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Ethiopia

Report on feed inventory and feed balance

2018

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Abbreviations

ADG	Average daily gain
B-G	Benishangul-Gemuz
CP	Crude protein
CSA	Central Statistical Agency
DCP	Digestible crude protein
DE	Digestible energy
DM	Dry matter
FAO	Food and Agriculture Organization of the United Nations
LU	Land use
LULC	Land use and land cover
ME	Metabolizable energy
MJ	Mega joule
MW	Molecular weight
MoALR	Ministry of Agriculture and Livestock Resources*
MoLF	Ministry of Livestock and Fisheries*
NE	Net energy
NGO	Non-governmental Organization
SNNPR	Southern Nation, Nationalities and People Regional
TLU	Tropical livestock unit
TMR	Total mixed ration
UMMB	Urea molasses multi-nutrient blocks

*In February 2018, the Ministry of Livestock and Fisheries (MoLF) has been merged back within the Ministry of Agriculture and Livestock Resources (MoALR).

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Executive summary

Over the past decades, Ethiopia has been affected by recurrent droughts, particularly in the south and southeastern areas of the country where communities primarily engage in pastoralism. Available evidence indicates that one of the main factors behind pastoral destitution in Ethiopia is the 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.

Feed inventory, feed balance, and a way towards business development and drought management

National Feed inventory

Four major cultivated crop-based forage production regions in Ethiopia are Oromia, Amhara, Southern Nation, Nationalities and People Regional (SNNPR) and Tigray. In Oromia, maize stover availability is highest (39 percent), followed by straws of sorghum (22 percent), wheat (16 percent) and teff (15 percent). In Amhara, availability of sorghum straw is highest (29 percent), followed by those of maize (25 percent) and teff (18 percent). In SNNPR, availability of straws of maize, sorghum and teff are 61, 13 and 11 percent respectively. In Tigray, sorghum straw availability is highest (55 percent). 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 percent), followed by chickpeas and grass peas straws. In Oromia, noug straw availability is highest (53 percent) and those of groundnut and linseed are 18 percent and 16 percent 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 percent respectively of the total metabolizable energy (ME) from the crop-based forages. 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 those of permanent crops and grazing biomass are 1.72 million tonnes and 57.09 million tonnes respectively. The contribution of grazing pastures being 1.08-fold higher than that of crop-based forages.

A total of 567 thousand tonnes of oilseed cakes are potentially available in Ethiopia in a year. Potential availability of noug cake is highest (34.2 percent), followed by sesame. 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 percent of the total oilseed cake production, each contributing 43.7 percent and 35.4 percent respectively. In Amhara production of sesame cake is highest (40 percent), followed by noug cake (24.5 percent); while in Oromia noug cake availability is highest (54.5 percent) and then is of linseed cake. The production of oilseed cakes in Somali, Harari, Gambela and Afar is negligible.

A total of 2 041 thousand 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 percent), followed by in Amhara (30.9 percent), SNNPR (10.2 percent) and Tigray (6.4 percent). 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 percent of the total. Potential annual pulse milling by-products (bran/bulule) availability is approximately 488 000 tonnes (almost 4.2-fold lower than of cereal brans). Oromia followed by Amhara and SNNPR contribute almost 97 percent 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. Other feed resources such as oilseed cakes, brans and molasses are also available in the regions of forage availability, and these are the main constutuents of total mixed ration (TMR) and densified forage-based TMR blocks.

Total annual potential biomass available for animal feeding in Ethiopia is 144.48 million tonnes, with embedded ME and CP respectively of 890 x 10^9 MJ and 7.49 million tonnes. The contribution of forages is 96.6 percent and 92 percent towards total ME and CP availability, suggesting little contribution of concentrate feeds towards ME and CP availability in Ethiopia. Poultry, aqua and pig feeds require energy- and protein-dense feed resources, which are highly scarce 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 (addressed in subsequent parts of this report). Concerted efforts are needed to enhance the availability of good quality feeds in Ethiopia.

National Feed Balance

The contributions of cattle, sheep and goats towards total ME requirements are 83 percent, 4.7 percent and 4.7 percent, while these figures for CP requirement are 79.5 percent, 6.1 percent and 5.5 percent. 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 percent as DM, while ME and CP deficiencies are 45 percent and 42 percent respectively, again suggesting lack of good quality feeds in the country. Two regions, Benishangul-Gemuz (B-G) and Gambela have positive feed balance which could be attributed to relatively low livestock population (due to presence of tsetse fly) in these regions. After considering the competitive uses of crop residues and export of oilseeds, the feed deficiency increased to 21 percent as DM, and 52 percent and 48 percent as ME and CP respectively. There is a need to consider

ways to meet these deficiencies. Some possible ways to achieve this are listed in the 'Way forward' section.

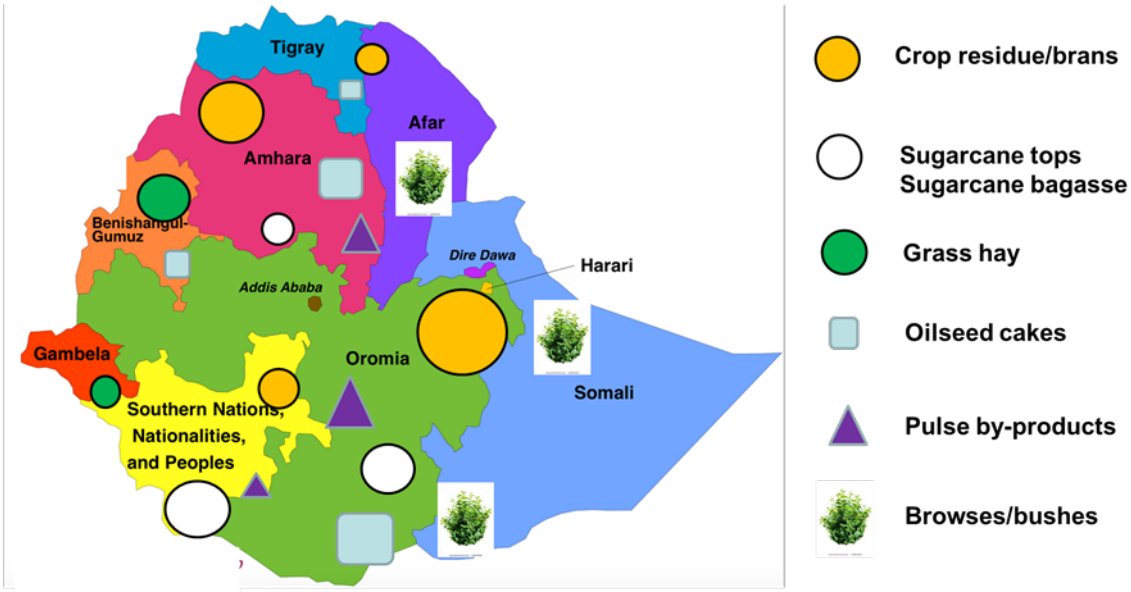
Implications

The feed inventory presented in this report also maps the availability of an array of biomasses, 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. The following figure 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 as $x10^3$ tonnes) respectively; while that of pasture grasses is much higher: 2 874.9 and 1 820.5 (both as $x10^3$ 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. The annual availability of sugarcane tops and sugarcane bagasse (both as $x10^3$ tonnes) in SNNPR is 110.2 and 123.4 respectively; while these values for Oromia are 42.9 and 48.1 and for Amhara are 22.9 and 25.5 respectively. 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 emergency periods.

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 molassess 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 percent 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. 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 percent of this protein consumption are from meat, crop residues could support protein requirement of 60 million people per year. In practice 100 percent 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.

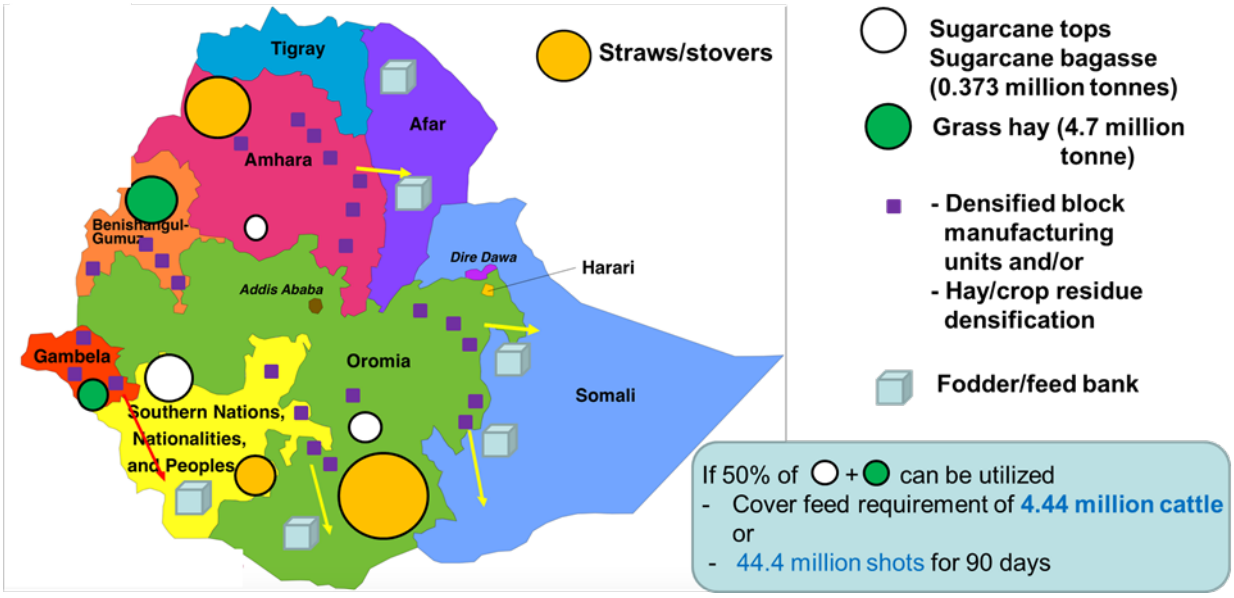


Source: FAO

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)

The cost of transport and storage could be decreased by densifying the forages. Technological options and machines required to harvest biomass and densify them are discussed separately. These options 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 (bailing, pelleting, briquetting, and formation of total mixed ration as mash, etc.).

Using the biomass availability data and biomass mapping information obtained in this study, a conceptual plan for establishing densification units and fodder banks is presented below. Densification units should be established near the places of biomass availability; and 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.



Source: FAO

Figure 2. A conceptual plan for establishment of densification units and fodder banks

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, placement of multi-nutrient blocks containing a commonly used tannin-inactivating agent, polyethylene glycol (MW 4 000) in rangelands could enhance the use of browses as animal feed and help prevent livestock mortality.

Feed production by the feed industry

An assessment of feed production by the feed manufacturing industry in Ethiopia was also made, showing the annual compound feed production of only 61 416 tonnes, which is far below the demand. During the last five years, prices of vitamin premixes and methionine remained relatively stable as compared to the trends in prices of mineral, lysine and salt. The average increase in price of supplements during the last five years has been about 41 percent. Currently a total of 81 enterprises under 5 major categories (private feed processing plants, farmers' unions feed processing plants, supplement importers/producers, feed manufacturing suppliers/producers and forage seed producer/suppliers) are operating in Ethiopian commercial feed sub-sector. The dominant enterprises are feed processing plants owned by private companies and farmers' unions engaged in production of the compound feed, followed by importers or manufactures of supplements (premixes, feed additives etc.) and feed processing machineries/equipment, and suppliers of forage seeds. A total of 32 privately owned feed processing plants are currently operational. In terms of geographic distribution, most of the enterprises are in Oromia and Addis Ababa regions with respective contribution of 37 percent and 31 percent. Amhara and SNNPR regions,

each account for 13 percent, while Tigrai region accounts for 6 percent of the total feed processing plants. Nationwide, 28 farmers' unions are engaged in commercial feed sector and they are evenly distributed across the four regional states mentioned above. A detail on the current status, challenges and opportunities of feed production in Ethiopia is presented in this report, and can also be accessed from: https://www.feedipedia.org/content/ethiopian-feed-industry-current-status-challenges-and-opportunities.

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. The findings would also open several avenues for preparing concepts and proposals to initiate new programmes; and 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. 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 MoLF, so that it is updated every year. FAO could provide tools and training to realise this.
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 MoLF 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 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. Also consider use of browse-enhancers for utilizing prosopis and acacia leaves as animal feed. Introduce prosopis-pod crushing machines for disintegrating the pods before using as animal feed.
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.).
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. Develop 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.
24. 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. Other plants such as lupin and camelina could also be introduced. 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 brewer's 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 and slaughterhouse waste as poultry and aquafeed should be considered.

Some of the above points have already been incorporated into FAO's Country and Regional Pastoralists Resilience Strategy, FAO's Regional Feed Strategy, and FAO Ethiopia Country Office's Livestock Programme, for implementation in the future; however, for sustainability of the programmes and activities and for realisation of their mega-scale impact, these must be led and driven be the MoLF.

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Introduction

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. The problem emanates from the continued reliance of herders on natural rain-fed pasture, despite a host of factors that are accelerating the scarcity of such resources. Climate change-induced droughts happening at short intervals, flash floods that happen at the end of drought episodes washing away the natural seed reserve, the coverage of invasive species and land degradation are some of the natural and climate related drivers.

Competing land use practices, changing demographics and dynamics in the country and the region as a whole are exacerbating factors. 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. Considerable investments and progress have been made in building the resilience of (agro)pastoralists livelihoods however the gap on feed resources is glaring and its impacts quite considerable (70–90 percent losses in livestock in 2016–2017 drought mainly due to lack of feed); especially the need for consistent and integrated investments actions. 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.

Livestock are vital for the food security of millions of people in Ethiopia and will remain important in the coming decades. Ethiopia has large livestock population, but still the demand of animal source foods for its human population is not met. This is mainly due to poor animal productivity. In addition to low genetic potential of animals and prevalence of animal diseases, feed shortage in terms of quantity and quality is considered as the major factor that hinders sustainable development of the livestock sector in Ethiopia. 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.

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 must be assessed and monitored to 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 utility 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. While feed balance is the balance between availability and demand. This report presents feed inventory and feed balance of Ethiopia. Feed inventory and feed balance in terms of dry matter, metabolizable energy (ME) and crude protein (CP) for each of the 10 regions of Ethiopia and for the nation have been established and reported. The contribution of the feed industry towards providing feeds is also provided in this part. It is expected that 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. The findings would also open several avenues for preparing concepts and proposals to initiate new programmes; and 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.

Methodoly used

The work has been conducted jointly with stakeholders in the feed value chain e.g., Ministry of Livestock and Fisheries, Ministry of Agriculture and Natural Resources, Central Statistical Agency, feed industry, feed traders, farmers, among others in the feed value chain.

The model and methodologies for establishment of feed inventory, animal nutrient requirements (as dry matter, DM; metabolizable energy, ME; and crude protein, CP) and feed balance, conducted for 10 regions of Ethiopia and the entire country, are essentially based on FAO (2012).

Methodologies for feed inventory and feed balance

The model used for establishment of feed inventory and feed balance is presented in Figure 3.

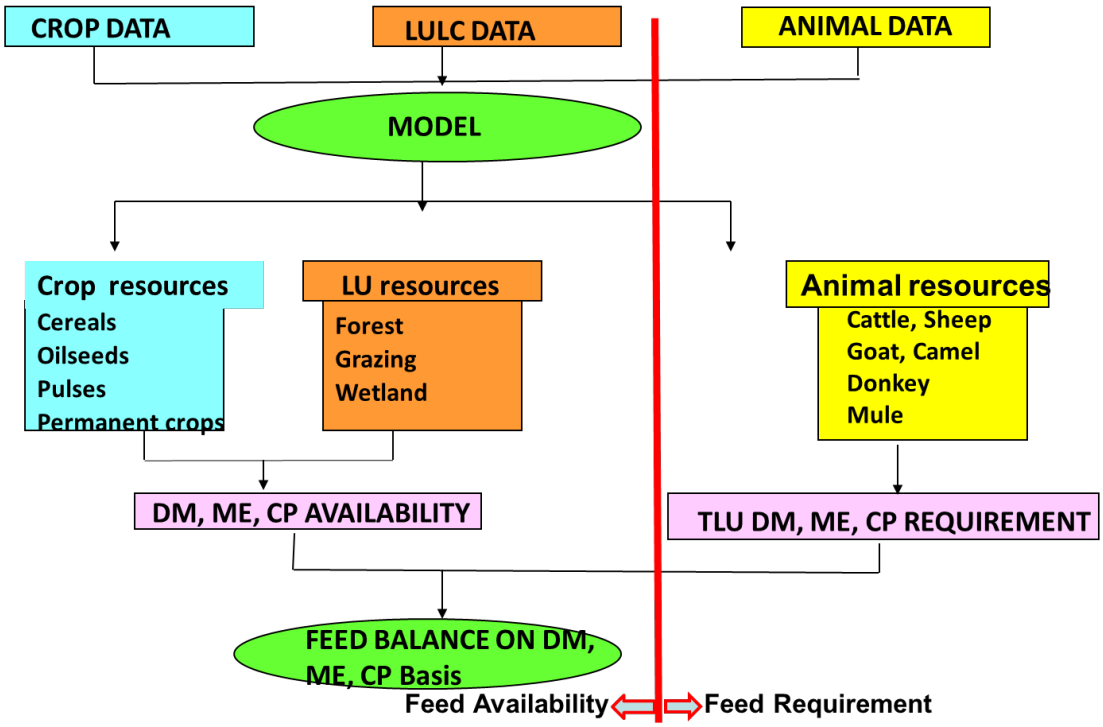


Figure 3. Model used for calculation of feed inventory and feed balance (LULC, Land Use and Land Cover; LU, Land Use; DM, Dry Matter; ME, Metabolizable Energy; CP, Crude Protein; TLU, Tropical Livestock Unit). Source: FAO (2012).

The feed resources have been assessed in the following categories:

Roughages

1. Cereal straws
2. Pulse aerial parts
3. Oilseed straw/aerial part
4. Grazing pasture
5. Stubble feeding (aftermath)
6. Root aerial parts
7. Permanent crops
8. Cultivated fodders

Concentrates

1. Pulse brans
2. Cereal brans
3. Oilseed cakes

Rangeland biomass as feed

Source of crop and livestock data

Livestock census and crop production data should be taken from Central Statistical Agency (CSA) of Ethiopia because this is the official data. (Note: In the present study Livestock census data (adjusted through survey sample) was of 2016-2017 (CSA, Report on Livestock and livestock characteristics, Statistical Bulletin 585, April 2017. Latest available data for meher and belg crop seasons were taken for estimation of feed availability. The data for meher season was for the year 2016–2017 and for belg season for 2015–2016 respectively (CSA, 2017: Crop and Livestock Product Utilization (Meher season), Statistical Bulletin 586, July 2017; and CSA 2016: Report on Area, Production and Farm Management Practice of Belg Season Crop, Statistical Bulletin 578, July 2016).

Factors used

For converting crop grains to crop residues, oilseeds to oilseed residues, cereal and pulse grains to their milling products obtained during processing, and permanent crops to their residues/by-products various factors were used. These factors have been derived from many publications: FAO (1987), Funte et al., 2010; Akgün et al., 2011; Ayoola et al., 2012; Bhattacharya et al., 1993; De Leeuw et al., 1990; Hemstock et al., 1994; Hofsetz and Silva, 2012; Nam et al., 2016; Rodríguez et al., 2010; Ramachandra et al., 2007; Tolera, 1990; Wu et al., 1993).

