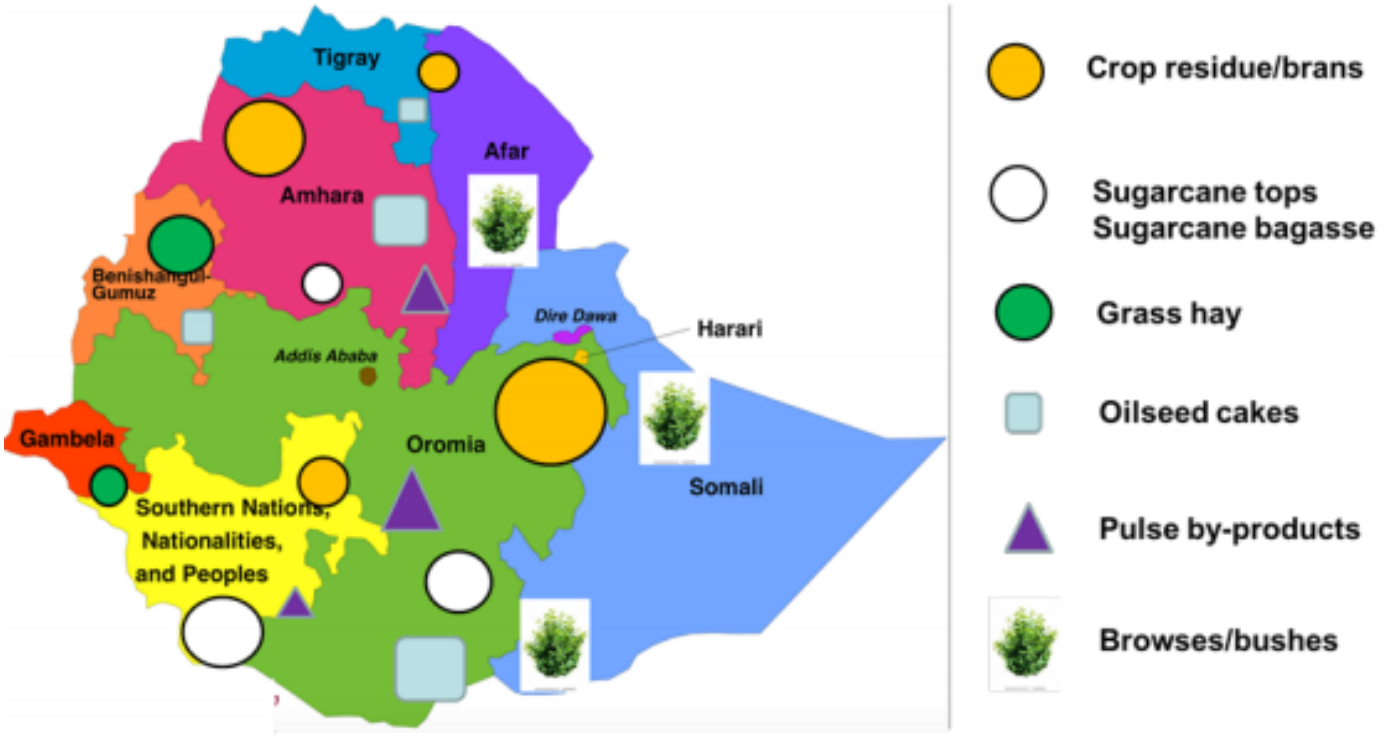

Figure 1. Pictorial presentation of various biomass available for meeting the feed requirements during droughts in Ethiopia (higher the dimension of the symbols, higher is the availability of the biomass it represents)

emergency periods. During the densification, these ingredients can be fortified to produce a balanced ration. In 2017, availability of another good feed, molasses in Ethiopia was 150 740.3 tonnes, which could be used for preparation of emergency feeds in the form of densified feed blocks and urea molasses multi-nutrient blocks (UMMB) or molasses could be fed by mixing with urea. Total production of crop residues in Ethiopia is 52.7 million tonnes. Literature suggests that on feeding crop residues *ad libitum* with an oilseed cake at 0.5% of body weight per day (0.5 to 1 kg per day depending on body weight of the animal) to ruminants, on an average 5 kg of crop residues can be turned into 1 kg animal live weight (Leng, 2004). This translates to production of 10.5 million tonnes of live animals annually (5 million tonnes of boneless meat containing *ca* 1.31 million tonnes protein). According to WHO, consumption of protein by an adult should be 60 g/day or 22 kg protein/year. If 100% of this protein consumption are from meat, crop residues could support protein requirement of 60 million people per year. In practice 100% of the protein consumption will not be from animal sources; plant sources would also contribute to the protein requirements, suggesting that efficient utilisation of crop residues could produce animal protein that could meet protein needs of a large segment of Ethiopian population.