For leaves and stems of banana, area under plantation was used; 1 hectare gives 8 000 kg leaves and stems on dry matter basis). For Enset, recently a study by Prof. Dr. Adugna Tolera's group showed number of trees/ha, DM kg/ha for food, DM kg/ha for feed, and DM kg/ha for other uses such as rope making, mulch for seedlings, house roof covering (mean + SD) were 7 630 ± 1 172.9, 100 700 ± 69 624.5, 33 686 ± 16 397.2 and 15 248 ± 7 523.5 respectively (unpublished). So on average 4.41 kg feed in DM (range being 2.14 to 8.07) can be obtained from one tree. According to CSA (2016–2017), 123 479 334 trees were harvested in

Ethiopia. Also according to CSA (2016–2017), 30.6 percent and 69.4 percent of the Enset food was produced from Oromia and SNNPR respectively. These are the main regions that have enset plantation (some plantation exists in Benishangul-Gemuz (B-G) as well, but it is negligible and not documented in the CSA document), and because distribution of trees harvested in these regions was not available in the CSA document, the proportion of food produced from these regions was taken to arrive at the number of trees harvested in Oromia and SNNPR (37 784 676 and 85 694 658 respectively). These numbers were multiplied by 4.41 kg to arrive at the enset feed available in these two regions.

Rangeland biomass as animal feed

Landsat data were used for categorization of each region area as Forest land, Grazing land, and Wetland. Land use and land cover data were obtained from Ethiopian Mapping Agency (EMA, 2013). The factors used for converting land area in hectare to biomass in tonnes were 1.2, 2, and 2 respectively (Amsalu and Addisu, 2014). However, lowland area in each of the regions was also determined using the same approach and the biomass per hectare for this land area was 0.56 tonne per hectare (Bediye and Feyissa, 2008).

Improvement in feed inventory and feed balance

In future, use of Ethiopia-specific factors to convert foods (e.g. grains, oilseeds, fruits, vegetables, etc.) to their by-products used as feed may be used. Local experts and institutions should build a database on these factors, and update land use and land cover pattern.

In this study contribution of agro-industrial by products has not been taken into account. According to experts, currently their contribution to National Feed Inventory and National Feed Balance is negligible and will not affect the conclusions drawn. Once their contribution as feed to livestock industry increases and reliable data are generated, these should be included in the National Feed Balance. Likewise, there is a need to take into account slaughter house wastes.

In the current inventory and feed balance for Ethiopia, the amount of cultivated fodder has not been taken into consideration. According to experts, currently the contribution of cultivated fodder is negligible and no reliable data for the availability of cultivated fodder are available. In future, when the contribution of cultivated fodder as animal feed increases in the country, reliable data should be generated and included in the National Feed Inventory and National Feed Balance.

There are many feed resources such as prosopis and acacia pods, browses, gibto, chat waste, cactus, amongt others which are uses as animal feed in Ethiopia; however, their amounts used as animal feed are not known. Studies are needed to quantify their contribution and include in the National Feed Inventory and National Feed Balance.

Based on the afore-mentioned information, there is a scope for improvement of feed inventory and feed balance data reported in this study.

Conversion of feed availability to metabolizable energy and crude protein

The availability of metabolizable energy (ME) and crude protein (CP) can be obtained by multiplying the feed availability (DM) to ME and CP contents. These values for the crop based residues and by-products were taken from various databases e.g. Feedipedia (2017), ILRI (2011); Gashaw and Defar (2017), Gudina et al. (2015), NDDB (2012), Bediye and Feyissa (2008), Bogale et al. (2008).

For pastures, CP and ME were taken as 85 g/kg and 8.6 MJ/kg for 9 months of the good season and 51 g/kg and 7.1 MJ/kg for rest of the 3 months of dry season (Keba et al., 2013; Talore et al., 2013). Weighted average for the year was: CP and ME of 76.5 g/kg and 8.23 MJ/kg. For banana leaves plus stems the values for CP and ME were 77 g/kg and 8.7 MJ/kg and these values for enset leaves plus stems were 74 and 8.9. For both these feed resources, a mix of two parts of stems and one part of leaves was taken; and the source of the values for the respective parts was: www.feedipedia.org

Before conducting the current assessment, an expert meeting involving animal nutrition experts from FAO and local institutions was organised in October 2017 to discuss the approach to be used. The approach and the factors used for preparation of feed inventory and feed balance were agreed upon.

Methods for calculation of feed requirements

Dry matter requirement of animals

The livestock number of different livestock species was converted to Tropical Livestock Units (TLU; 250 kg = 1 TLU) by taking factors of 0.7, 0.1, 0.1, 1, 0.5, 0.7 and 0.9 for cattle, sheep, goat, camel, donkey, mule and horse respectively (Jahnke, 1982; Gryseels, 1988; Yadessa et al., 2016). The dry matter intake per TLU was estimated as 2.5 percent of the body weigh i.e. 6.25 kg/day. These values were agreed through an experts meeting held in Addis Ababa in October 2017.

Metabolizable energy requirement of animals

Cattle and sheep

For these animal species, IPCC (2006) methodology based on estimation of Net Energy (NE) and then conversion to Gross Energy (GE) was followed. Thereafter, GE was converted to Metabolizable Energy (ME) using the factor of 0.81.

For cattle and sheep, NEs for maintenance, activity and growth were calculated. Also for cattle, NE for annual milk production and for sheep, NE for milk production (equation used from the IPCC, 2006 was that for 'milk production unknown) were included in the respective NEs (*Note: in the current study, wool for sheep was not taken into account because CSA does not give yearly wool production data*). For calculation of NE for activity according to IPCC (2006), milking cows were assigned to moderate grazing, dry cows and bulls to extensive grazing and draught animals were considered to work 6 h/day.

The feed dry matter digestibility, estimated for diets generally consumed by livestock in Ethiopia was taken as 46.5 percent (FAO & NZAGGRC, 2017).

For calculation of NE for activity according to IPCC (2006), sheep of < 6 month of age were assigned to moderate grazing (1 km/day) and sheep > 6 months of age to extensive grazing (5 km/day).

Goat

Daily ME in MJ required for maintenance of 0.452 (body weight, BW)^0.75; and for growth, ME of 27.7 MJ/kg BW gain were taken (Salah et al., 2014).

For estimation of ME for activity (grazing): for goat of < 6 months, it was taken as zero; for goats of age > 6 months and < 1 year, it was taken as 25 percent of maintenance; and for adult goats, it was 50 percent of maintenance.

Camel

The maintenance ME requirement was calculated separately for camels in Afar which are smaller (275 kg BW); and for rest of the camels, which are larger (400 kg BW).

The equation used for maintenance requirement was

$$\text{ME in MJ} = 0.435\ (\text{BW})^{0.75}$$ (Wardeh, 1997; Nagpal, 2016).

For ME of grazing and daily work for 4 hours, 40 percent of the maintenance ME was taken.

Horses

The DE of maintenance was taken as 33.3 kcal/kg BW (0.139427 MJ/kg BW) and ratio of ME to DE was 0.87 (Ralston, 2016; NRC, 2007). Adult weight of horses used for calculation was 250 kg. For work, an additional 40 percent of the maintenance energy requirement was taken.

Donkeys and mules.

For donkeys, maintenance requirement as DE, MJ/day was calculated as per NRC (1989) = [0.975+ (0.021*BW in kg)]*4.187. Adult weight of donkey used was 150 kg. For work, an additional 40 percent of the maintenance energy requirement was taken. The DE was converted to ME by multiplying by a factor of 0.87. The approach used for mules was the same as donkeys except that the mature body weight taken was 200 kg.

ME requirement for growth was not taken into consideration for horses, donkey and mules because of unavailability of reliable growth data.

Various parameters used in the equations were taken from literature (Belay and Haile, 2011; Abegaz and Gizaw, 2015; Salah et al., 2014; Wardeh, 1997; Nagpal, 2016; Tadesse et al., 2016; NRC, 1989, 2007; Ralston, 2016) and some were based on expert opinion.

Crude protein requirement of animals

Cattle

For maintenance, a value of 3.2 g digestible crude protein (DCP)/kg $BW^{0.75}$; and for growth, DCP requirement of 0.3 g DCP/g of average daily weight gain, ADG (Salah et al., 2014; values for tropical animals from Table 2) were used to calculate the requirement of DCP of maintenance and growth. These values were converted to CP requirement by taking CP digestibility of 52 percent. Therefore, the values of 6.15 g CP/kg $BW^{0.75}$ for maintenance and 0.58 g CP/g ADG for growth were taken.

Sheep

For maintenance, a value of 2.8 g digestible crude protein (DCP)/kg $BW^{0.75}$; and for growth, DCP requirement of 0.2 g DCP/g of average daily weight gain, ADG (Salah et al., 2014; values for tropical animals from Table 2) were used to calculate the requirement of DCP of maintenance and growth. These values were converted to CP requirement by taking CP digestibility of 52 percent. Therefore, the values of 5.38 g CP/kg $BW^{0.75}$ for maintenance and 0.3846 g CP/g ADG for growth were taken.

Goat

For maintenance, a value of 2.9 g digestible crude protein (DCP)/kg $BW^{0.75}$; and for growth, DCP requirement of 0.2 g DCP/g of average daily weight gain, ADG (Salah et al., 2014; values for tropical animals from Table 2) were used to calculate the requirement of DCP of maintenance and growth. These values were converted to CP requirement by taking CP digestibility of 52 percent. Therefore, the values of 5.58 g CP/kg $BW^{0.75}$ for maintenance and 0.3846 g CP/g ADG for growth were taken.

Camel

A value of 2.2 g digestible crude protein (DCP)/kg $BW^{0.75}$ (Nagpal, 2016) was used to calculate the maintenance requirement of DCP which was then converted to CP requirement by taking CP digestibility of 52 percent. Therefore, the values of 4.23 g CP/kg $BW^{0.75}$, BW of 275 kg for camel in Afar region and BW of 400 kg for camel in other regions were used to calculate CP requirements. CP requirement per litre of milk production taken was 96 g.

Results

Region-wise potential feed availability is presented below. Ethiopia has 10 regions: Tigray, Afar, Amhara, Oromia, Somali, Southern Nation, Nationalities and People Regional (SNNPR), Benishangul-Gemuz (B-G), Gambela, Dire Dawa and Harari. The feed inventory has been presented in the following categories:

Cereal straws; Cereal brans; Pulse aerial parts; Oilseed straw/aerial part; Grazing pasture; Stubble feeding (aftermath); Root aerial parts; Permanent crops; Pulse brans; and Oilseed cakes. Cultivated fodders were not considered because their contribution to total energy needs of the animals is negligible (< 0.1 percent; Experts' opinion) and also their reliable production data are not available.

Crop residues have a number of competitive uses. Also oilseeds are being exported from Ethiopia. These were taken into account in arriving at actual national feed inventory and feed balance from the potential ones. So there has been two feed inventories: potential and actial. Likewise, there were two sets of feed balances: one, based on potential feed inventory and the other on actual feed inventory.

Potential availability of dry matter, metabolizable energy and crude protein

Total dry matter availability of the feed resources presented here is the sum of the availability for meher and belg seasons. For contribution of each of these seasons, see Annex 1 of this part of the report.

(The values reported are: DM as x10^3 tonne/year, ME as MJ x10^3 /year and CP as kg x10^3 /year; unless otherwise stated.)

Tigray

Cereal straws and stovers

Sorghum straw availability in terms of DM, ME and CP was highest (*ca* 54 percent), followed by straws of finger millet, teff, maize and wheat (7 to 11 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	282.14	9.9	2228908	10.9	11567.75	10.8
Barley	193.99	6.8	1260941	6.2	7371.65	6.9
Wheat	243.52	8.5	1534177	7.5	7792.65	7.3
Maize	264.89	9.3	2013166	9.9	9800.94	9.2
Sorghum	1566.41	54.9	11434808	56.1	57957.24	54.4
Finger millet	301.91	10.6	1902021	9.3	12076.32	11.3
Oats/'Aja'	0.1574	0.01	1039	0.005	5.67	0.0
Rice	1.3076	0.05	7584	0.037	54.92	0.1
Total	**2854**	**100**	**20382644**	**100**	**106627**	**100**

Cereal brans

The availability of brans is in the similar order as the cereal grains.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP %
Teff	18.74	14.4	224880	14.2	3373.20	19.1
Barley	12.89	9.9	130189	8.2	1804.60	10.2
Wheat	16.18	12.4	182810	11.5	2588.47	14.6
Maize	12.90	9.9	141954	9.0	1535.68	8.7
Sorghum	54.11	41.6	714252	45.0	6330.87	35.8
Finger millet	14.90	11.5	190720	12.0	2041.30	11.5
Oats/'Aja'	0.01	0.01	137	0.01	1.93	0.0
Rice	0.0868	0.07	1373	0.09	12.33	0.1
Total	**130**	**100**	**1586315**	**100**	**17688**	**100**

Pulse straws

Among the pulses, horse bean availability is the highest (*ca* 40 percent), and those of chickpeas and grass peas are almost same (*ca* 18 percent). Availabilities of CP and ME are also in the same order.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Horse beans	24.15	40.1	154560	36.7	1787.10	33.1
Field peas	2.37	3.9	18723	4.5	194.34	3.6
Haricot beans	3.26	5.4	23146	5.5	374.90	7.0
Chick-peas	11.09	18.4	78739	18.7	1120.09	20.8
Lentils	7.89	13.1	59175	14.1	552.30	10.2
Grass pea	11.04	18.3	82800	19.7	1324.80	24.5
Fenugreek	0.44	0.73	3564	0.85	44.00	0.82
Total	**60.24**	**100**	**420707**	**100**	**5397.5**	**100**

Oilseed straws

Sesame straw availability is the highest (82 percent) and those of Niger and linseed straws are 8 to 9 percent.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Noug/Niger	13.70	8.7	69859.44	6.6	725.99	5.5
Linseed	12.54	8.0	72721.15	6.9	789.90	6.0
Groundnut	1.53	0.97	9156.47	0.86	99.19	0.75
Sesame	129.57	82.3	907020.80	85.7	11661.70	87.8
Rapeseed	0.0519	0.03	280.42	0.03	3.012	0.02
Total	**157**	**100**	**1059038**	**100**	**13280**	**100**

Vegetable plant aerial parts

Availability of tomato aerial plant parts is the highest (39.6 percent), followed by those of green pepper and red pepper (*ca* 27 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Lettuce	0.016	0.4	111.30	0.4	2.07	0.4
Head cabbage	0.211	5.5	1476.30	5.5	27.42	5.5
Tomatoes	1.512	39.6	10582.74	39.6	196.54	39.5
Green pepper	1.039	27.2	7273.35	27.2	135.08	27.2
Red pepper	1.045	27.3	7317.24	27.3	135.89	27.3
Total	**3.823**	**100**	**26761**	**100**	**497**	**100**

Root crop aerial parts

Availability of potato aerial parts is highest (36 percent), followed by those of onion and garlic (*ca* 31 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Carrot	0.0314	1.1	220.08	1.2	3.62	1.1
Onion	0.8832	31.5	5387.52	29.2	79.49	24.1
Potato	1.0077	36.0	7558.20	41.0	168.29	51.0
Garlic	0.8783	31.4	5269.92	28.6	78.17	23.7
Total	**2.80**	**100**	**18436**	**100**	**330**	**100**

Oilseed cakes

Availability of sesame cake is highest (81 percent), followed by those of Noug and linseed

	Total (DM)	Total (DM) %	Total ME (MJ)	Total ME %	Total CP (kg)	Total CP %
Noug	4.77	9.9	42961.50	7.4	1498.88	7.3
Linseed	4.18	8.7	52694.46	9.0	1426.10	7.0
Groundnut	0.4102	0.85	4800.00	0.82	164.10	0.8
Sesame	38.70	80.5	483800.00	82.8	17378.10	84.9
Rapeseed	0.0173	0.04	209.57	0.04	6.58	0.03
Total	**48**	**100**	**584466**	**100**	**20474**	**100**

Afar

Cereal and pulse straws

Among cereals, availability of maize straw is highest, followed by sorghum straw.

	Total (DM)	Total ME (MJ)	Total CP (kg)
Teff	1.35	10665	55.35
Maize	80.37	610812	2973.69
Sorghum	7.34	53582	271.58
Horse bean	0.40	2560	29.60
Field peas	0.20	1580	16.40
Total	**89.66**	**679199**	**3346.6**

Total cereal straws/stovers = 89.06 ($x10^3$ tonnes)/year
Total pulse straw = 0.60 ($x10^3$ tonnes)/year
Cereal and pulse straws 89.66 ($x10^3$ tonnes)/year

Cereal brans

The order of availability is the same as that of the cereals.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	0.09	2.1	1080	2.3	16.20	3.2
Maize	3.92	92.0	43120	90.8	466.48	91.1
Sorghum	0.25	5.9	3300	6.9	29.25	5.7
Total	**4.26**	**100**	**47500**	**100**	**511.9**	**100**

Oilseed cakes

Oilseeds are not grown in Afar.

Amhara

Cereal straws, stovers and brans

Availability of sorghum straw is highest (29 percent), followed by straws of maize (25 percent) and teff (18 pecent). The pattern of their bran availability is also the same.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	2242.65	18.3	17716935	20.0	91948.65	20.0
Barley	787.86	6.4	5121090	5.8	29938.68	6.5
Wheat	1529.77	12.5	9637551	10.9	48952.64	10.7
Maize	3102.86	25.3	23581736	26.6	114805.80	25.0
Sorghum	3608.66	29.4	26343218	29.7	133520.40	29.1
Finger millet	858.29	7.0	5407227	6.1	34331.60	7.5
Oats/'Aja'	6.14	0.05	40524	0.0	221.04	0.0
Rice	123.45	1.0	716010	0.8	5184.90	1.1
Total	**12259.7**	**100**	**88564291**	**100**	**458903.7**	**100**

Cereal brans

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	148.99	23.7	1787848	24.0	26817.71	29.8
Barley	52.34	8.3	528636.7	7.1	7327.64	8.1
Wheat	101.63	16.1	1148419	15.4	16260.80	18.1
Maize	151.17	24.0	1662870	22.3	17989.23	20.0
Sorghum	124.67	19.8	1645248	22.1	14582.88	16.2
Finger millet	42.36	6.7	542171.6	7.3	5802.93	6.4
Oats/'Aja'	0.4076	0.06	5584.2	0.1	78.67	0.1
Rice	8.20	1.3	129560	1.7	1164.40	1.3
Total	**629.8**	**100**	**7450337.5**	**100**	**90024.3**	**100**

Pulse straws

Among pulses, availability of horse beans is highest (33 percent), followed by those of chickpeas (22 percent) and grass peas (16 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Horse bean	409.28	33.2	2619392	29.7	30286.72	27.0
Field pea	61.08	5.0	482532	5.5	5008.56	4.5
Haricot bean	55.37	4.5	393127	4.5	6367.55	5.7
Chick-pea	268.57	21.8	1906847	21.6	27125.57	24.2
Lentil	105.72	8.6	792900	9.0	7400.40	6.6
Grass pea	191.80	15.5	1438500	16.3	23016.00	20.5
Fenugreek	26.78	2.2	216918	2.5	2678.00	2.4
Mung bean/"Masho"	86.31	7.0	785421	8.9	8458.38	7.5
Gibto	28.94	2.4	176534	2.0	1910.04	1.7
Total	**1233.9**	**100**	**8812171**	**100**	**112251.2**	**100**

Oilseed straws

Availability is in the decreasing order: sesame (46 percent), noug (24 percent), rape seed (9 percent) and soyabean (6 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Noug	141.82	24.1	723282	19.9	7516.46	17.6
Linseed	29.93	5.1	173594	4.8	1885.59	4.4
Groundnut	21.09	3.6	126540	3.5	1370.85	3.2
Sunflower	23.06	3.9	142972	3.9	1314.42	3.1
Safflower	12.25	2.1	98000	2.7	1470.00	3.4
Sesame	270.97	46.1	1896790	52.2	24387.3	56.9
Rapeseed	54.65	9.3	295110	8.1	3169.70	7.4
Soyabean	33.71	5.7	178663	4.9	1719.21	4.0
Total	**587.5**	**100**	**3634951**	**100**	**42833.5**	**100**

Vegetable aerial parts

Red pepper aerial parts form the bulk (75 percent) of available aerial parts.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Head cabbage	1.88	4.0	13160	4.0	244.4	4.0
Ethiopian cabbage	3.21	6.9	22470	6.9	417.3	6.9
Tomatoes	2.73	5.9	19110	5.9	354.9	5.9
Green pepper	3.73	8.0	26110	8.0	484.9	8.0
Red pepper	35.05	75.2	245350	75.2	4556.5	75.2
Total	**46.6**	**100**	**326200**	**100**	**6058**	**100**

Root crop aerial parts

Availability of potato parts is highest (70 percent), followed by those of onion (21 percent) and garlic (6 percent) in this category.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Beetroot	0.40	0.2	3520	0.3	104.00	0.4
Carrot	0.33	0.2	2310	0.2	37.95	0.1
Onion	42.91	21.3	261751	18.2	3861.90	13.2
Potato	141.88	70.4	1064100	74.1	23693.96	81.0
Garlic	12.94	6.4	77640	5.4	1151.66	3.9
Sweet potato	3.08	1.5	27104	1.9	406.56	1.4
Total	**201.5**	**100**	**1436425**	**100**	**29256.0**	**100**

Oilseed cakes

Among the oilseeds, sesame availability is highest (40 percent) followed by noug (25 percent) and soyabean (12 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Noug/Niger	49.42	24.6	444793.1	20.0	15518.34	19.2
Linseed	9.98	5.0	125773.7	5.7	3403.877	4.2
Safflower	4.27	2.1	35441.0	1.6	1058.96	1.3
Sesame	80.94	40.3	1011750.0	45.5	36342.06	45.0
Rapeseed	18.23	9.1	220583.0	9.9	6927.40	8.6
Groundnut	5.69	2.8	66573.0	3.0	2276.00	2.8
Sunflower	8.04	4.0	64320.0	2.9	2492.40	3.1
Soyabean	24.08	12.0	252840.0	11.4	12762.40	15.8
Total	**201.0**	**100**	**2222074**	**100**	**80781.0**	**100**

Oromia

Cereal straws, stovers and brans

Maize straw availability is highest (39 percent), followed by those of sorghum (21.7 percent), wheat (16 percent) and teff (15 percent). Bran availability is also in the same order as those of the cereals.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	2861.23	14.7	22603717	16.0	117310.4	16.3
Barley	1352.58	6.9	8791770	6.2	51398.04	7.2
Wheat	3109.66	16.0	19590858	13.8	99509.12	13.8
Maize	7550.02	38.7	57380152	40.5	279350.7	38.8
Sorghum	4222.87	21.7	30826951	21.8	156246.2	21.7
Finger millet	313.53	1.6	1975239	1.4	12541.2	1.7
Oats/'Aja'	61.19	0.3	403854	0.3	2202.84	0.3
Rice	15.80	0.1	91640	0.06	663.6	0.1
Total	**19486.9**	**100**	**141664181**	**100**	**719222.1**	**100**

Cereal brans

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	190.08	18.6	2280960	19.4	34214.4	23.8
Barley	89.86	8.8	907586	7.7	12580.4	8.8
Wheat	206.59	20.2	2334467	19.8	33054.4	23.0
Maize	367.82	36.0	4046020	34.4	43770.58	30.5
Sorghum	145.88	14.3	1925616	16.4	17067.96	11.9
Finger millet	15.47	1.5	198016	1.7	2119.39	1.5
Oats/'Aja'	4.07	0.4	55759	0.5	785.51	0.5
Rice	1.05	0.1	16590	0.1	149.10	0.1
Total	**1020.8**	**100**	**11765014**	**100**	**143741.7**	**100**

Pulse straws

Among straws, availability of horse beans is highest, followed by those of haricot and chickpea.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Horse bean	654.32	46.3	4187648	43.0	48419.68	38.2
Field pea	78.45	5.6	619755	6.4	6432.90	5.1
Haricot bean	266.0	18.8	1888600	19.4	30590.00	24.2
Chick-pea	191.78	13.6	1361638	14.0	19369.78	15.3
Grass pea	85.58	6.1	641850	6.6	5990.60	4.7
Vetch	109.37	7.7	820275	8.4	13124.40	10.4
Fenugreek	20.82	1.5	168642	1.7	2082.00	1.6
Mung bean/"Masho"	6.48	0.5	58968	0.6	635.04	0.5
Total	**1412.8**	**100**	**9747376**	**100**	**126644.4**	**100**

Oilseed straws

Noug straw availability is highest (53 percent) and those of groundnut and linseed are 18 percent and 16 percent respectively.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Noug/Niger	386.88	52.9	1973088	48.8	20504.64	47.1
Linseed	118.22	16.2	685676	17.0	7447.86	17.1
Groundnut	130.04	17.8	780240	19.3	8452.60	19.4
Safflower	0.44	0.06	3520	0.1	52.80	0.12
Sesame	53.23	7.3	372610	9.2	4790.70	11.0
Rapeseed	21.89	3.0	118206	2.9	1269.62	2.9
Soyabean	20.92	2.9	110876	2.7	1066.92	2.5
Total	**731.6**	**100**	**4044216**	**100**	**43585.1**	**100**

Vegetable plant aerial parts

Red pepper and Ethiopian cabbage form a bulk (74 percent) of the available feeds in this category.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Lettuce	0.01	0.01	70	0.01	1.3	0.01
Head cabbage	6.57	6.6	45990	6.6	854.1	6.6
Ethiopian cabbage	30.1	30.2	210700	30.2	3913.0	30.2
Tomatoes	7.3	7.3	51100	7.3	949.0	7.3
Green pepper	12.24	12.3	85680	12.3	1591.2	12.3
Red pepper	43.59	43.7	305130	43.7	5666.7	43.7
Total	**99.8**	**100**	**698670**	**100**	**12975.3**	**100**

Root crop aerial parts

In this category, sweet potato and potato contribute 45 percent and 41 percent respectively of the biomass.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Beetroot	4.15	0.8	36520	0.9	1079	1.5
Carrot	1.18	0.2	8260	0.2	135.7	0.2
Onions	30.76	6.2	187636	4.7	2768.4	3.8
Potatoes	203.96	40.9	1529700	38.1	34061.3	46.4
Garlic	14.81	3.0	88860	2.2	1318.1	1.8
Taro	22.14	4.4	210330	5.2	4760.1	6.5
Sweet potatoes	221.92	44.5	1952896	48.7	29293.4	39.9
Total	**498.9**	**100**	**4014202**	**100**	**73416.1**	**100**

Oilseed cake

Availability of noug cake is highest (55 percent), followed by those of linseed and groundnut (16 percent and 14 percent respectively).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Noug/Niger	134.82	54.5	1213386.0	47.3	42333.70	48.3
Linseed	39.43	15.9	496847.2	19.4	13446.42	15.3
Safflower	0.1547	0.06	1284.4	0.05	38.38	0.04
Sesame	15.90	6.4	198767.0	7.8	7139.71	8.2
Rapeseed	7.30	3.0	88359.4	3.5	2774.92	3.2
Groundnut	34.96	14.1	409032.0	16.0	13984.00	16.0
Soyabean	14.95	6.0	156975.0	6.1	7923.50	9.0
Total	**247.5**	**100**	**2564651**	**100**	**87640.6**	**100**

Somali

Cereal straws and stovers

Sorghum (64 percent) and maize (32 percent) straws form the bulk of feeds in this category.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Barley	0.75	0.3	4875	0.2	28.50	0.3
Wheat	9.22	3.3	58086	2.9	295.04	2.9
Maize	88.64	32.1	673664	33.2	3279.68	32.3
Sorghum	177.48	64.3	1295604	63.8	6566.76	64.6
Oats/'Aja'	0.02	0.01	132	0.01	0.72	0.01
Total	**276.1**	**100**	**2032361**	**100**	**10170.7**	**100**

Cereal brans

Availability of cereal brans is in the same order as those of cereal straws.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Barley	0.05	0.45	505	0.37	7.0	0.52
Wheat	0.61	5.5	6893	5.1	97.6	7.3
Maize	4.32	38.9	47520	35.0	514.1	38.5
Sorghum	6.13	55.2	80916	59.6	717.2	53.7
Total	**11.11**	**100**	**135834**	**100**	**1335.9**	**100**

Pulse straws

Haricot bean straw forms the bulk (97 percent) of feed in this category.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Field peas	0.03	2.7	237	3.0	2.46	1.9
Haricot beans	1.09	97.3	7739	97.0	125.35	98.1
Total	**1.12**	**100**	**7976**	**100**	**127.81**	**100**

Oilseed straw

Only groundnut straw is available.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Groundnut straw	7.71	100	46260	100	501.15	100

Total oilseed straw = 7.71 ($x10^3$ tonnes/year)

Vegetable plant aerial plants

Tomato aerial plant availability is high (97 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Tomato	0.32	97.0	2240	97.0	41.6	97.0
Green pepper	0.01	3.0	70	3.0	1.3	3.0
Total	**0.33**	**100**	**2310**	**100**	**42.9**	**100**

Total vegetable plant aerial parts = 0.33 ($x10^3$ tonnes/year)

Root crop aerial part

In this category only onion aerial parts are available.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Onion	3.32	100	20252	100	298.8	100

Total root crop aerial part = 3.32 ($x10^3$ tonnes/year)

Oilseed cake

Only groundnut cake is available.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Groundnut	2.69	100	31473	100	1076	100

Benishangul-Gemuz (B-G)

Cereal straws and stovers

In this category, sorghum straw availability is highest, followed by those of maize (40 percent) and finger millet (11 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	34.68	4.7	273972	5.0	1421.9	5.1
Barley	1.28	0.2	8320	0.2	48.6	0.2
Wheat	5.60	0.8	35280	0.7	179.2	0.6
Maize	299.36	40.3	2275136	41.8	11076.3	39.7
Sorghum	312.78	42.1	2283294	42.0	11572.9	41.5
Finger millet	83.85	11.3	528255	9.7	3354.0	12.0
Oats/'Aja'	0.05	0.01	330	0.01	1.8	0.01
Rice	6.22	0.8	36076	0.66	261.2	0.9
Total	**743.8**	**100**	**5440663**	**100**	**27915.9**	**100**

Cereal brans

The availability order is the same as that of cereal straws.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	2.30	7.1	27600	7.0	414.0	10.2
Barley	0.09	0.3	909	0.2	12.6	0.3
Wheat	0.37	1.1	4181	1.1	59.2	1.5
Maize	14.32	44.1	157520	40.1	1704.1	41.8
Sorghum	10.81	33.3	142692	36.4	1264.8	31.0
Finger millet	4.14	12.8	52992	13.5	567.2	13.9
Oats/'Aja'	0.0034	0.01	46.58	0.01	0.65	0.02
Rice	0.41	1.3	6478	1.7	58.2	1.4
Total	**32.4**	**100**	**392418**	**100**	**4080.7**	**100**

Pulse straws

Availabilities of straws of haricot bean, field peas and horse bean are 51, 23 and 15 percent respectively.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Horse beans	2.66	14.6	17024	12.7	196.84	10.8
Field peas	4.25	23.3	33575	25.0	348.50	19.2
Haricot beans	9.35	51.2	66385	49.3	1075.25	59.1
Chick-peas	0.39	2.1	2769	2.1	39.39	2.2
Lentils	0.02	0.1	150	0.11	1.40	0.1
Fenugreek	0.01	0.05	81	0.06	1.00	0.05
Mung bean/"Masho"	1.6	8.8	14560	10.8	156.80	8.6
Total	**18.3**	**100**	**134544**	**100**	**1819.2**	**100**

Oilseed straws

Groundnut straw availability is highest (45 percent), followed by those of sesame (26 percent) and soyabean (31 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Noug/Niger	15.13	9.3	77163	7.8	801.89	7.2
Linseed	0.45	0.28	2610	0.3	28.35	0.3
Groundnut	72.04	44.5	432240	43.9	4682.6	42.3
Safflower	1.56	0.96	12480	1.3	187.20	1.7
Sesame	41.88	25.9	293160	29.8	3769.20	34.0
Rapeseed	0.53	0.33	2862	0.3	30.74	0.3
Soyabean	30.86	19.1	163558	16.6	1573.86	14.2
Total	**162.0**	**100**	**984073**	**100**	**11074**	**100**

Vegetable aerial plants

Red pepper and Ethiopia cabbage form bulk of feeds in this category (70 and 22 percent respectively).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Head cabbage	0.05	2.2	350	2.2	6.5	2.2
Ethiopian cabbage	0.50	21.8	3500	21.8	65	21.8
Tomato	0.09	3.9	630	3.9	11.7	3.9
Green pepper	0.05	2.2	350	2.2	6.5	2.2
Red pepper	1.60	69.9	11200	69.9	208	69.9
Total	**2.3**	**100**	**16030**	**100**	**297.7**	**100**

Root crop aerial parts

Potato and sweet potato aerial parts form a bulk of the feed in this category (54 and 35 percent respectively).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Beetroot	0.01	0.2	88	0.23	2.60	0.4
Carrot	0.00024	0.01	1.68	0.00	0.0276	0.0
Onions	0.26	5.5	1586	4.2	23.40	3.2
Potatoes	2.54	53.5	19050	50.1	424.18	58.1
Taro	0.29	6.1	2755	7.3	62.35	8.5
Sweet potatoes	1.65	34.7	14520	38.2	217.80	29.8
Total	**4.75**	**100**	**38000.7**	**100**	**730.4**	**100**

Oilseed cakes

Soyabean cake availability is highest (37 percent), followed by groundnut cake (32 percent) and sesame cake (21 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Noug/Niger	5.27	8.8	47459.97	7.1	1655.83	6.1
Linseed	0.1509	0.3	1902.05	0.3	51.48	0.2
Safflower	0.5431	0.9	4507.73	0.7	134.69	0.50
Sesame	12.51	20.8	156365.80	23.3	5616.66	20.8
Rapeseed	0.1773	0.3	2145.79	0.3	67.39	0.3
Groundnut	19.37	32.2	226629.00	33.8	7748.00	28.7
Soyabean	22.05	36.7	231525.00	34.5	11686.50	43.4
Total	**60.1**	**100**	**670535.3**	**100**	**26960.5**	**100**

Total oilseed cakes = 60.1 ($x10^3$ tonne/year)

Southern Nation, Nationalities and People Regional (SNNPR)

Cereal straws, stovers and brans

Availability of straws of maize, sorghum and teff are 61, 13 and 11 percent respectively. The availability of cereal brans is also in the same order.

Cereal straws/stovers

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	441.97	10.9	3491563	11.6	18120.77	12.1
Barley	206.47	5.01	1342055	4.5	7845.86	5.2
Wheat	377.53	9.3	2378439	7.9	12080.96	8.0
Maize	2473.99	61.0	18802324	62.6	91537.63	61.0
Sorghum	538.07	13.3	3927911	13.1	19908.59	13.3
Finger millet	8.70	0.2	54810	0.18	348.00	0.23
Oats/'Aja'	0.42	0.01	2772	0.01	15.12	0.01
Rice	8.48	0.2	49184	0.16	356.16	0.24
Total	**4056.0**	**100**	**30049058**	**100**	**150213.0**	**100**

Cereal brans

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Teff	29.36	14.1	352320	14.9	5284.8	19.0
Barley	13.72	6.6	138572	5.9	1920.8	6.9
Wheat	25.08	12.0	283404	12.0	4012.8	14.4
Maize	120.53	57.9	1325830	56.2	14343.1	51.4
Sorghum	18.59	8.9	245388	10.4	2175.0	7.8
Finger millet	0.43	0.21	5504	0.2	58.9	0.2
Oats/'Aja'	0.03	0.01	411	0.02	5.8	0.02
Rice	0.56	0.27	8848	0.4	79.5	0.3
Total	**208.3**	**100**	**2360277**	**100**	**27880.7**	**100**

Pulse straws

Availability of haricot bean straw is highest (58 percent), followed by that of horse bean (37 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Horse beans	209.41	36.8	1340224	34.3	15496.3	27.5
Field peas	8.83	1.6	69757	1.8	724.1	1.3
Haricot beans	328.64	57.7	2333344	59.8	37793.6	67.1
Chick-peas	19.41	3.4	137811	3.5	1960.4	3.5
Lentils	0.56	0.1	4200	0.1	39.2	0.07
Grass pea	1.53	0.3	11475	0.3	183.6	0.33
Fenugreek	0.42	0.07	3402	0.1	42	0.07
Mung bean/ "Masho"	0.50	0.09	4550	0.1	49	0.09
Total	**569.3**	**100**	**3904763**	**100**	**56288.2**	**100**

Oilseed straw

Highest availability is of groundnut straw (72 percent), which is followed by those of rapeseed (12 percent) and linseed (5 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Noug	1.25	4.7	6375	4.1	66.25	3.9
Linseed	1.39	5.3	8062	5.2	87.57	5.1
Groundnut	18.9	71.7	113400	72.5	1228.5	71.9
Sunflower	0.32	1.2	1984	1.3	18.24	1.1
Safflower	0.44	1.7	3520	2.3	52.8	3.1
Sesame	0.71	2.7	4970	3.2	63.9	3.7
Rapeseed	3.07	11.7	16578	10.6	178.06	10.4
Soyabean	0.28	1.1	1484	0.95	14.28	0.8
Total	**26.4**	**100**	**156373**	**100**	**1709.6**	**100**

Vegetable plant aerial parts

Ethiopian cabbage and red pepper aerial parts form the bulk of the feed in this category (87 percent and 9 percent respectively).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Head cabbage	2.89	1.5	20230	1.5	375.7	1.5
Ethiopian	172.67	86.7	1208690	86.7	22447.1	86.7
Tomatoes	0.32	0.16	2240	0.16	41.6	0.2
Green pepper	5.47	2.8	38290	2.8	711.1	2.8
Red pepper	17.86	9.0	125020	9.0	2321.8	9.0
Total	**199.2**	**100**	**1394470**	**100**	**25897.3**	**100**

Root crop straws

Potato, taro and sweet potato straws availability is 40, 25 and 23 percent respectively.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Beetroot	2.12	0.2	18656	0.2	551.2	0.3
Carrot	0.67	0.07	4690	0.06	77.1	0.0
Onions	9.07	0.96	55327	0.69	816.3	0.5
Potato	373.09	39.5	2798175	35.1	62306.0	38.7
Yam	107.3	11.4	965700	12.1	18241.0	11.3
Garlic	7.25	0.77	43500	0.55	645.3	0.4
Taro	232.76	24.6	2211220	27.7	50043.4	31.1
Sweet potato	213.51	22.6	1878888	23.6	28183.3	17.5
Total	**945.8**	**100**	**7976156**	**100**	**160863.6**	**100**

Oilseed cake

Availability of groundnut cake is highest (67 percent) and that of rapeseed is 14 percent. Linseed and noug cakes availability is around 6 percent each.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Noug/Niger	0.44	5.7	3919.83	4.5	136.76	4.6
Linseed	0.46	6.1	5849.13	6.7	158.30	5.4
Safflower	0.15	2.0	1279.11	1.5	38.22	1.3
Sesame	0.21	2.8	2668.93	3.0	95.87	3.3
Rapeseed	1.02	13.5	12393.69	14.1	389.22	13.2
Groundnut	5.08	66.8	59436.00	67.7	2032.00	68.8
Sunflower	0.11	1.5	880.00	1.0	34.10	1.2
Soyabean	0.13	1.7	1365.00	1.6	68.90	2.3
Total	**7.61**	**100**	**87791.7**	**100**	**2953.4**	**100**

Gambela

Cereal, pulse, oilseed and vegetable residues

Among cereal straws, maize straw availability is highest (68 percent), followed by that of sorghum (31 percent). Haricot bean straw and Ethiopia cabbage aerial parts were the only feed resources available in the pulse straw and vegetable plant aerial part categories. Availability of sesame and noug straws is 75 and 25 percent respectively.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Cereal straws/stovers						
Teff	0.023	0.05	182	0.06	0.94	0.06
Barley	0.06	0.1	390	0.1	2.28	0.1
Maize	29.69	68.0	225644	69.0	1098.53	67.9
Sorghum	13.57	31.1	99061	30.3	502.09	31.0
Rice	0.33	0.8	1914	0.6	13.86	0.9
Total	**43.7**	**100**	**327191**	**100**	**1617.7**	**100**
Cereal brans[1]						
Maize	1.45	74.7	15950	70.9	172.55	74.8
Sorghum	0.47	24.2	6204	27.6	54.99	23.8
Rice	0.022	1.1	348	1.5	3.12	1.4
Total	**1.94**	**100**	**22502**	**100**	**230.7**	**100**
Pulse straw						
Haricot beans	0.122	100	866.2	100	14.03	100
Oilseed straws						
Noug/Niger	0.12	25.5	612	20.0	6.36	16.8
Sesame	0.35	74.5	2450	80.0	31.50	83.2
Total	**0.47**	**100**	**3062**	**100**	**37.9**	**100**
Vegetable plant aerial parts						
Ethiopian cabbage	0.046	100	322	100	5.98	100
Oilseed cake[1]						
Sesame	0.1047		1308.25		46.99	

1, concentrate, rest are forages
Total cereal straws/stovers = 43.67 ($x10^3$ tonnes/year)
Total cereal brans = 1.942 ($x10^3$ tonnes/year)
Total pulse straws/stovers = 0.122 ($x10^3$ tonnes/year)
Total oilseed straws = 0.47 ($x10^3$ tonnes/year)
Total vegetable plant aerial parts = 0.046 ($x10^3$ tonnes/year)
Total oilseed cakes = 0.1047 ($x10^3$ tonnes/year)

Harari

Cereal, pulse, oilseed and vegetable residues

Among cereal straws sorghum straw availability is highest (84 percent), followed by that of maize (16 percent). Field bean straw availability is 74 percent in the pulse straw category.