The cost of transport and storage could be decreased by densifying the forages. Technological options and machines vary from low to high cost ones. Business approaches must be developed and implemented to achieve and sustain the use of the densification approaches. The densification plants should be set up near the place of biomass availability and this report provides guidance for the identification of places for erection of such plants, and for using other densification approaches (baling, pelleting, briquetting, and formation of total mixed ration as mash, etc.).

The densified feeds as blocks, pellets or bales could be transported to fodder/feed banks that must be near to the places where droughts generally occur. These banks should be established and stored before the droughts strike. The distribution of feed from these banks would decrease livestock mortality and morbidity in the lowlands during droughts and would also stem increase in feed prices in the highlands, which generally occurs during droughts. The feed banks would also help in decreasing volatility in feed cost.

At times of severe drought, browses present *in situ* could constitute a bulk of feed for livestock. These feed resources are rich in polyphenolics (tannins) -- anti-nutritional factors that limit nutrient availability and decrease nutrient utilization in animals. For areas rich in browses, introduction of browse-enhancers could enhance the use of browses as animal feed and help prevent livestock mortality.

Way forward

The findings reported in this study would help taking informed decisions on meeting feed shortages in drought-prone areas and in building sustainable livestock production systems on sound footings in Ethiopia. Based on the analysis conducted in this study, some concrete steps that may be taken are:

1. Institutionalize work on generation of Feed Inventory and Feed Balance within the concerned ministry, so that it is updated every year.

2. Consider establishing fodder/feed banks near the places affected by droughts, and use densification technologies at places of biomass availability to densify feeds to reduce transport and storage costs (jointly with the ministry and communities, mapping of exact locations for setting up of feed banks and densifying units should be initiated as soon as possible).

3. Develop a plan to secure: a) grasses to produce hay, densified blocks or pellets from Benishangul-Gemuz and Gambela regions, and b) sugarcane tops and bagasse for preparation of densified complete feed blocks; and implement the plan.

4. Promote agricultural mechanization e.g. local production of hydraulic presses, forage harvesters, high-throughput balers, forage choppers, etc.

5. Promote fodder production as a cash crop, and widely promote use of fodder shredders, fodder balers, silo compressors etc.

6. Promote establishment of commercial units for multi-nutrient block production, forage chopping,

forage densification and pre-mix production.

7. Promote the use of urea-molasses multi-nutrient blocks in the rangelands, near the water points or at places where animals gather during nights, especially when the quality of grazing pasture decreases in dry periods.

8. Introduce approaches to efficiently use *in situ* browse biomass available during droughts, using browse-enhancers. Introduce prosopis-pod crushing machines for disintegrating the pods before using as animal feed. Pastoralists must not feed whole pods.

9. Introduce thornless cactus for rangeland rehabilitation and develop local businesses around this plant because of its multi-uses.

10. Develop low cost feeding troughs and promote their use to decrease feed wastage.

11. Develop strategies to efficiently utilize agro-industry by-products e.g. use of: a) dryers for increasing shelf-life of brewer's grains, and b) molasses tanks for storing molasses for use as animal feed, among others.

12. Develop public-private partnerships with the feed industry and assist the industry in using good manufacturing and good hygiene practices, and promote strategic establishment of animal feed manufacturing plants in feed-deficient regions.

13. Map out specific area-size and intensity/volume of the flood for potential irrigation in the spate irrigation system to be devoted for fodder production. Establish spate irrigation to facilitate fodder production by the cooperatives and commercial entities and make provision for livestock water outlets along canals.

14. Map out areas along the river most suitable for production of improved forage crops, and support communities in planting and managing upgraded fodder production (alfalfa, Sudan grass, green panic grass, Rhodes grass etc.). Most of the low-lands in Ethiopia are rain-fed and dry. Under such conditions, native pastures adaptable to harsh conditions should be promoted. Extensive local knowledge exists with pastoralists on native grasses that have good quality, which must be harnessed. The seed production and distribution system for good quality native grasses should be strengthened. Unfortunately, this aspect is currently being neglected. Several good native grasses are on the verge of extinction.