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Cereal straws/stovers						
Wheat	0.20	0.58	1260	0.50	6.4	0.50
Maize	5.46	15.9	41496	16.4	202.02	15.9
Sorghum	28.72	83.5	209656	83.1	1062.64	83.6
Total	**34.4**	**100**	**252412**	**100**	**1271.1**	**100**
Cereal brans						
Wheat	0.01	0.79	113	0.70	1.6	1.1
Maize	0.27	21.3	2970	18.4	32.13	21.5
Sorghum	0.99	78.0	13068	80.9	115.83	77.5
Total	**1.27**	**100**	**16151**	**100**	**149.6**	**100**
Pulse straws						
Field pea	0.01	73.5	79	75.6	0.82	66.4
Haricot bean	0.0036	26.5	25.56	24.4	0.414	33.6
Total	**0.0136**	**100**	**104.56**	**100**	**1.234**	**100**
Oilseed straw						
Groundnut	5.22	100	31320	100	339.3	100
Vegetable plant aerial parts						
Sweet potato	0.23	100	2024	100	29.9	100
Oilseed cakes						
Sesame	0.068	22.9	854.25	24.1	30.68	25.0
Groundnut	0.23	77.2	2691	75.9	92	75.0
Total	**0.298**	**100**	**3545.3**	**100**	**123**	**100**

Total cereal straws/stovers = 34.37 ($x10^3$ tonnes/year)
Total cereal brans = 1.27 ($x10^3$ tonnes/year)
Total pulse straws = 0.0136 ($x10^3$ tonnes/year)
Total oilseed straws = 5.22 ($x10^3$ tonnes/year)
Total vegetable plant aerial parts = 0.23 ($x10^3$ tonnes/year)
Total oilseed cakes = 0.298 ($x10^3$ tonnes/year)

Dire Dawa

Cereal, pulse, oilseed and vegetable residues and oilseed cake

Among cereal straws, sorghum straw availability is 98 percent. In the pulse category, haricot bean straw and field bean straw availabilities are 55 and 45 percent respectively. Among oilseed cakes, groundnut cake availability is highest (83 percent).

	Total (DM)	Total (DM) as %	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Cereal straws/stovers						
Maize stover	0.84	1.8	6384	1.9	31.08	1.8
Sorghum stover	45.96	98.2	335508	98.1	1700.52	98.2
Total	**46.8**	**100**	**341892**	**100**	**1731.6**	**100**
Cereal Bran						
Maize	0.04	2.5	440	2.1	4.76	2.5
Sorghum	1.59	97.5	20988	98.0	186.03	97.5
Total	**1.63**	**100**	**21428**	**100**	**190.8**	**100**
Pulse straw						
Field peas	0.51	45.1	4029	47.8	41.82	37.0
Haricot bean	0.62	54.9	4402	52.2	71.30	63.0
Total	**1.13**	**100**	**8431**	**100**	**113.1**	**100**
Oilseed straw						
Groundnut	0.33	100	1980	100	21.45	100
Vegetable plant aerial parts						
Tomato	0.1035	100	724.5	100	13.46	100
Oilseed cakes						
Sesame	0.021804	16.5	272.6	17.5	9.79	18.20
Groundnut	0.11	83.3	1287	82.5	44.00	81.78
Total	**0.132**	**100**	**1559.6**	**100**	**53.8**	**100**

Total cereal straws/stovers = 46.84 ($x10^3$ tonnes/year)
Total cereal brans = 1.63 ($x10^3$ tonnes/year)
Total pulse straws = 1.13 ($x10^3$ tonnes/year)
Total oilseed straws = 0.33 ($x10^3$ tonnes/year)
Total vegetable plant aerial parts = 0.1035 ($x10^3$ tonnes/year)
Total oilseed cakes = 0.13804 ($x10^3$ tonnes/year)

Potential availability of feed resources

Annual potential availability of some important permanent crops

(enset and banana leaves and stems, sugarcane tops and bagasse) based biomass ($x10^3$ tonnes/year)

Following table gives potential availability of permanent crops that are fully or partially used (banana and enset leaves and stems and sugarcane tops) or have potential (sugarcane bagasse) for use as animal feed. For production of complete feed rations in the form of blocks or pellets using sugarcane tops and/or bagasse, the availability is highest in SNNPR, followed by Oromia and Amhara. In other regions their availability is negligible.

	Banana leaves and stem	Enset leaves and stem	Sugarcane tops	Sugarcane bagasse	TOTAL
Tigray	1.475	0	0	0	**1.48**
Afar	0	0	0	0	**0**
Amhara	10.84	0	22.88	25.63	**59.35**
Oromia	113.19	166.63	42.92	48.07	**370.81**
Somali	3.90	0	0	0	**3.90**
B-G	5.24	0	0.329	0.368	**5.94**
SNNPR	365.92	377.91	110.16	123.38	**977.37**
Gambela	0	0	0	0	**0**
Harari	0.41	0	0	0	**0.41**
Dire Dawa	0	0	0	0	**0**
Total	**501.0**	**544.5**	**176.3**	**197.4**	**1419.2**

Annual potential availability of metabolizable energy (ME) and crude protein (CP) of some important permanent crops (enset and banana leaves and stems, sugarcane tops and bagasse) for all regions (all values as $x10^3$)

In this category, highest contribution towards CP and ME is of SNNPR (*ca* 70 percent), followed by Oromia (*ca* 26 percent). The contribution of other regions is negligible for both CP and ME.

Region	Banana leaves and stem		Enset leaves and stem		Sugarcane tops		Sugarcane bagasse		Total			
	CP (kg)	ME (MJ)	CP (kg)	ME (MJ)	CP (kg)	ME (MJ)	CP (kg)	ME (MJ)	CP (kg)	%	ME (MJ)	%
Tigray	113.59	12834.24	0	0	0	0	0	0	113.59	0.1	12834.2	0.1
Afar	0	0	0	0	0	0	0	0	0	0	0	0
Ahmara	834.98	94342	0	0	1121.11	183037.8	461.16	171654.0	2417.25	2.7	449034	3.8
Oromia	8715.86	984779	12330.7	1483011	2102.93	343334.7	865.20	322048.2	24014.69	26.4	3133173	26.2
Somali	300.3	34316	0	0	0	0	0	0	300.30	0.3	34316	0.3
B-G	403.55	45596	0	0	16.12	2631.5	6.63	2468.3	426.30	0.5	50695	0.4
SNNPR	28175.63	3183480	27965.6	3363429	5398.01	881307.5	2222.64	827316.0	63761.88	70.0	8255533	69.2
Gambela	0	0	0	0	0	0	0	0	0	0	0	0
Harari	31.28	3534	0	0	0	0	0	0	31.28	0.03	3534	0.03
Dire Dawa	0	0	0	0	0	0	0	0	0	0	0	0
Total	**38575.2**	**4358881**	**40296.3**	**4846440**	**8638.2**	**1410312**	**3555.64**	**1323487**	**91065.28**	**100**	**11939120**	**100**

Grazing area (ha) and potential availability of grazing biomass (x10^3 tonnes/year)

The following table gives grazing biomass availability by taking into consideration three and two zones respectively of Somali and Afar as per CSA (2016–2017). The livestock population data are also available for these areas in CSA (2016–2017). Grazing biomass availability is highest in Oromia and then is in Amhara.

Region	Forest area (ha)	Grassland area (ha)	Wetland (ha)	Forest grazing biomass (x10^3 tonnes/year)	Grassland grazing biomass (x10^3 tonnes/year)	Wetland grazing biomass (x10^3 tonnes/year)
Tigray	443426	3070649	19827.9	438.71	4266.00	39.66
Afar*	1271	3740.487	0	711.40	2094.00	0
Amhara	1875150	7179510	374100.3	2156.80	11024.96	748.20
Oromia	8749607	12384610	248907.2	9055.86	11652.83	497.81
Somali*	399992	4453285	12880.0	223.99	2493.84	25.76
B-G	1064838	3279071	27606.7	687.71	2131.97	55.21
SNNPR	4160207	3467283	150845.4	3945.23	2667.18	301.69
Gambela	942626	2024733	46831.6	589.97	1136.83	93.66
Harari	5875	7480.377	2.1	6.06	10.79	0.00424
Dire Dawa	23095	25072	2.38	17.68	17.97	0.00476

Factors used for converting hectares to grazing biomass in tonne: Forest land 1.2, Grassland 2.0, and Wetland 2.0 (as per Amsalu and Addisu, 2014) for mid and highland; For each region, lowland area was calculated, and a factor of 0.56 tonne/ha taken for both forest land and grassland that was in lowland; while for wetland the factor used was 2 tonnes/ha).

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

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

Annual production of metabolizable energy (ME) and crude protein (CP) through grazing biomass (all values as x10^3)

Region	Total grazing feed		Total ME		Total CP	
	Tonne	%	MJ	%	kg	%
Tigray	4744.4	8.3	39046206	8.3	362945	8.3
Afar**	2800.0	4.9	23044000	4.9	214200	4.9
Amhara	13929.9	24.4	114643431	24.4	1065641	24.4
Oromia	21206.5	37.2	174529487	37.2	1622297	37.2
Somali*	2743.6	4.8	22579828	4.8	209885	4.8
B-G	2874.9	5.0	23660369	5.0	219929	5.0
SNNPR	6914.1	12.1	56903026	12.1	528929	12.1
Gambela	1820.5	3.2	14982369	3.2	139265	3.2
Harari	16.9	0.03	138733	0.03	1290	0.03
Dire Dawa	35.7	0.06	293424	0.06	2727	0.06
Total	**57086.4**	**100**	**469820874**	**100**	**4367108**	**100**

*Somali crop, grazing area and livestock data correspond to the three zones as per CSA (2016–2017).

** Afar data corresponding to two zones (1 and 3) as per CSA (2016–2017)

Potential production of cultivated crop-based forages (x10^3 tonnes/year)

Four major cultivated crop-based forage production regions in Ethiopia are, in the order mentioned, Oromia, Amhara, SNNPR and Tigray. In Oromia, maize straw availability is highest (39 percent), followed by sorghum (22 percent), wheat (16 percent) and teff (15 percent) straws. In Amhara, availability of sorghum straw is highest (29 percent), followed by straws/stover of maize (25 percent) and teff (18 percent). In SNNPR, availability of straws of maize, sorghum and teff are 61, 13 and 11 percent respectively. In Tigray, sorghum straw availability is highest (55 percent). The pattern of availability of pulse straw is also the same as cereal straws and stovers; highest being in Oromia followed by Amhara. In Oromia, the availability of horse bean straw is highest, followed by those haricot and chickpea; and in Amhara availability of horse bean straw is also highest (33 percent), followed by chickpeas and grass peas straws. In Oromia, noug straw availability is highest (53 percent) and those of groundnut and linseed are 18 percent and 16 percent respectively, while in Amhara, sesame and noug are the main straws available.

Region	Cereal straws/ Stovers	Pulse straws	Oilseed straws	Vegetable plant aerial parts	Root crop aerial parts	Total Residues in respective regions (x10^3 tonnes)/year
Tigray	2854.33	60.25	157.39	3.82	2.80	3078.59
Afar	89.06	0.60	0	0	0	89.66
Amhara	12259.68	1233.84	587.47	46.59	201.54	14329.12
Oromia	19486.89	1412.79	731.62	99.81	498.92	22230.03
Somali	276.11	1.12	7.71	0.33	3.32	288.59
B-G	743.83	18.29	162.45	2.29	4.75	931.61
SNNPR	4055.62	569.32	26.37	199.22	945.76	5796.28
Gambela	43.67	0.122	0.47	0.046	0	44.31
Harari	34.37	0.0136	5.22	0.23	0	39.83
Dire Dawa	46.84	1.13	0.33	0.1035	0	48.40
Total	**39890.4**	**3297.5**	**1679.0**	**352.4**	**1657.1**	**46876.4**

Annual potential metabolizable Energy (ME as MJ) availability from cultivated crop-based forages (x10^3)

Three regions are the main source of ME from crop-based forages in Ethiopia. These being Oromia, Amhara and SNNPR, contributing 47, 30 and 13 percent of the total ME respectively.

Annual potential metabolizable energy (ME as MJ x10^3/year) of cultivated crop-based forages

Region	Cereal straws/stovers		Pulse straws		Oilseed straws		Vegetable plant aerial parts		Root crop aerial parts		Total ME	
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
Tigray	20382644	7.0	420707	1.8	1059038	11.9	26760.93	1.1	18436	0.1	21907586	6.5
Afar	675059	0.2	4140	0.8	0	0.0	0	0.0	0	0	848342	0.3
Amhara	88564291	30.6	8812171	38.0	3634951	40.8	326200	13.4	1436425	10.7	102774038	30.3
Oromia	141664181	48.9	9747376	42.0	4044216	45.4	698670	28.6	4014202	29.8	160168645	47.3
Somali	2032361	0.7	7976	0.03	46260	0.52	2310	0.1	20252	0.2	2109159	0.6
B-G	5440663	1.9	134544	0.6	984073	11.1	16030	0.7	38001	0.3	6613311	1.9
SNNPR	30049058	10.4	3904763	16.8	156373	1.8	1394470	57.1	7976156	59.1	43480820	12.8
Gambela	327190.7	0.1	866	0.0	3062	0.03	322	0.01	0	0	331441	0.10
Harari	252412	0.1	104	0.0	31320	0.4	2024	0.08	0	0	285861	0.08
Dire Dawa	341892	0.12	8431	0.04	1980	0.02	724.5	0.03	0	0	353028	0.10
Total	**289729752**	**100**	**23210222**	**100**	**8902235**	**100**	**2440751**	**100**	**13485036**	**100**	**338872229**	**100**

Potential annual crude protein (CP as kg) availability from cultivated crop-based forages (x10^3)

As far the ME, three regions are the main sources of CP from crop-based forages. These being Oromia, Amhara and SNNPR, contributing 44, 29 and 18 percent of the total CP respectively.

Potential crude protein (CP as kg x10^3/year) of cultivated crop-based forages

Region	Cereal straws/stovers		Pulse straws		Oilseed straws		Vegetable plant aerial parts		Root crop aerial parts		Total CP	
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Total amount	%
Tigray	106627.1	7.2	5397.5	1.8	13279.8	11.7	497	1.1	329.6	0.12	126131.0	5.7
Afar	3300.6	0.2	46.0	0.0002	0	0.00	0	0	0	0	3346.6	0.15
Amhara	458903.7	31.0	112251.2	37.1	42833.5	37.8	6058	13.2	29256.0	11.1	649302.5	29.4
Oromia	719222.1	48.6	126644.4	41.8	43585.1	38.4	12975	28.3	73416.0	27.7	975843.0	44.2
Somali	10170.7	0.7	127.8	0.04	501.2	0.4	42.9	0.09	298.8	0.11	11141.4	0.50
B-G	27915.9	1.9	1819.2	0.60	11073.8	9.8	297.7	0.7	730.4	0.3	41837.0	1.9
SNNPR	150213.1	10.1	56288.2	18.6	1709.6	1.5	25897.3	56.5	160863.6	60.8	394971.8	17.9
Gambela	1617.7	0.11	14.0	0.005	37.9	0.03	5.98	0.013	0	0	1675.6	0.08
Harari	1271.06	0.09	1.23	0.0004	339.3	0.3	29.9	0.07	0	0	1641.5	0.07
Dire Dawa	1731.6	0.12	113.1	0.037	21.45	0.02	13.46	0.03	0	0	1879.6	0.09
Total	**1480974**	**100**	**302657**	**100**	**113382**	**100**	**45818**	**100**	**264565**	**100**	**2207771**	**100**

Potential oilseed cake production (x10^3 tonnes/year)

A total of 567 thousand tonnes of oilseed cake are potentially available in Ethiopia. Potential availability of noug cake is highest (34.2 percent), followed by of sesame. 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 percent of the total production, contributing 43.7 percent and 35.4 percent respectively. In Amhara, production of sesame cake is highest (40 percent), followed by noug cake (24.5 percent); while in Oromia noug cake availability is highest (54.5 percent) and then is of linseed cake. The production of oilseed cakes in Somali, Harari, Gambela and Afar is negligible.

Region	Noug/Niger	Linseed	Safflower	Sesame	Rapeseed	Groundnut	Sunflower	Soyabean	Total oilseed cake in respective regions (x10^3 tonnes)/year
Tigray	4.773	4.182	0	38.704	0.1732	0.4102	0	0	**48.21**
Afar	0	0	0	0	0	0	0	0	**0**
Amhara	49.421	9.982	4.270	80.938	18.230	5.69	8.035	24.08	**200.65**
Oromia	134.821	39.432	0.155	15.901	7.302	34.96	0	14.95	**247.52**
Somali	0	0	0	0	0	2.69	0	0	**2.69**
B-G	5.273	B-G	5.273	B-G	5.273	B-G	5.273	B-G	5.27
SNNPR	0.436	0.464	0.154	0.2135	1.024	5.08	0.11	0.13	**7.61**
Gambela	0	0	0	0.1047	0	0	0		**0.105**
Harari	0	0	0	0.0683	0	0.23	0	0	**0.298**
Dire Dawa	0	0	0	0.0218	0	0.11	0	0	**0.132**
Total	**194.724**	**54.212**	**5.122**	**148.461**	**26.907**	**68.540**	**8.145**	**61.21**	**567.31**

Potential cereal bran production (x10^3 tonnes/year)

A total of 2 041 thousand tonnes of cereal brans are potentially available in Ethiopia. The highest production is in Oromia (50 percent), followed by Amhara (30.9 percent), SNNPR (10.2 percent) and Tigray (6.4 percent). In other regions the potential availability is low.

Region	Teff	Barley	Wheat	Maize	Sorghum	Finger Millet	Oats	Rice	Total bran in respective regions (x10^3 tonnes)/year
Tigray	18.74	12.89	16.18	12.90	54.11	14.90	0.01	0.0869	**129.82**
Afar	0.09	0	0	3.92	0.25	0	0	0	**4.26**
Amhara	148.98	52.34	101.63	151.17	124.64	42.36	0.408	8.20	**629.75**
Oromia	190.08	89.86	206.59	367.82	145.88	15.47	4.07	1.05	**1020.82**
Somali	0	0.05	0.61	4.32	6.13	0	0	0	**11.11**
B-G	2.30	0.09	0.37	14.32	10.81	4.14	0.0034	0.41	32.44
SNNPR	29.36	13.72	25.08	120.53	18.59	0.43	0.03	0.56	**208.30**
Gambela	0	0	0	1.45	0.47	0	0	0.022	**1.94**
Harari	0	0	0.01	0.27	0.99	0	0	0	**1.27**
Dire Dawa	0	0	0	0.04	1.59	0	0	0	**1.63**
Total	**389.55**	**168.95**	**350.46**	**676.74**	**363.46**	**77.30**	**4.52**	**10.33**	**2041.34**

Annual potential crude protein (CP as kg) and metabolizable energy (ME as MJ) availability from concentrates: oilseed cakes and cereal brans (x10^3)

Oromia, Amhara, SNNPR and Tigray are the main regions of CP availability from concentrates, contributing approximately 49, 31, 10 and 7 percent of the total respectively.

Annual potential availability of crude protein (CP) and metabolizable energy (ME) of oilseed cake and cereal brans (all values as x10^3)

Region			Oilseed cake			Cereal bran		
	CP (kg)	%	ME (MJ)	%	CP (kg)	%	ME (MJ)	%
Tigray	20473.76	9.3	584465.5	9.5	17688.39	6.2	1586315	6.7
Afar	0	0	0	0.0	511.93	0.2	47500	0.2
Amhara	80781.44	36.7	2222074	36.0	90024.26	31.5	7450338	31.3
Oromia	87640.63	39.8	2564651	41.6	143741.7	50.3	11765014	49.4
Somali	1076	0.5	31473	0.5	1335.89	0.47	135834	0.6
B-G	26960.54	12.2	670535.3	10.9	4080.706	1.4	392418.6	1.6
SNNPR	2953.367	1.3	87791.69	1.4	27880.72	9.8	2360277	9.9
Gambela	46.99234	0.02	1308.25	0.02	230.66	0.08	22501.6	0.09
Harari	122.6847	0.05	3545.25	0.06	149.56	0.05	16151	0.06
Dire Dawa	53.79	0.02	1559.55	0.03	190.79	0.06	21428	0.09
Total	**220109.2**	**100**	**6167404**	**100**	**285834.6**	**100**	**23797777**	**100**

Potential availability of stubble feeding amount available (aftermath) (x10^3 tonnes/year)

The order of availability of stubble feeding is the same as that of cereal straws: highest being in Oromia and then in Amhara.

Region	Belg	Meher	Total (Belg + Meher)
Tigray	3.7681	461.247	465.015
Afar	11.8559	3.562	15.417
Amhara	76.2428	1745.738	1821.981
Oromia	281.4728	2396.007	2677.480
Somali	2.2916	36.0140	38.306
B-G	2.0967	83.494	85.591
SNNPR	268.2332	442.572	710.805
Gambela	3.4022	3.554	6.957
Harari	0.1111	4.3409	4.452
Dire Dawa	0.0122	5.3798	5.392
Total	**649.49**	**5181.91**	**5831.40**

Annual potential metabolizable energy (ME) and crude protein (CP) availability from stubble feeding (all values are $x10^3$)

The pattern is similar to that of the cereal straws: Oromia > Amhara > SNNPR > Tigray. In rest of the regions the contribution of stubble feeding is negligible.

Region	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Tigray	3156522.5	7.9	17612.4	8.0
Afar	104653.9	0.3	583.9	0.3
Amhara	12367607.0	31.2	69007.5	31.2
Oromia	18174734.2	45.9	101409.6	45.9
Somali	260019.0	0.7	1450.8	0.7
B-G	580993.1	1.5	3241.7	1.5
SNNPR	4824941.6	12.2	26921.7	12.2
Gambela	47220.9	0.1	263.5	0.1
Harari	30220.2	0.07	168.6	0.1
Dire Dawa	36600.6	0.09	204.2	0.1
Total	**39583516**	**100**	**220864**	**100**

Annual potential pulse milling by-products (bulule) availability (values as $x10^3$ tonnes)

Availability is highest in Oromia, followed by Amhara and SNNPR. These three regions contribute almost 97.7 percent of the total pulse by-product availability.

Region	Total
Tigray	7.873
Afar	0.0805
Amhara	176.822
Oromia	201.759
Somali	0.2856
B-G	2.906
SNNPR	97.766
Gambela	0.0240
Harari	0
Dire Dawa	0.1476
Total	**487.66**

Annual potential metabolizable energy (ME) and crude protein (CP) availability from pulse milling by-products (all values are $x10^3$)

Availability is highest in Oromia, followed by Amhara and SNNPR. These three regions contribute almost 97 percent of the total ME and CP production in this category.

Region	Total ME (MJ)	Total ME as %	Total CP (kg)	Total CP as %
Tigray	8502.7	1.6	1511.6	1.6
Afar	87.0	0.02	15.46	0.016
Amhara	190967.4	36.3	33949.8	36.3
Oromia	217899.4	41.4	38737.7	41.4
Somali	308.5	0.06	54.8	0.06
B-G	3139.0	0.6	558.0	0.6
SNNPR	105587.0	20.0	18771.0	20.0
Gambela	25.9	0.005	4.6	0.005
Harari	0	0.00	0	0
Dire Dawa	159.5	0.03	28.4	0.03
Total	**526677**	**100**	**93631**	**100**

Annual potential availability of feed resources as dry matter (x10^3 tonnes)

In Ethiopia, availability (in million tonnes) of total crop-based forage is approx. 52.7 and that of grazing biomass 57.1. Total feed availability in Ethiopia is 114.4 million tonnes. The contribution of forages is 97.4 towards total biomass availability, suggesting very low contribution of concentrate feeds.

	Forages (x10^3 tonnes/year)			Permanent crops (x10^3 tonnes/ year)***	Concentrate feeds (x10^3 tonnes/year)			Feed available (million tonnes/ year
Region	Total crop-residue based forages	Total Stubble feeding	Total grazing feed		Oilseed cake	Cereal bran	Pulse by-products (Bulule)	
Tigray	3078.6	465.0	4744.4	1.654	48.21	129.817	7.873	8.475
Afar**	89.7	15.4	2800.0	0	0	4.260	0.0805	2.909
Amhara	14329.1	1822.0	13930.0	62.287	200.65	460.035	176.822	30.981
Oromia	22253.1	2677.5	21206.5	511.820	255.56	1020.82	201.759	48.126
Somali*	288.6	38.3	2743.6	0.505	2.69	11.110	0.2856	3.085
B-G	931.6	85.6	2874.9	7.217	60.07	32.440	2.906	3.999
SNNPR	5796.3	710.8	6914.1	1064.685	7.61	208.300	97.766	14.800
Gambela	44.3	6.96	1820.5	0	0.105	1.942	0.0240	1.874
Harari	39.8	4.45	16.9	0.426	0.298	1.270	0	0.063
Dire Dawa	48.4	5.39	35.7	0.0052	0.132	1.630	0.1477	0.0915
Total	**46900**	**5831**	**57086**	**1649**	**575.4**	**1871.6**	**487.7**	**114.4**

All values are on dry matter basis

*Somali crop, grazing area and livestock data correspond to the three zones as per CSA, 2016-2017

** Afar data corresponding to two zones (1 and 3)

*** all permanent crops taken

Annual potential metabolizable energy (ME) availability by taking potential availability of feed resources (all values as MJ x10^3)

Among the forages, grazing forage has the highest contribution, followed by crop-residue based forages; and among the concentartes the contribution of cereal brans is highest, followed by oilseed cakes.

	Forages				Concentrate feeds		
Region	Total crop-residue based forages	Total Stubble feeding	Grazing feed	Permanent crop[a]	Oilseed cake	Cereal bran	Pulse by-products (Bulule)
Tigray	21907586	3156522.5	39046206.3	12834.2	584465.5	1586315	8502.7
Afar	848342	104653.9	23044000**	0	0	47500	86.9
Amhara	102774038	12367607.0	114643431	449033.9	2222074	7450338	190967.4
Oromia	160168645	18174734.2	174529487	3133173	2564651	11765014	217899.4
Somali	2109159	260018.9	22579828*	34316.1	31473	135834	308.5
B-G	6613310	580993.0	23660369.4	50695.4	670535.3	392419	3139.0
SNNPR	43480820	4824941.6	56903026.5	8255533	87791.7	2360277	105587.0
Gambela	331441	47220.9	14982369.3	0	1308.3	22502	25.9
Harari	285860	30220.2	138733.1	3534.3	3545.3	16151	0
Dire Dawa	352027	36600.5	293424.2	0	1559.6	21428	159.5
Total	**338872229**	**39583516**	**469820875**	**11939120**	**6167404**	**23797777**	**526676**

All values are on dry matter basis

[a], only bagasses, sugarcane tops, banana leaves, enset leaves and stems taken

*Somali crop, grazing area and livestock data correspond to the three zones as per CSA (2016–2017).

** Afar grazing data corresponding to two zones (1 and 3) as per CSA (2016–2017)

Annual potential metabolizable energy (ME) availability from total forages and total concentrate feed (all values as MJ $x10^3$)

Total ME availability is 890 x 10^9 MJ. The contribution of forages (included grazing biomass) is 96.6 percent towards total ME availability, suggesting very low contribution of concentrate feeds to ME availability in Ethiopia. Poultry, aqua and pig feeds require energy-dense feed resources, which are highly deficient in Ethiopia.

Region	Total forage ME (MJ)	Total forage ME as %	Total concentrate ME (MJ)	Total concentrate ME as %	Total feed as MJ	Total forage ME as %
Tigray	64123148.7	7.5	2179283.2	7.2	66302432.0	96.7
Afar	23996995.9	2.8	47587.0	0.2	24044582.9	99.8
Amhara	230234109.9	26.8	9863379.4	32.4	240097489.3	95.9
Oromia	356006039.2	41.4	14547564.4	47.7	370553603.6	96.1
Somali	24983322.1	2.9	167615.5	0.6	25150937.6	99.3
B-G	30905368.6	3.6	1066092.9	3.5	31971461.5	96.7
SNNPR	113464321.1	13.2	2553655.7	8.4	116017976.8	97.8
Gambela	15361031.1	1.8	23835.8	0.08	15384866.9	99.8
Harari	458348.1	0.05	19696.3	0.06	478044.4	95.9
Dire Dawa	683052.2	0.08	23147.0	0.08	706199.3	96.7
Total	**860215737**	**100**	**30491857**	**100**	**890707594**	**96.6**

Feed: forage plus concentrate

In the calculation for forages, Somali crop, grazing area and livestock data correspond to the three zones; and Afar data corresponding to two zones (1 and 3) as per CSA (2016–2017)

Annual poteintial crude protein availability by taking potential availability of all feed resources (all values as kg x10^3)

Among the forages, grazing forages have the highest contribution, followed by crop-residue based forages; and among the concentartes the contribution of cereal brans is highest, followed by oilseed cakes.

	Forages				Concentrate feeds		
Region	Total crop-residues based forages	Total Stubble feeding	Grazing feed	Permanent crop[a]	Oilseed cake	Cereal bran	Pulse by-products
Tigray	126131.0	17612.5	362944.7	113.59	20473.76	17688.39	1511.60
Afar	3301.2	583.9	214200**	0	0	511.93	15.46
Amhara	649302.5	69007.5	1065641	2417.25	80781.44	90024.26	33949.77
Oromia	975843.0	101409.6	1622297	24014.69	87640.63	143741.70	38737.67
Somali	11141.4	1450.8	209885.4*	300.30	1076.00	1335.89	54.85
B-G	41837.0	3241.8	219929.3	426.30	26960.54	4080.71	558.04
SNNPR	394971.8	26921.7	528928.5	63761.88	2953.37	27880.72	18771.01
Gambela	1675.6	263.5	139265	0	46.99	230.66	4.61
Harari	1641.5	168.6	1289.6	31.28	122.68	149.56	0
Dire Dawa	1879.6	204.2	2727.5	0	53.79	190.79	28.35
Total	**2207724.6**	**220864.1**	**4367107.9**	**91065.28**	**220109.20**	**285834.61**	**93631.37**

All values are on dry matter basis

[a], only sugarcane tops, banana leaves, enset leaves and stems and bagasse taken

*Somali crop, grazing area and livestock data correspond to the three zones as per CSA (2016–2017).

** Afar grazing data corresponding to two zones (1 and 3) as per CSA (2016–2017)

Annual potential crude protein (CP) availability from total forages and concentrate feeds (all values as kg x10^3)

Total CP availability is 7.49 million tonnes. The contribution of forages (included grazing biomass) is 92 percent towards total CP availability, suggesting little contribution of concentrate feeds to CP availability in Ethiopia. Poultry, aqua and pig feeds require protein-dense feed resources, which are highly deficient in Ethiopia.

Region	Total forage CP (kg)	Total forage CP as %	Total concentrate CP (kg)	Total concentrate CP as %	Total feed as CP	Total forage CP as %
Tigray	506801.8	7.4	39673.75	6.6	546475.51	92.7
Afar	218085.2	3.2	527.39	0.09	218612.55	99.8
Amhara	1786368.2	25.9	204755.47	34.2	1991123.71	89.7
Oromia	2723564.2	39.5	270120.00	45.1	2993684.24	91.0
Somali	222777.9	3.2	2466.74	0.41	225244.62	98.9
B-G	265434.4	3.9	31599.29	5.3	297033.67	89.4
SNNPR	1014583.9	14.7	49605.11	8.3	1064189.02	95.3
Gambela	141204.1	2.1	282.27	0.05	141486.32	99.8
Harari	3131.0	0.05	272.24	0.05	3403.20	92.0
Dire Dawa	4811.3	0.07	272.93	0.05	5084.23	94.6
Total	**6888560.9**	**100**	**599575.2**	**100**	**7488136.1**	**92.0**

Feed: forage plus concentrate This table has been corrected taking values from the above table

In the calculation for forages, Somali's crop, grazing area and livestock data correspond to the three zones; and Afar data corresponding to two zones (1 and 3) as per CSA (2016–2017)

Annual feed balance taking potential availability of feed resources, on dry matter basis

For Somali, the feed balance has turned out to be positive, which may not be taken as for whole Somali. It is for three zones of Somali for which CSA data are available. B-G and Gambela regions have positive feed balance which could be attributed to relatively low livestock population (due to presence of tsetse fly) in these regions. The positive feed balance for B-G and Gambela regions suggests that biomass can be harvested from these regions, densified and transported to feedbanks in the areas where the droughts occur.

	Forages ($x10^3$ tonnes/year)			Permanent crops ($x10^3$ tonnes/ year)***	Concentrate feeds ($x10^3$ tonnes/year)			Feed available (million tonnes/ year	Feed requirements (million tonnes/ year)	Feed Balance (absolute)
Region	Total crop-residue based forages	Total Stubble feeding	Total grazing feed		Oilseed cake	Cereal bran	Pulse by-products (Bulule)			
Tigray	3078.6	465.0	4744.4	1.654	48.21	129.82	7.87	8.475	10.2626	**-17.4**
Afar**	89.7	15.4	2800.0	0	0	4.26	0.0805	2.909	4.4847	**-35.1**
Amhara	14329.1	1822.0	13929.9	62.287	200.65	460.04	176.82	30.981	34.2703	**-9.6**
Oromia	22253.1	2677.5	21206.5	511.820	255.56	1020.82	201.76	48.126	50.1610	**-4.1**
Somali*	288.6	38.3	2743.6	0.505	2.69	11.11	0.2857	3.085	2.3465	**+31.5**
B-G	931.6	85.6	2874.9	7.217	60.07	32.44	2.90	3.999	1.4601	**+173.9**
SNNPR	5796.3	710.8	6914.1	1064.685	7.61	208.30	97.76	14.800	22.5408	**-34.4**
Gambela	44.3	7.0	1820.5	0	0.105	1.94	0.0240	1.874	0.4876	**+284.3**
Harari	39.8	4.4	16.9	0.426	0.298	1.27	0	0.063	0.1564	**-59.7**
Dire Dawa	48.4	5.4	35.7	0.0052	0.132	1.63	0.1476	0.0915	0.1850	**-50.6**
Total	**46899.5**	**5831.4**	**57086.4**	**1648.60**	**575.4**	**1871.62**	**487.7**	**114.41**	**126.4**	**-9.5**

All values are on dry matter basis

*Somali crop, grazing area and livestock data correspond to the three zones as per CSA, 2016–2017; ** Afar data corresponding to two zones (1 and 3)

*** all permanent crops taken; Feed DM requirement is based on conversion of livestock number to Tropical Livestock Units (TLU; I TLU = 250 kg) and then taking 2.5 percent of the body weight as daily feed intake as DM.

Species- and region-wise annual metabolizable energy (ME) requirements (MJ x10^3)

The ME requirement is highest in Oromia, followed by Amhara, SNNPR and Tigray. Among the animal species, the requirement of cattle is highest (*ca* 83 percent), while that of sheep and goats is *ca* 4.7 percent each.

Region	Species								
	Cattle	Sheep	Goat	Camel	Horse	Donkey	Mule	Total for Region	% Region wise
Tigray	110880132	5050420	11538486	1080535	59118	6434852	73537	135117080	8.3
Afar	27703157	4284251	8789426	7454267	2030	780549	8747	49022426	3.0
Amhara	373823523	26523568	15893459	1415463	7244659	22970492	1783863	449655028	27.7
Oromia	551863187	24362781	20183630	6224965	20091218	26465271	1349693	650540745	40.0
Somali	12489631	2538895	3909771	6036001	3394	1070060	0	26047752	1.6
B-G	17574231	246287	1055301	0	39670	596891	17175	19529555	1.2
SNNPR	245561826	12621013	13625045	31433	5991166	6224082	714524	284769089	17.5
Gambela	5992519	109598	248979	0	11576	13353	732	6376757	0.4
Harari	1453064	17622	181888	106407	0	102736	0	1861717	0.11
Dire Dawa	1112609	159054	518758	163070	852	140882	0	2095227	0.13
TOTAL Species wise	**1348453879**	**75913489**	**75944743**	**22512142**	**33443683**	**64799168**	**3948272**	**1625015376**	**100**
Species wise (%)	**83.0**	**4.7**	**4.7**	**1.4**	**2.1**	**4.0**	**0.2**	**100**	-

Species- and region-wise annual crude protein (CP) requirements (kg)

The CP requirement is highest in Oromia, followed by Amhara, SNNPR and Tigray. Among the animal species, the requirement of cattle is highest (*ca* 80 percent), while that of sheep and goats is 6 percent and 5.5 percent respectively.

Region	Species							Total for respective region	Region wise (%)
	Cattle	Sheep	Goat	Camel	Horse	Donkey	Mule		
Tigray	827201240	51920647	107874742	7505192	437585	68176725	770586	1063886717	8.3
Afar	230073684	44314029	81756592	56785849	15026	8269851	91655	421306686	3.3
Amhara	2753535252	271250980	152001958	9831542	53623981	243370473	18692907	3502307094	27.2
Oromia	4198218765	249490179	192276522	47281610	148712465	280397368	14143283	5130520192	39.8
Somali	102278928	26656700	36030423	44443818	25120	11337203	0	220772191	1.7
B-G	134436935	2551169	10224918	0	293635	6324008	179978	154010643	1.2
SNNPR	1926261187	132201883	124075621	218328	44345797	65943631	7487419	2300533866	17.9
Gambela	49671585	1148411	2347620	0	85682	141470	7672	53402440	0.4
Harari	12520883	184294	1720758	739085	0	1088481	0	16253501	0.13
Dire Dawa	9352332	1643246	4834452	1132656	6309	1492634	0	18461628	0.14
Total Species wise	**10243550792**	**781361536**	**713143606**	**167938079**	**247545600**	**686541844**	**41373499**	**12881454956**	**100**
Species wise (%)	**79.5**	**6.1**	**5.5**	**1.3**	**1.9**	**5.3**	**0.3**	-	-

Annual feed balance as metabolizable energy (ME) and crude protein (CP) based on potential availability (feed availability and animal requirement data for ME are in $x10^3$ MJ and for CP are in $x10^3$ kg)

As far the feed balance on DM basis, B-G and Gambela have positive feed balance, while rest of the regions have negative feed balance. At the country level th4 deficiency of CP and ME is 42 percent and 45 percent. It is important to recall that the deficiency of DM was only 9 percent . These results suggest that there is severe deficiency of good quality feed in Ethiopia. These have wide implications for sustainable development of the livestock sector and in particularly of the poultry and aqua sectors.