15. Through fodder producers and cooperatives, facilitate fodder production in the identified sites including sites from where prosopis bushes have been cleared. Thornless cactus plantation in the cleared areas may also be considered.

16. Within the developed schemes, promote agroforestry with the introduction of dual purpose crops, legumes, horticulture, dates, fruit trees and nuts within and between fodder production to enhance income from cash crops, food security and dietary diversification.

17. Where physical infrastructures cannot be developed for forage/feed storage, identify potential retreat areas where the growth of pasture under natural condition will allow the conservation of fodder *in situ* for use during short or extended dry spells.

18. Through community consultations design and implement sustainable community-based management systems for fodder production, conservation and sustainable utilization in the enclosed potential retreat/contingency areas; and also build capacity of the communities in these operations. Support the establishment of pastoralist grazing cooperatives and community groups to manage community contingency grazing, fodder production, utilization in the conserved areas.

19. Increase access to feeds and implement strategies to efficiently utilize them in fattening units run by privates or community-based groups, to increase pastoralists profits. Facilitate the establishment of pastoralist livestock fattening cooperatives and link them to the animal feed producers.

20. Map out blocks of land for rangeland rehabilitation (preferably using dry grazing areas and along traditional stock routes) with legumes and grasses.

21. Map out legislation and regulatory framework on animal feeds, prioritise and develop them.

22. Support implementation of the recently

developed feed quality and safety standards, jointly with Ethiopian Standard Agency.

23. Increase number of feed analysis laboratories in the private as well as public sectors

Integrate quality control systems in the existing feed analysis laboratories and get them accredited.

Ethiopia is highly deficient in ME and CP for feeding animals. In addition to implementing innovative feed production and feeding strategies, for efficient use of available resources, some possible ways to bridge the gap between ME and CP availability and requirements could be as follows: Extension of the area under oilseed production and increase in number of oil extraction units within the country coupled with limiting import of refined oil from abroad; other plants such as camelina could be introduced; and the plantation of lupins (already available in western Amhara region) expanded. Propagation of thornless cactus in lowlands will increase availability of ME. The cessation of wastages in various feed resources including agro-industrial and food processing by-products would also help. Efficient utilization of molasses and brewers grains as animal feed is another option to meet the deficiency of ME and CP. According to some field workers, a large quantity of these valuable resources is currently being wasted. The Government of Ethiopia has ambitious plan to extend areas under sugarcane plantation. This will increase the availability of molasses, bagasse and sugarcane top, which if directed for animal feeding would also help the livestock sector. Use of insect meal, algae and slaughterhouse waste as poultry and aquafeed should be considered.

Further Reading

- CSA (2016-2017). Agriculture Sample Survey Livestock. Central Statistical Agency of Ethiopia, Addis Ababa, Ethiopia. http://www.statsethiopia.gov.et/our-survey-reports
- FAO. 2012. Crop residue based densified total mixed ration – A user-friendly approach to utilise food crop by-products for ruminant production, by T.K. Walli, M.R. Garg & Harinder P.S. Makkar. FAO Animal Production and Health Paper No. 172. Rome, Italy. http://www.fao.org/3/i2728e/i2728e00.pdf
- FAO. 2018. Ethiopia: Report on feed inventory and feed balance, 2018. http://www.fao.org/3/ca1718en/CA1718EN.pdf (this is the source of this article).
- FAO. 2019. Ethiopia. Availability and utilization of agroindustrial by-products as animal feed 2018. Rome. 64 pp. Licence: CC BY-NC-SA 3.0 IGO. http://www.fao.org/3/CA3600EN/ca3600en.pdf
- Leng, R. 2004. Protein sources for the animal feed industry. Series title: FAO Animal Production and Health Proceedings – 1, 390 pages, ISBN: 9251050120.
- Shapiro, B.I., Gebru, G., Desta, S., Negassa, A., Nigussie, K., Aboset, G. and Mechal, H. 2015. Ethiopia livestock master plan. ILRI Project Report. Nairobi, Kenya: International Livestock Research Institute (ILRI). https://cgspace.cgiar.org/bitstream/handle/10568/68037/lmp_roadmaps.pdf?sequence=1

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