Region	Total ME availability	Total CP availability	Total ME requirement	Total CP requirement	Feed ME balance	Feed CP balance
Tigray	66302432.0	546475.5	135117079.6	1063886.717	-50.9	-48.6
Afar	24044582.9	218612.6	49022426.0	421306.685	-50.9	-48.1
Amhara	240097489.3	1991123.7	449655028.1	3502307.094	-46.6	-43.1
Oromia	370553603.6	2993684.2	650540744.9	5130520.192	43.03	-41.6
Somali	25150937.6	225244.6	26047752.2	220772.191	-3.44	+2.0
B-G	31971461.5	297033.7	19529555.3	154010.643	+63.7	+92.9
SNNPR	116017976.8	1064189.0	284769089.5	2300533.866	-59.3	-53.7
Gambela	15384866.9	141486.3	6376756.8	53402.439	+141.3	+164.9
Harari	478044.4	3403.2	1861716.8	16253.501	-74.3	-79.1
Dire Dawa	706199.3	5084.2	2095226.6	18461.628	-66.3	-72.5
Total	**890707594.2**	**7488136**	**1625015376**	**12965925.6**	**-45.2**	**-42.3**

Annual percent feed balance as dry matter, crude protein (CP) and metabolizable energy (ME)

Ethiopia is deficient of dry matter by 9 percent while the ME and CP deficiencies are 45 percent and 42 percent respectively, again suggesting lack of good quality feeds in the country. Two regions

Feed balance based on potential feed availability

Region	Feed dry matter balance (%)	Feed metabolizable energy balance (%)	Feed crude protein balance (%)
Tigray	-17.4	-50.9	-48.6
Afar	-35.1	-50.9	-48.1
Amhara	-9.6	-46.6	-43.1
Oromia	-4.0	-43.0	-41.6
Somali	+31.5	-3.4	+2.0
B-G	+173.9	+63.7	+92.9
SNNPR	-34.2	-59.3	-53.7
Gambela	+284.3	+141.3	+164.9
Harari	-59.7	-74.3	-79.1
Dire Dawa	-50.6	-66.3	-72.5
Total	**-9.4**	**-45.2**	**-42.3**

Actual national feed inventory and feed balance

Crop residues have a number of competitive uses. Also oilseeds are being exported from Ethiopia. These were taken into account in arriving at actual national feed inventory and feed balance from the potential ones. For competitive uses of crop residues, a questionnaire-based approach was used. Details are available in Annex 2. Oilseed export data were obtained from statistical databases.

Annual actual use of some important permanent crops (enset and banana leaves and stems, sugarcane tops and bagasse) based biomass (10^3 tonnes/year) after taking into account their competitive uses

Sugarcane tops and/or bagasse availability is highest in SNNPR, followed by Oromia and Amhara. In other regions their availability is negligible. Banana leaves have other competitive uses and a portion of sugarcane tops is burnt and not used for livestock feeding or as a mulch.

Region	Banana leaves and stem	Enset leaves and stem*	Sugarcane tops	Sugarcane bagasse	TOTAL
Tigray	1.269	0	0	0	**1.269**
Afar	0	0	0	0	**0**
Amhara	5.42	0	13.73	1.28	**20.43**
Oromia	56.60	166.63	30.04	4.807	**258.08**
Somali	1.56	0	0	0	**1.56**
B-G	2.62	0	0.2302	0.0368	**2.887**
SNNPR	329.33	377.91	77	0	**784.24**
Gambela	0	0	0	0	**0**
Harari	0.203	0	0	0	**0.203**
Dire Dawa	0	0	0	0	**0**
Total	**397.0**	**544.5**	**121.0**	**6.124**	**1068.7**

*Based data on enset feed amount per tree; obtained from Prof. Adeguna Tolera

Annual actual availability of metabolizable energy (ME) and crude protein (CP) from some important permanent crops (enset and banana leaves and stems, sugarcane tops and bagasse) after taking into account their competitive uses (all values as $x10^3$)

In this category highest contribution towards CP and ME is of SNNPR (*ca* 74 percent), followed by Oromia (*ca* 24 percent). The contribution of other regions is negligible for both CP and ME.

Region	Banana leaves and stem		Enset leaves and stem		Sugarcane tops		Sugarcane bagasse		Total			
	CP (kg)	ME (MJ)	CP (kg)	ME (MJ)	CP (kg)	ME (MJ)	CP (kg)	ME (MJ)	CP (kg)	%	ME (MJ)	%
Tigray	97.7	11037.5	0	0	0	0	0	0	97.69	0.13	11037.5	0.12
Afar	0	0	0	0	0	0	0	0	0	0	0	0
Amhara	417.5	47171.1	0	0	672.67	109822.7	23.06	8582.7	1113.22	1.45	165576.5	1.8
Oromia	4357.9	492389.4	12330.7	1483010.8	1472.05	240334.3	86.52	32204.8	18247.20	23.72	2247939.0	24.1
Somali	120.1	13726.4	0	0	0	0	0	0	120.12	0.16	13726.4	0.2
B-G[a]	201.8	22797.8	0	0	11.29	1842.0	6.63	2468.3	219.67	0.29	27108.2	0.3
SNNPR	25358.1	2865132.0	27965.6	3363429.3	3778.61	616915.3	0	0	57102.28	74.24	6845477.0	73.5
Gambela[a]	0	0	0	0	0	0	0	0	0	0	0	0
Harari[a]	15.6	1767.2	0	0	0	0	0	0	15.64	0.02	1767.2	0.02
Dire Dawa[b]	0	0	0	0	0	0	0	0	0	0	0	0
Total	**30568.7**	**3454021**	**40296.3**	**4846440.1**	**5934.6**	**968914.4**	**116.2**	**43255.8**	**76915.8**	**100**	**9312632**	**100**

*Based data on enset feed amount per tree; obtained from Prof. Adeguna Tolera

[a] similar to that of Oromia, and [b] similar to that of Somali

Annual actual availability of oilseed cake production for livestock production (x10^3 tonnes)

After taking into consideration oilseed exports, only 378.4 thousand tonnes of oilseed cakes are available for animal feeding. The availability being highest in Oromia, followed by Amhara and B-G. At a country level, availability of noug seed cake is highest (46.3 percent), followed by groundnut cake (18.1 percent) and linseed cake (14.3 percent).

Region	Noug/Niger*	Linseed	Safflower	Sesame**	Rapeseed	Groundnut	Sunflower	Soyabean***	Total oilseed cake
Tigray	4.296	4.182	0	0	0.1732	0.41	0	0	**9.06**
Afar	0	0	0	0	0	0	0	0	**0**
Amhara	44.472	9.982	4.2703	0	18.2299	5.69	8.035	15.82	**106.50**
Oromia	121.340	39.432	0.1547	0	7.3024	34.96	0	9.82	**213.01**
Somale	0	0	0	0	0	2.69	0	0	**2.69**
B-G	4.746	0.1509	0.5431	0	0.1773	19.37	0	14.49	**39.47**
SNPPR	0.392	0.4642	0.1541	0	1.0242	5.08	0.11	0.085	**7.31**
Gambela	0	0	0	0	0	0	0		**0**
Harari	0	0	0	0	0	0.23	0	0	**0.23**
Dire Dawa	0	0	0	0	0	0.11	0	0	**0.11**
Total	**175.25**	**54.21**	**5.12**	**0**	**26.91**	**68.54**	**8.15**	**40.21**	**378.38**

*10 percent of Niger/noug seed is exported on average per year and hence 10 percent of Niger cake excluded from the calculations (10 percent less in each the region of availability), ** Sesame cake was excluded because 75 percent of the sesame seed production is exported and the rest used for human consumption (a negligible part is used for oil extraction in Ethiopia and hence sesame cake availability for feeding was taken as zero)

*** Soybean export has been of 21 000 tonnes in 2016 (deducted from the region of production based on weighted average production); source: USDA 2016. Global Agriculture Information Network (GAIN) Report Number ET1611, Addis Ababa, Ethiopia (https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Ethiopia%E2%80%99s%20Oilseed%20Production%20Forecast%20to%20Increase%20Despite%20Drought_Addis%20Ababa_Ethiopia_4-22-2016.pdf)

Annual actual crude protein (CP as kg) and metabolizable energy (ME as MJ) availability from oilseed cakes (x10^3) after taking into account export of oilseeds

Both for ME and CP availability, the contribution is highest for Oromia (56 percent) followed by Amhara (28 percent) and B-G (11 percent). The contribution of other regions to oilseed cake availability is negligible.

Region	Oilseed cake			
	CP (kg)	%	ME (MJ)	%
Tigray	3095.7	2.3	100666	2.6
Afar	0	0.0	0	0.0
Amhara	38507.5	28.4	1079049	27.6
Oromia	73549.6	54.3	2190703	56.1
Somali	174.9	0.1	16140	0.4
B-G	17168.9	12.7	429994	11.0
SNNPR	2820	2.1	84258	2.2
Gambela	0	0.0	0	0.0
Harari	92.0	0.07	2691	0.07
Dire Dawa	44.0	0.03	1287	0.03
Total	**135453**	**100**	**3904788**	**100**

Ten percent of Niger/noug seed is exported on average per year and hence 10 percent of Niger cake excluded from the calculations (10 percent less in each the region of availability); Sesame cake was excluded because 75 percent of the sesame seed production is exported and the rest used for human consumption (a negligible part is used for oil extraction in Ethiopia and hence sesame cake availability for feeding was taken as zero); Soya bean export has been on 21 000 tonnes in 2016 (deducted from the region of production based on weighted average production); source: USDA 2016. Global Agriculture Information Network (GAIN) Report Number ET1611, Addis Ababa, Ethiopia

(https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Ethiopia%E2%80%99s%20Oilseed%20Production%20Forecast%20to%20Increase%20Despite%20Drought_Addis%20Ababa_Ethiopia_4-22-2016.pdf)

Actual use of cultivated crop-based forages (x10^3 tonnes/year) for animal feeding after taking into account competitive used of feed resources

There are many competitive uses of crop-based forages e.g. mulch, fuel (cooking), roof making, packing, etc (see Annex 2). The data below is the extent of use of crop-based forages only for feeding. Almost 70 percent of the available crop-based forages is used for animal feeding. Some of these crop residues are burnt on the field and this could be avoided. Sesame straw (aerial parts) are either burnt or used to a small extent for animal feeding. According to local experts, farmers are not aware of the quality of sesame straw. This straw is of good quality. Also large amounts of various crop residues are wasted. A concerted effort is needed to enhance their utilization.

Region	Cereal straws/ Stovers	Pulse straws	Oilseed straws	Vegetable plant aerial parts	Root crop aerial parts	Total Residues in respective regions (x10^3 tonnes)/ year
Tigray	2608.2	54.40	74.52	2.27	1.90	2741.3
Afar	88.9	0.60	0	0	0	89.5
Amhara	10033.8	1233.85	452.60	46.59	201.54	11968.4
Oromia	11268.7	952.27	305.19	0	0	12526.1
Somali	228.9	0.57	7.71	0	0	237.2
B-G	430.1	12.34	67.72	0	0	510.2
SNNPR	3332.7	503.53	15.15	175.88	705.58	4732.9
Gambela	25.3	0.082	0.20	0	0	25.6
Harari	19.9	0.009	2.45	0	0	22.4
Dire Dawa	38.8	0.56	0.33	0	0	39.7
Total	**28075.4**	**2757.6**	**922.9**	**224.74**	**909.0**	**32889.6**

Annual actual availability of metabolizable energy (ME as MJ x10^3) for animal feeding from cultivated crop-based forages after taking into account their competitive uses

Three regions are the main sources of ME from crop-based forages. These being Oromia, Amhara and SNNPR, contributing 38, 36 and 15 percent of the total ME respectively. Due to various competitive uses of crop residues such as roof and wall making, as fuel or mulch, the ME content decreased by 30 percent. A part of the crop residues is also burnt which also contributed to the loss in ME. This loss can be avoided and diverted to animal feeding.

Region	Cereal straws/stovers		Pulse straws		Oilseed straws		Vegetable plant aerial parts		Root crop aerial parts		Total ME	
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
Tigray	18605639	9.1	381297	2.0	496649	9.1	15869	1.0	12847	0.2	19512301.3	8.2
Afar	673459	0.3	4140	0.02	0	0.0	0	0.0	0	0.00	677599.3	0.3
Amhara	72476161	35.5	8812171	45.6	2803582	51.4	326200	20.7	1436425	20.0	85854539.0	36.1
Oromia	82365074	40.3	6607935	34.2	1610414	29.5	0	0.0	0	0.00	90583423.0	38.1
Somali	1684993	0.8	3869.67	0.02	46260	0.9	0	0.0	0	0.00	1735122.7	0.7
B-G	3163260	1.6	91210	0.5	391860	7.2	0	0.0	0	0.00	3646330.0	1.5
SNNPR	24837740	12.2	3437754	17.8	90644	1.7	1231160	78.3	5719873	79.8	35317170.9	14.8
Gambela	189771	0.09	589	0.00	1225	0.02	0	0.00	0	0.00	191585.0	0.08
Harari	146399	0.07	70.9	0.00	12528	0.2	0	0.00	0	0.00	158997.9	0.07
Dire Dawa	283456	0.14	4090	0.02	1980	0.04	0	0.00	0	0.00	289526.0	0.12
Total	**204425952**	**100**	**19343126**	**100**	**5455142**	**100**	**1573229**	**100**	**7169145**	**100**	**237966594.7**	**100**

Annual actual crude protein (CP as kg x10^3) availability for use as animal feed from cultivated crop-based forages after taking into account their competitive uses

Three regions are the main source of CP from crop-based forages in Ethiopia. These being Amhara, Oromia and SNNPR, contributing 36, 34 and 20 percent of the total CP respectively. Due to various competitive uses of crop residues such as roof and wall making, as fuel or mulch the ME content decreased by 31 percent. A part of the crop residues is also burnt which also contributes to the loss in CP. This loss can be avoided and diverted to animal feeding.

Region	Cereal straws/stovers		Pulse straws		Oilseed straws		Vegetable plant aerial parts		Root crop aerial parts		Total CP	
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Total amount	%
Tigray	97475	9.3	4943	1.9	6189.1	10.0	294.7	1.0	241.2	0.2	109142.9	7.1
Afar	3292	0.3	46	0.02	0	0.00	0	0.00	0	0.0	3338.3	0.2
Amhara	375884	35.9	112251	44.2	33014.1	53.1	6058.0	20.7	29256.0	20.0	556463.1	36.3
Oromia	418656	40.0	86806	34.2	16964.2	27.3	0	0.00	0	0.00	522426.5	34.1
Somali	8432	0.8	64	0.03	501.2	0.8	0	0.00	0	0.00	8997.7	0.6
B-G	16250	1.6	1247	0.5	4310.1	6.9	0	0.00	0	0.00	21806.7	1.4
SNNPR	123599	11.8	48725	19.2	987.8	1.6	22864.4	78.3	110153.9	78.9	306330.7	20.0
Gambela	938	0.09	9.6	0.00	14.8	0.02	0	0.00	0	0.00	962.6	0.06
Harari	737	0.07	0.9	0.00	132.3	0.2	0	0.00	0	0.00	870.4	0.06
Dire Dawa	1436	0.14	57.2	0.02	21.5	0.03	0	0.00	0	0.00	1514.2	0.10
Total	**1046700**	**100**	**254150**	**100**	**62135**	**100**	**29217**	**100**	**139651**	**100**	**1531853**	**100**

Annual actual metabolizable energy (ME) availability from forages after taking into account their competitive uses and from concentrates after taking into account export of oilseeds (all values as MJ x10^3)

The difference between potential and actual values were only for crop residues and permanent crops because of their various competitive uses, and in oilseed cakes because seeds of some of them (sesame, noug and soybean) are exported.

	Forages				Concentrate feeds		
Region	Total crop-residue based forages	Total Stubble feeding	Grazing feed	Permanent crop[a]	Oilseed cake	Cereal bran	Pulse byproducts (Bulule)
Tigray	19512301.3	3156522.5	39046206	11037	100666	1586315	8502.7
Afar	677599.3	104653.9	23044000**	0	0	47500	87.0
Amhara	85854539.0	12367607.0	114643431	165577	1079049	7450338	190967.4
Oromia	90583423.0	18174734.5	174529487	2247939	2190703	11765014	217899.4
Somali	1735122.7	260018.9	22579828*	13726	16140	135834	308.5
B-G	3646330.0	580993.1	23660369	27108	429994	392419	3139.0
SNNPR	35317170.9	4824941.6	56903027	6845477	84258	2360277	105587.0
Gambela	191585.0	47220.9	14982369	0	0	22502	25.9
Harari	158997.9	30220.2	138733.1	1767	2691	16151	0
Dire Dawa	289526.0	36600.5	293424.2	0	1287	21428	159.5
Total	**237966595**	**39583516**	**469820875**	**9312632**	**3904788**	**23797777**	**526676**

All values are on dry matter basis

[a] only bagasses, sugarcane tops, banana leaves, enset leaves and stems taken

*Somali crop, grazing area and livestock data correspond to the three zones as per CSA (2016–2017).

** Afar grazing data corresponding to two zones (1 and 3) as per CSA (2016–2017)

Annual actual metabolizable energy (ME) availability from total forages and concentrates (all values as MJ x10^3)

Total ME actually availabile is *ca* 785 x 10^9 MJ. The contribution of forages is 96.4 percent towards total ME availability, suggesting very low contribution of concentrate feeds to ME availability in Ethiopia. Poultry, aqua and pig feeds require energy-dense feed resources, which are highly deficient in Ethiopia.

Region	Total forage ME (MJ)	Total forage ME as %	Total concentrate ME (MJ)	Total concentrate ME as %	Total feed as MJ	Total forage ME as %
Tigray	61726068	8.2	1695483	6.0	63421551	97.3
Afar	23826253	3.2	47587	0.2	23873840	99.8
Amhara	213031154	28.2	8720354	30.9	221751508	96.1
Oromia	285535584	37.7	14173616	50.2	299709200	95.3
Somali	24588696	3.3	152283	0.5	24740979	99.4
B-G	27914801	3.7	825551	2.9	28740352	97.1
SNNPR	103890616	13.7	2550122	9.0	106440738	97.6
Gambela	15221175	2.0	22528	0.08	15243703	99.9
Harari	329718	0.04	18842	0.07	348560	94.6
Dire Dawa	619551	0.08	22875	0.08	642425	96.4
Total	**756683618**	**100**	**28229242**	**100**	**784912859**	**96.4**

Feed: forage plus concentrate

In the calculation for forages, Somali crop, grazing area and livestock data correspond to the three zones; and Afar data corresponding to two zones (1 and 3) as per CSA (2016–2017)

Annual actual crude protein (CP) availability after taking into account competitive uses of forages and export of oilseeds (all values as kg x10^3)

Among the forages, grazing forages have the highest contribution, followed by crop-residue based forages; and among the concentartes the contribution of cereal brans is highest, followed by oilseed cakes. The contribution of crop residues has decreased due to their several competitive uses. Likewise, contribution of concentrate feeds decreased due to export of oilseeds.

	Forages			Concentrate feeds			
Region	Total crop residues based forages	Total Stubble feeding	Grazing feed	Permanent crop[a]	Oilseed cake	Cereal bran	Pulse byproducts
Tigray	109143	17613	362945	97.7	3095.7	17688.4	1511.6
Afar	3338	584	214200**	0	0	511.9	15.5
Amhara	556463	69008	1065641	1113.2	38507.4	90024.3	33949.8
Oromia	522427	101410	1622297	18247.2	73549.6	143741.7	38737.7
Somali	8998	1451	209885*	120.1	174.9	1335.9	54.9
B-G	21807	3242	219929	219.7	17168.9	4080.7	558.0
SNNPR	306331	26922	528929	57102.3	2820.0	27880.7	18771.0
Gambela	963	264	139265	0	0	230.7	4.6
Harari	870	169	1290	15.6	92.0	149.6	0
Dire Dawa	1514	204	2727	0	44.0	190.8	28.4
Total	**1531853**	**220864**	**4367107**	**76916**	**135453**	**285835**	**93632**

All values are on dry matter basis

[a] only sugarcane tops, banana leaves, enset leaves and stems and bagasse taken

*Somali crop, grazing area and livestock data correspond to the three zones as per CSA (2016–2017).

** Afar grazing data corresponding to two zones (1 and 3) as per CSA (2016–2017)

Annual actual crude protein (CP) availability from total forages and total concentrate feeds (all values as kg x10^3)

Total actual CP availability is 6.71 million tonnes. The contribution of forages is 92 percent towards total CP availability, suggesting little contribution of concentrate feeds to CP availability in Ethiopia. Poultry, aqua and pig feeds require protein-dense feed resources, which are highly deficient in Ethiopia.

Region	Total forage CP (kg)	Total forage CP as %	Total concentrate CP (kg)	Total concentrate CP as %	Total feed as CP	Total forage CP as %
Tigray	489798	7.9	22296	4.3	512093	95.7
Afar	218122	3.5	527	0.1	218650	99.8
Amhara	1692225	27.3	162482	31.6	1854706	91.2
Oromia	2264380	36.5	256029	49.7	2520409	89.8
Somali	220454	3.6	1566	0.3	222020	99.3
B-G	245197	4.0	21808	4.2	267005	91.8
SNNPR	919283	14.8	49472	9.6	968755	94.9
Gambela	140491	2.3	235	0.05	140726	99.8
Harari	2344	0.04	242	0.05	2586	90.7
Dire Dawa	4446	0.07	263	0.05	4709	94.4
Total	**6196741**	**100**	**514919**	**100**	**6711660**	**92.3**

Feed: forage plus concentrate This table has been corrected taking values from the above table

In the calculation for forages, Somali's crop, grazing area and livestock data correspond to the three zones; and Afar data corresponding to two zones (1 and 3) as per CSA (2016–2017)

Annual feed balance taking into account actual availaibility of feed resources (on dry matter basis) after taking into account competitive uses of crop residues and export of oilseeds.

The feed balance in the following table is based on the reported CSA (2016–2017) data. Somali's crop, grazing area and livestock data correspond to the three zones as per CSA, and for Afar all data corresponding to two zones (1 and 3). For Somali, the feed balance has turned out to be positive, which may not be taken as for whole Somali. It is for three zones for which CSA data are available. B-G and Gambela regions have positive feed balance which could be attributed to relatively low livestock population (due to presence of tsetse fly) in these regions. At the national level the feed deficiency on dry matter has increased from 9 percent to 21 percent because of competitive uses of crop residues and export of oilseeds.

	Forages ($x10^3$ tonnes/year)			Permanent crops ($x10^3$ tonnes/ year)***	Concentrate feeds ($x10^3$ tonnes/year)			Feed available (million tonnes/ year	Feed requirements (million tonnes/ year)	Feed Balance (absolute)
Region	Total crop-residue based forages	Total Stubble feeding	Total grazing feed		Oilseed cake	Cereal bran	Pulse by-products (Bulule)			
Tigray	2741	465	4744	1.27	**9.06**	129.82	7.87	8.10	10.26	**-21.1**
Afar**	90	15.4	2800	0	**0**	4.26	0.08	2.91	4.48	**-35.1**
Amhara	11968	1822	13930	20.43	**106.50**	460.04	176.82	28.48	34.27	**-16.9**
Oromia	12526	2678	21207	258.08	**213.01**	1020.82	201.76	38.11	50.16	**-24.0**
Somali*	237	38.3	2744	1.56	**2.69**	11.11	0.286	3.04	2.347	**+29.4**
B-G	510	85.6	2875	2.89	**39.47**	32.44	2.91	3.55	1.460	**+143.0**
SNNPR	4733	711	6914	784.24	**7.31**	208.30	97.77	13.46	22.54	**-40.3**
Gambela	25.6	7.0	1821	0	**0**	1.94	0.024	1.86	0.488	**+280.4**
Harari	22.4	4.5	16.9	0.20	**0.23**	1.27	0	0.045	0.156	**-71.0**
Dire Dawa	39.7	5.4	35.7	0	**0.11**	1.63	0.148	0.082	0.185	**-55.5**
Total	**32890**	**5832**	**57086**	**1069**	**378.4**	**1871.6**	**487.7**	**99.6**	**126.35**	**-21.2**

All values are on dry matter basis

*Somali crop, grazing area and livestock data correspond to the three zones as per CSA, 2016–2017; ** Afar data corresponding to two zones (1 and 3)

*** all permanent crops taken; Feed DM requirement is based on conversion of livestock number to Tropical Livestock Units (TLU; I TLU = 250 kg) and then taking 2.5 percent of the body weight as daily feed intake as DM.

Annual feed balance as metabolizable energy (ME) and crude protein (CP) based on actual feed availability (feed use and animal requirement data for ME are as $x10^3$ MJ and for CP are as $x10^3$ kg)

As far the feed balance on DM basis, B-G and Gambela have positive ME and CP feed balances, while rest of the regions have negative feed balance. After taking into account the competitive uses of crop residues and export of oilseeds, the deficiencies of CP and ME have further accentuated. The deficiency of ME has increased from 45 percent to 52 percent and of CP from 42 percent and 48 percent. These results again suggest that there is severe deficiency of good quality feed in Ethiopia. These is a need to consider ways to meet these deficiencies. These is a need to consider ways to meet these deficiencies. Some possible ways could be to extend the area under oilseed production and increase number of oil extraction units within the country. Other plants such as lupin and camelina could also be introduced. 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 molassess and brewer's grains as animal feed is another option to meet the deficiency of ME and CP. Acording to field workers, a large quantity of these valuable resoirces is currently being wasted. The Government of Ethiopia has ambitious plan to extend sugarcane production. This will increase the production of molasses, baggase and sugarcane tops, which if directed for animal feeding would also help the livestock sector. Use of insect meal and slaughterhouse waste as poullty and aquafeed should be considered. For alternative approaches to enhance availability of protein and energy rich feeds, refer to reviews and documents published recently by FAO.

Region	Total ME availability	Total CP availability	Total ME requirement	Total CP requirement	Feed ME balance	Feed CP balance
Tigray		512093	135117080	1063887	-53.1	-51.9
Afar	23873840	218650	49022426	421307	-51.3	-48.1
Amhara	221751508	1854706	449655028	3502307	-50.7	-47.0
Oromia	299709200	2520409	650540745	5130520	-53.9	-50.9
Somali	24740979	222020	26047752	220772	-5.0	+0.6
B-G	28740352	267005	19529555	154011	+47.2	+73.4
SNNPR	106440738	968755	284769090	2300534	-62.6	-57.9
Gambela	15243703	140726	6376757	53402	+139.1	+163.5
Harari	348560	2586	18617170	16254	-81.3	-84.1
Dire Dawa	642425	4709	2095227	18462	-69.3	-74.5

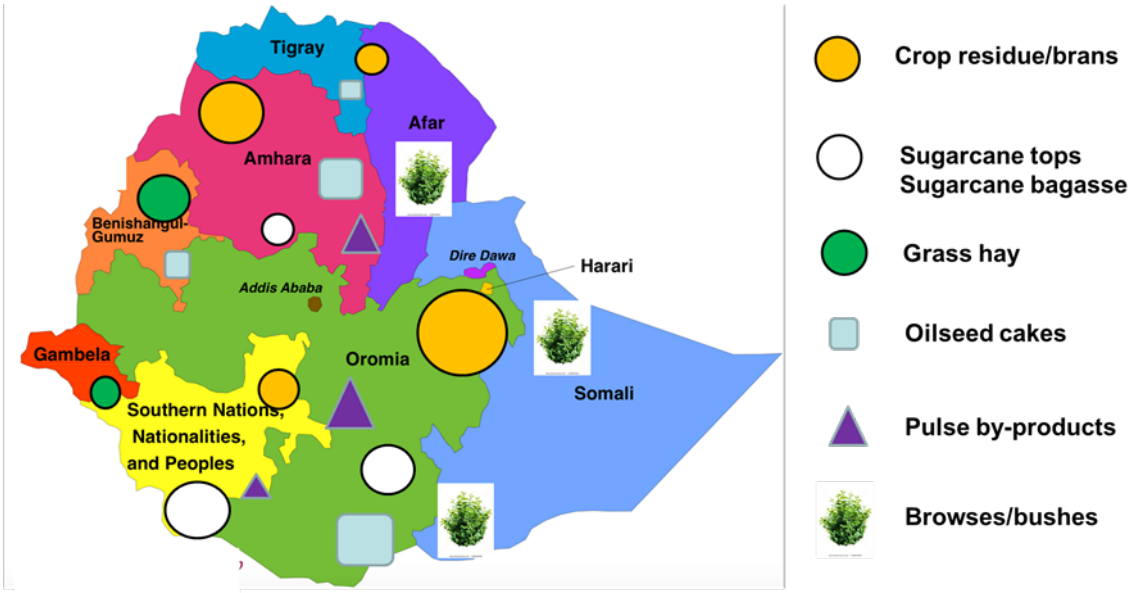
Annual percent feed balance as dry matter, crude protein (CP) and metabolizable energy (ME) based on actual availability of feed resources (after taking into account competive uses)

Region	Feed dry matter balance (%)	Feed metabolizable energy balance (%)	Feed crude protein balance (%)
Tigray	-21.1	-53.1	-51.9
Afar	-35.1	-51.3	-48.1
Amhara	-16.9	-50.7	-47.0
Oromia	-24.0	-53.9	-50.9
Somali	+29.4	-5.0	+0.6
B-G	+144.3	+47.2	+73.4
SNNPR	-40.3	-62.6	-57.9
Gambela	+280.4	+139.1	+163.5
Harari	-71.0	-81.3	-84.1
Dire Dawa	-55.5	-69.3	-74.5
Total	**-21.2**	**-51.7**	**-48.2**

Biomass availability and opportunities for investment and managing droughts

The feed inventory presented in this report also maps the availability of an array of biomass, which could form the basis for development of agro-based industries (Figure 4). The information generated through this study would assist the government, donors, entrepreneurs and the private sector in formulating investment strategies for the development of agro-based sector. Ethiopia is actively developing Integrated Agro-Industrial Parks. The information generated could also be made use 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 value chains linked to use and misuse of 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.

For effective management of droughts, the biomass required to make feed available to overcome the feed shortages in emergencies are crop residues including straws, sugarcane tops and bagasse, grass hay, pulse and cereal milling by-products (brans) and oilseed cakes. The following figure shows their availability in Ethiopia. Higher the dimension of the symbols higher is the availability of the biomass that it represents. 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 2874.9 and 1820.5 (both $x10^3$ tonnes) respectively. Other biomass that could be used are sugarcane tops and sugarcane bagasse, which are available in high amounts in SNNPR, Oromia and Amhara. The 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 10^3 tonnes) and for Oromia are 42.9 and 48.1 (both 10^3 tonnes) respectively.



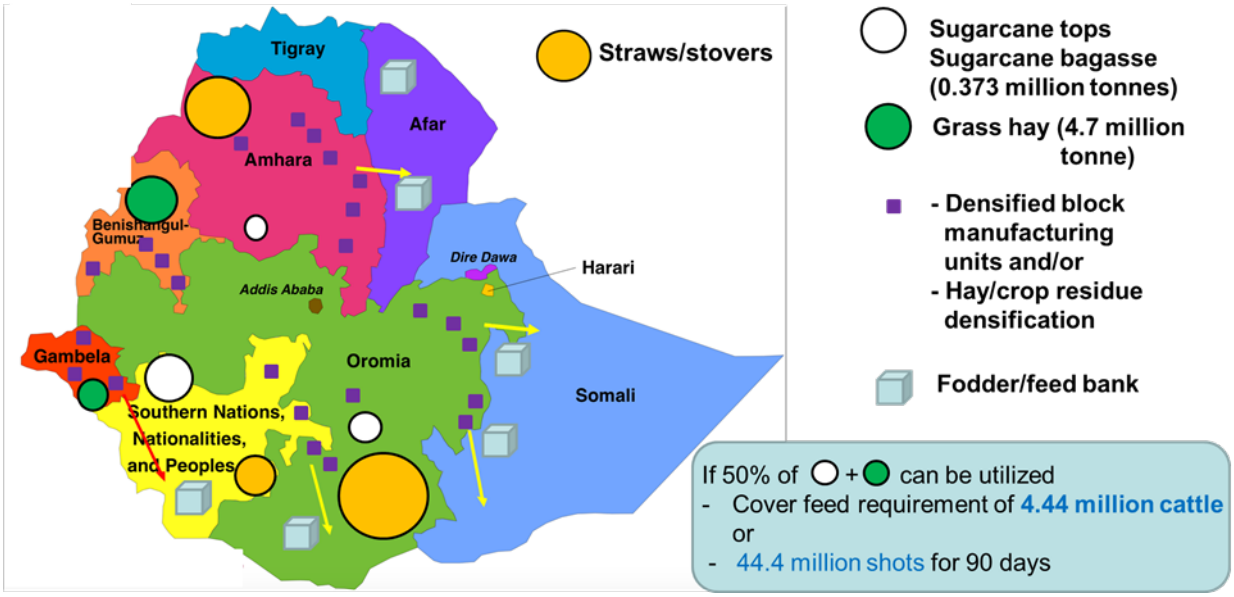
Source: FAO

Figure 4. Biomass availability in Ethiopia

These biomasses and in particular a mix of bagasse, sugarcane tops, grass hay and cereal straws (in different ratios, depending on their availability) can be used to prepare densified complete feed blocks for emergency periods. As an example, if 50 percemt of sugarcane tops, sugarcane bagasse and grasses that are available in the two surplus regions (B-G and Gambela) could be effectively used, it would meet feed requirement of a large number of animals during the dry period (Figure 5). Densification would decrease transport and storage costs. During emergencies such as droughts, a large amount of feed is transported from highlands to lowlands that are generally affected by droughts. It has been observed that the cost of transport of feed is 4–5 times higher than that of feed.

Approaches for densification, machinery required, and business opportunities are discussed in subsequent parts. The densification plants should be set up near the place of biomass availability and this report provides guidance towards the identification of places for erection of such plants, and also for using other densification approaches (baling, pelleting, briquetting, and formation of total mixed ration in mash or block forms, etc.).

Using the biomass availability data and biomass mapping information obtained from this study, a concencentual plan for establishing densification units and fodder banks is presented below. Densification units should be established near the places of biomass availability; and the densified feeds as blocks, pellets or bales could be transported to fodder/feed banks that must be near to the places where the 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 highlands, which generally occurs during droughts. The feed banks would also help in decreasing volatility in feed cost.



Source: FAO

Figure 5. A conceptual framework for establishment of densification units and fodder banks

At times of severe drought, browses present *in situ* could constitute a bulk of feed for livestock. Unfortunately, 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, placement of multi-nutrient blocks containing a commonly used tannin-inactivating agent, polyethylene glycol (MW 4 000) in rangelands could enhance use of browses and help prevent livestock mortality.

Feed production by the Ethiopian feed industry: status, challenges and opportunities

Introduction

Ethiopia is a country with largest livestock population in Africa and with a huge livestock genetic diversity. In the second Growth and Transformation Plan (GTP), Ethiopian government has identified livestock sector as a new source of economic growth. The rationale in using livestock sector as a growth driver emanates from the unexploited potential of the sector and a wide range of agro-industries to be created along the path of market led economy and commercialization.

In general, the feed sub-sector is central for all livestock commodities and is a key pillar of livestock growth and transformation from various perspectives. From production point of view, animal production is essentially a conversion of feed into animal product dictating the level of production and product quality and safety. From economic point of view about 70 percent of the cost of animal production is feed and suggesting economic feasibility of animal agriculture is mainly a function of quantity or quality of nutrients and the science of feeding. Thus feed is a point of convergence and a critical commodity for which all livestock species compete, and it is a major pillar towards ensuring economic, social and environmental goals of livestock production (Makkar, 2016).

As is the case for other growing economies, the demand for livestock commodities in Ethiopia is rapidly growing. Compared to the production base year of 2014/15 with estimated 167million liters of milk, 1.3 million tonnes of red meat and 419 million eggs, the projected demand is expected to be 1490 million liters of milk, 1.9 million tonnes of red meat and 3.9 billion eggs by 2020 (LMP, 2015). Also, at global and regional levels the demand for livestock products is projected to increase by 60–70 percent by 2050 from the current level (Makkar, 2016). Thus, commercial feed sector in Ethiopia should take advantage of the global and the country's economic growth and the increased future animal source food consumption. Historically, the development of feed processing plants in Ethiopia dates back to the beginning of modern livestock husbandry in the early 1950s followed by establishment of feed processing enterprises during the socialist regime. As a follow up of the new economic policy since 1991 the feed processing enterprises operated by government were privatized and a number of feed processing plants of various capacities came into operation. Overall assessment of the Ethiopian feed processing plants was carried out in 2012 by the Ethiopian Animal Feed Industry Association (EAFIA, 2012). However, in the market led economy where production signals are derived from market it is rational to expect basic changes and dynamism in overall status, challenges and opportunities. The objective of this paper is to provide an overview of the current status, key challenges, and the way forward for the Ethiopian feed industry.

Current status

Industry structure of commercial feed sub-sector in Ethiopia. Currently a total of 81 enterprises under 5 major categories are operating in Ethiopian commercial feed sub-sector. The dominant enterprises are feed processing plants owned by private companies and farmers unions engaged in production of compound feed followed by importers or manufactures of supplements (premixes, feed additives etc.) and of feed processing machineries/equipment and suppliers of forage seeds.

A total of 32 privately owned feed processing plants are currently operational. In terms of geographic distribution, most of the enterprises are located in Oromia and Addis Ababa regions with respective contribution of 37 and 31 percent. The Amhara and Southern Nation, Nationalities and People Regional (SNNPR) states, each account for 13 percent while Tigrai region accounts for 6 percent of the total feed processing plants. Nationwide, there are a total of 28 farmers' unions engaged in commercial feed sector and they are evenly distributed across the four regional states mentioned above. In terms of presence of enterprises dedicated to the commercial feed production and service delivery, about 42 percent of the administrative zones (20 zones) in the major regional states i.e. Amhara, Oromia, SNNPR and Tigrai are not yet covered. Additionally, no feed enterprise (feed processing plant, farmers unions, importers of feed supplement, suppliers of feed equipment etc.) exist in the regional states of Afar, Somali, Gambella, Benishangul-Gemuz, Harari and Dire Dawa. Apparently, most of these regional states are dominated by the pastoral and agro-pastoral production system where livestock production forms the basis of livelihood of the community and feed intervention is central to their development agenda.

Industry structure and regional distribution of enterprises engaged in feed industry

Region	Number of enterprises in each category					Total Enterprises
	Feed processing Plants	Farmers Union	Supplement importers/ Manufacturers	Feed processing machineries/ Equipment	Forage seeds	
Addis Ababa	10	1	10	4	1	**26**
Oromia	12	6	4	1	0	**23**
Amhara	4	7	0	0	0	**11**
SNNPRS	4	6	1	0	0	**11**
Tigrai	2	8	0	0	0	**10**
Total	**32**	**28**	**15**	**5**	**1**	**81**

There are a total of 12 enterprises engaged in importation of supplements (premixes, additives and vitamins) while 3 enterprises are engaged in manufacturing of supplements, making a total of 15 enterprises engaged in the supply of feed supplements. In terms of geographical distribution of enterprises engaged in importation or manufacturing of supplements, most of them are in Addis Ababa (ten enterprises) followed by Oromia (four enterprises) and SNNPR (one enterprise) states. Domestic production of feed supplements is currently limited to mineral supplements and effective microbes and delivery of premixes depends on import. Major categories of premixes include premixes for egg production (rearing premix, starter premix and layer premix), broiler premix (broiler starter, broiler grower and finisher) and ruminant premix which contains vitamins, trace element, minerals and other additives

Currently there are a total of 5 enterprises engaged in importation or manufacturing feed processing machineries or equipment and they are all located in Addis Ababa. Commercial forage seed production is currently limited to one enterprise located in Addis Ababa.

Facilities and capacities of feed processing plants. In terms of facilities, all the privately owned feed processing plants have feed mill, mixer and storage places for ingredients and for processed feeds. Only few plants mill limestone and make multi-nutrient blocks. Pellet maker is limited to two feed processing plants, liquid mixer exists only in one feed processing plant and no feed processing plant has a laboratory for analysis of ingredients and feeds. The average installed capacity of the private feed processing plants is 5.4 tonnes per hour while the operational capacity is 3.0 tonnes per hour, suggesting most of the plants are operating at an average of 54 percent of their installed capacity. Most feed processing plants are currently operating below their installed capacity mainly due to low demand for the product, shortage of ingredients and inconsistent supply of electricity. Average operational capacity of feed processing plants at farmers' unions level is 2.0 tonnes per hour. In terms of operational capacity as percentage of installed capacity for

the feed mixer, farmers' unions are currently operating at an average processing capacity of 66 percent.

Price trends of feed ingredients and formula feeds

Price trends of feed ingredients taking base year of 2010/11 and average price of 2016 suggest an average increase of 52 percent across five years and at an annual increase of 11 percent. Likewise, average percentage change in price of compound feeds suggests average increase of 85 percent with estimated annual rate of increase of 17 percent per year.

Price trends of major feed ingredients (Birr per tonne)

Item number	Ingredient	2010/11 price	2015/16 price	Percentage change
1	Maize	4000	5100	28
2	Wheat bran	2800	4170	49
3	Wheat middling	3000	4200	40
4	Noug cake	3000	4800	60
5	Rapeseed cake	1300	2900	123
6	Soybean meal	7500	12000	60
7	Cottonseed cake	4550	5000	10
	Average			52
	Percentage change per annum			11

Price trends of major compound feeds (Birr per tonne)

Item Number	Ingredient	2010/11 price	2015/16 price	Percentage change
1	Layers ration	5030	660	66
2	Growers ration	5520	860	86
3	Chick starter ration	6550	630	63
4	Dairy ration	3340	830	83
5	Calves ration	4280	1000	100
6	Heifer ration	2800	1300	130
7	Beef cattle ration	3520	730	73
8	Sheep ration	3540	820	82
	Average			82
	Percentage change per annum			16.4

Production of major compound feeds

Annual compound feed production by both private and farmers' unions feed processing plants in 2015/16 has been estimated at 61416 tonnes (excluding home-made mixed feed). In terms of enterprise category, privately owned feed processing plants account for 84 percent while those of farmers' unions accounted for the rest 16 percent of the total annual production. Regarding feed type, poultry feed accounted for 56 percent of annual compound feed production while dairy feed, beef cattle feed and other feeds respectively accounted for 26, 15 and 3 percent.

Major compound feeds produced by private and farmers union feed processing plants during September 2015 to August 2016 in tonne/year

Feed type	Private processing plants	Farmers unions processing plants	**Total**	**Percentage share of compound feed**
Dairy feed	11920	4156	**16076**	**26.2**
Beef cattle	3439	5372	**8811**	**14.3**
Poultry feed	34362	143	**34505**	**56.2**
Other feeds	1929	95	**2024**	**3.3**
Total	**51650**	**9767**	**61416**	**100**
Percentage share	**84.1**	**15.9**	**100**	-

Feed supplements/additives and feed processing machineries

Assessments on imports of supplements or feed additives suggest a total of 677 tonnes of feed supplements have been imported by 5 companies in 2015/16. An appraisal of supply of feed processing machineries indicated a total of 119 pieces of equipment (16 mixers, 102 choppers and 1 forage harvester) have been imported and made available to commercial livestock producers, university farms, private feed companies during the last four years. Likewise, a total of 122 different machines (20 mixers, 22 choppers, 15 mills and 65 compound mills and mixers) have been locally manufactured during the last four years and made available to users.

Trends in price of feed supplements/additives

Increase in price of supplements varied with the type of supplement. During the last five years, prices of vitamin premixes and methionine remained relatively stable as compared to the trends in prices of mineral, lysine and salt. The average increase in price of supplements during the last five years has been about 41 percent.

Key challenges in Ethiopian feed industry

Commercial feed sector in Ethiopia, like any other emerging sector along the path of market led economy, is currently facing a number of challenges. Major challenges are presented below.

High price of feed ingredients and compound feeds. Seasonality, shortage and very high prices of feed ingredients are key challenges for sustainable and affordable delivery of compound feeds. During the last five years, prices of feed ingredients

and compound feeds have increased by an average of 52 and 82 percent respectively, leading to low demand of compound feeds. This situation has even led to closing of some commercial farms (dairy and beef), essentially due to low return on the investment.

Un-fair taxation policy on feed ingredients and compound feeds. Commercial feed sub-sector and livestock production in general have long been suffering from un-fair taxation. On ruminant feeds, 15 percent value added tax (VAT) is charged on feed ingredients and compound feeds leading to double taxation for feed ingredients and formula/compound feeds. On poultry feeds, since most of the feed supplements especially the premixes are imported from abroad, the government has taken positive measure recently in removing VAT on poultry feed ingredients and formula feeds.

*Feed safety and quality***.** Ensuring feed safety and quality is recently one of the key challenges in the commercial feed sector. It is also of high importance for the livestock producers and consumers of animal source foods. Among feed safety issues, the recent detection of high aflatoxin levels in oilseed cakes and compound feeds has raised serious concerns in ensuring the desired quality and safety of feed along the food value chain. Additionally, the need for maintaining the desired level of nutritional and quality standards of feed ingredients and compound feeds is also a challenge for commercial feed producers, the regulatory body and livestock producers. Lack of confidence of livestock owners on the quality of compound feed is also one of the reasons for not using such feeds. There is also a need to update feed quality and safety standards.

Demand of compound feed. Compound feed production and intensification of animal agriculture are key processes which ought to go hand-in-hand towards transforming animal agriculture. Although market led economy and commercialization of animal agriculture have opened new avenues to achieve this goal, increase in demand of compound feeds has not yet reached to the desired level. Thus, most of the feed processing plants are operating below capacity.

Imports of premixes, minerals and vitamins. Among various inputs, premixes, minerals and vitamins are critical in supporting the desired level of animal productivity. However, they are currently imported from abroad using hard currency and their prices are very high.

Research and extension support for commercial feed sector. Technical services (research and extension) in promoting the commercial feed sector (use of alternative feeds for compound feeds; use of innovative approaches in import substitution via local production of feed supplements; research, extension and infrastructure development support in forage seed and feed processing machineries; on-farm testing and promotion of compound feeds, and technical support for feed safety and quality regulation) are very weak or non-existent.

Feed quality and safety analytical service. Most private and farmers union feed processing plants are currently facing serious challenges in analytical services mainly because of high cost and inadequate service delivery. There are no well equipped and accredited labs to the satisfaction of the commercial feed sector. To

date only one commercial lab that undertakes modest number of analysis is available. Labs in public institution have limitations in capacity and mode of service delivery to support the commercial feed sector. In terms of scope, the existing labs are very much limited to the conventional analysis and there are no labs to support analyses required for ensuring feed quality and safety.

Organizational capacity of Ethiopian Animal Feed Industry Association (EAFIA). EAFIA was established in 2008 by feed factory owners, private dairy farmers and farmers' unions. As a young institution it has not yet reached to the desired level of operation. It is currently facing several challenges, among them technical, financial, and organizational deserve attention. Technically, members of EAFIA have not yet developed the required capacity for internal or self regulation for ensuring the desired quality and safety of their products. In terms of finance, the major source of finance so far has been project based and such a source is not sustainable. From organizational point of view, all feed factory owners are not yet members of EAFIA and a lot more remains to be done to make EAFIA an influential association.

Opportunities for the Ethiopian Feed Industry

Among the aforementioned challenges the key concern in commercial feed sector is resourcing of the quality ingredients throughout the year at affordable price. For this to happen the following issues deserve special attention.

Feed Ingredients (maize and soya bean). Adequate opportunities currently exist to produce maize and soya bean for feed production in Ethiopia. Last five decades of research and technological advances have led to the availability of varietal choices and production packages. Additionally, huge land is available for commercial production of these commodities. These offer opportunities to enhance their production in Ethiopia.

Compound feed (ruminant, poultry and aqua-culture). Production of compound feed in Ethiopia has almost doubled during the last five years. However, the quantity being produced currently does not match the huge livestock population the country has. Additionally, region-wide distribution of feed processing plants is uneven and is limited to only some regions and zones. Additional new business opportunities for example compound feed production for aqua-culture are emerging.

Feed Supplements or inoculants. In terms of feed supplements (premixes, minerals and vitamins) Ethiopia is very much dependent on their import. Imported products are usually generic and not tailored for local purpose. Additionally, from economic point of view, hard currency is required to procure them from abroad. Therefore, alternatives have to be sought and developed from technical and economic perspectives for sustainable supply. Domestic production of feed supplements is emerging with wider business opportunities as a result of intensification of livestock production. Thus, there are opportunities for foreign direct investment or involvement of local investors in domestic production of feed supplements. The production of effective microbes as feed inoculants is currently a take off point with huge business opportunity in commercial feed sector.

Improved forage and natural pasture. Research and development efforts in improved forage production during the last five decades has led to varietal development and production practices. However, adoption of the technology and commercialization have lagged behind because of a number of factors pertaining to technical (technology and approach), socio-economic, policy and institutional (actors convergence) issues (Gberemedhin et al., 2003, Shelton et al., 2005). As has been noted in various tropical countries, failure of the technology in meeting farmers' expectations, lack of participatory approach in technology development and absence of farmer-centered research and extension programs were the major factors contributing to low adoption. Limitations in partnership between relevant stakeholders (government, private and farmers) and lack of long term commitment by key players have also been noted to contribute to low adoption. From socio-economic and policy perspectives (availability of land, land tenure system, degree of market orientation, income of farmers) were also among the key factors influencing the adoption of improved forage production technologies. The market led economic policy and commercialization is an opportunity for increased adoption of such technologies to cater to the needs of domestic, regional or global markets. High biomass of improved forages can be produced, processed and made available for use. The commercial forage seed production also offers business opportunities for foreign direct investment or through local investment.

While there is feed deficit in certain part of the country, there are areas e.g. Gambella, Benishangul-Gemuz regions where abundant feed such as natural pasture is produced and is not effectively utilized. Specifically in the savanna grass land of these regions, natural pasture is underutilized. Thus, in such environment natural pasture can be harvested at the right time, baled and transported to feed deficit areas or areas where there is effective demand.

By-products of agro-industry. By-products of sugar industry (molasses, bagasse, sugarcane tops), breweries and food processing industries are not yet effectively utilized for animal feed production. The increasing number of upcoming sugar industry projects, breweries and agro- and food-industries would provide opportunities for improving feed supply through utilization of alternative feeds. Additionally, abattoir by-products such as bone, blood and meat can be converted to animal feed and incorporated into non-ruminant feeds.

Total mixed ration/alternative feeds in ruminant and non-ruminant rations. Incorporation of crop residues or hay into total mixed ration is among the technological alternatives to enhance utilization of low quality roughages, increase feed conversion efficiency and economic returns from the livestock production. Production of total mixed ration can be commercialized, offering investment and job creation opportunities. Search for other alternative feed ingredients (in addition to those mentioned above) such as locally adapted lesser-known and lesser-utilized resources and their inclusion in ruminant and non-ruminant rations also provides opportunities for investment.

Feed processing machineries, equipment and tools. Feed processing machineries, equipment and tools are currently supplied by few companies. Taking into account the need for modernization of the feed industry dictated by commercialization of

livestock production, there will be high demand for feed processing machineries. A revolution is needed in this field for making the feed industry vibrant.

Laboratory service delivery in feed quality and safety. Commercial feed sub-sector is currently encountering lack of laboratory service delivery system for feed quality and safety assessment. Labs rendering such services are very limited in number and scope, and mode of service delivery needs to be efficient and reliable. Taking into account the future growth of the feed industry, establishment of laboratory service delivery system by commercial labs is an opportunity for investment.

Enhancing capacity and impact of EAFIA. Quite a range of opportunities exist for improving overall organizational capacity of EAFIA. Financially, securing funds from alternative sources can be designed and implemented. In addition, EAFIA can link with key actors (research, academia, development organizations, International institutions) engaged in feed value chain to improve its efficiency and impact. It may develop a status of non-profit organization so that it can participate in the activities of development and international organizations. EAFIA can also make the best use of its technical advisory board to develop an action plan for the next 5 to 6 years.

Conclusions

Based on the above analysis the following conclusion can be drawn:

- Estimated at 61 416 tonnes, the annual compound feed production is far below the demand.
- Domestic production of supplements and feed additives is in infancy and the country's requirement heavily depends on import, demanding technical and policy interventions.
- The prices of feed ingredients and compound feeds have increased at an alarming rate demanding technical and policy support. While moving towards conducting comprehensive and systematic studies in a coordinated manner, technical solutions in using alternative feed ingredients available in various geographic locations can be harnessed and used. Additionally, policy interventions such as removal of the VAT on key feed ingredients and compound feeds targeted for ruminant livestock is critical for reducing the price of feeds and thus contributing to the sustainable development of the feed industry. Feed companies should diversify their product i.e. produce total mixed ration in mash, block or pellet form, multi-nutrient blocks, feed supplements/additives, among others.
- Feed companies should go beyond customary activity of only feed production, and complement their engagement in promoting their products, for example through their own extension and outreach activities.
- In the light of the ongoing development of Integrated Agro-industrial Parks, supply of feed ingredients can be enhanced by integrating the feed processing plants to these initiatives. The Integrated Agro-industrial Parks, among various activities, are involved in processing of crops and other agro- and food-products, and they generate a huge volume of by-products for use as feed ingredients for feed processing plants. The integration would be a win-win situation both in terms of creating effective demand and supply

towards enhancing the feed value chain, creating jobs and mitigating disposal problems of by-products.

- Access to quality feed should be enhanced by providing special support e.g. making available finance, improving overall infrastructure, providing market information to feed micro-businesses (private dealers, marketers and organized youth) at the grass root level. Franchised model business arrangement would help in improving access to inputs required to manufacture feeds.
- Although animal feed by and large is a private good, extensive technical and policy support such as research, regulatory framework and conducive policy environment are required from the public domain.
- As a young institution, strengthening the organizational capacity of the Ethiopian Animal Feed Industry Association deserves attention to spear head the development of feed industry.

This part is a collaborative effort of a group of workers comprising of the writer of this report, Seyoum Bediye[1], and Gemechu Nemi[2] ([1]Ethiopian Institute of Agricultural Research, [2]Ethiopian Animal Feed Industry Association). An article based on this part has been published in www.feedipedia.org (Broadening Horizons, No. 50 February 2018).

Way forward

The findings reported in this study have opened several avenues for preparing concepts and proposals to initiate new programmes. Some concrete steps that may be taken are:

1. Institutionalize work on generation of Feed Inventory and Feed Balance within the MoLF, so that it is updated every year. FAO could provide tools and training to realise this.
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 MoLF 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 block preparation; and implement the plan.
4. Promote agricultural mechanization e.g. local production of hydraulic presses, forage harvesters, high-throughput balers, etc.
5. Promote fodder production as a cash crop and not as backyard fodder production, and widely promote use of fodder shredders, fodder balers, silo compressors etc.
6. Promote establishment of commercial units for multi-nutrient block production, forage shredding and chopping, forage densification, vitamin and mineral production.
7. Promote the use of urea-molasses multi-nutrient blocks in the rangelands, near the water points 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. Also consider use of browse-enhancers for utilizing prosopis and acacia leaves as animal feed. Introduce prosopis-pod crushing machines for disintegrating the pods before their use as animal feed.
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 agroindustry 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, among others).
15. Through fodder producers and cooperatives, facilitate fodder production in the identified sites including sites from where prosopis bushes have been cleared.
16. Within the developed schemes, promote agroforestry with the introduction of dual purpose crops with a focus on 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 and conservation areas.
19. Increase access to feeds and implement strategies to efficiently utilize them into 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. Develop 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
24. Integrate quality control systems in the existing feed analysis laboratories and get them accredited.

Ethiopia is highly deficient in metabolzable energy (ME) and crude protein (CP) for feeding animals. In addition to implementing innvovative feed production and feeding strategies that would make the 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. Other plants such as lupin and camelina could also be introduced. Propagation of thornless cactus in lowlands will increase availability of ME. The cessastion of wastages in various feed resources including agro-industrial and food processing by-products would also help. Efficient utilization of molassess and brewer's grains as animal feed is another option to meet the deficiency of ME and CP. Acording to some field workers, a large quantity of these valuable resources is currently being wasted. The Government of Ethiopia has ambitious plan to extend sugarcane production. This will increase the availability of molasses, baggase and sugarcane top, which if directed for animal feeding would also help the livestock sector. Use of insect meal and slaughterhouse waste as poullty and aquafeed should be considered.

Annex 1. Potential availability of animal feeds

Tigray

Cereal straws/stovers (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	6.423	275.717	282.140
Barley	0	193.991	193.991
Wheat	0	243.520	243.520
Maize	0	264.890	264.890
Sorghum	0	1566.412	1566.412
Finger millet	0	301.908	301.908
Oats/'Aja'	0	0.157	0.157
Rice	0	1.308	1.308

Total cereal straws/stovers = 2854.327 (x10^3 tonnes)/year

Cereal brans (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	0.43	18.32	18.74
Barley	0.00	12.89	12.89
Wheat	0	16.18	16.18
Maize	0	12.90	12.90
Sorghum	0.00	54.11	54.11
Finger millet	0.00	14.90	14.90
Oats/'Aja'	0.00	0.01	0.01
Rice	0	0.0868	0.0868

Total brans = 129.82 (x10^3 tonnes)/year

Pulse straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Horse beans	0	24.15	24.15
Field peas	0	2.37	2.37
Haricot beans	0	3.26	3.26
Chick-peas	0	11.09	11.09
Lentils	0	7.89	7.89
Grass pea	0	11.04	11.04
Fenugreek	0	0.44	0.44

Total pulse straws = 60.248 (x10^3 tonnes/year)

Oilseed straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Noug/Niger	0	13.698	13.698
Linseed	0	12.538	12.538
Groudnuts	0	1.5261	1.5261
Sesame	0	129.574	129.574
Rapeseed	0	0.05193	0.05193

Total oilseed straws = 157.3884 (x10^3 tonnes/year)

Vegetable plant aerial parts (x10^3 tonnes/year)

	Belg season	Meher season	Total
Lettuce	0	0.0159	0.0159
Head cabbage	0	0.2109	0.2109
Tomatoes	0	1.5118	1.5118
Green pepper	0	1.0390	1.0390
Red pepper	0	1.0453	1.0453

Total vegetable aerial parts = 3.823 (x10^3 tonnes/year)

Root crop aerial parts (x10^3 tonnes/year)

	Belg season	Meher season	Total
Carrot	0	0.03144	0.03144
Onions	0	0.8832	0.8832
Potatoes	0	1.0078	1.0078
Garlic	0	0.8783	0.8783

Total root crop aerial parts = 2.80 (x10^3 tonnes/year)

Permanent crops (10^3 tonnes/year)

Bananas peel	0.01692
Banana stems and leaves	1.4752
Lemons peel	0.0627
Mango peel	0.0174
Mangoes kernel	0.0407
Oranges peel	0.0409

Oilseed cakes (x10^3 tonnes/year)

	Belg season	Meher season	Total
Noug/Niger	0	4.7735	4.7735
Linseed	0	4.1821	4.1821
Groundnut	0	0.4102	0.4102
Sesame	0	38.7040	38.7040
Rapeseed	0	0.01732	0.01732

Total oilseed cakes = 48.21 (x10^3 tonnes/year)

Afar

Cereal and pulse straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	0	1.35	1.35
Maize	59.22	21.14	80.37
Sorghum	0	7.34	7.34
Horse bean	0.20	0.20	0.40
Field peas	0.10	0.10	0.20

Total cereal straws/stovers = 89.06 (x10^3 tonnes)/year
Total pulse straw = 0.60 (x10^3 tonnes)/year

Cereal and brans (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	0.00	0.09	0.09
Maize	2.89	1.03	3.92
Sorghum	0.00	0.25	0.25

Total cereal brans = 4.26 (x10^3 tonnes)/year)

Oilseed cakes: NIL

Permanent crops (10^3 tonnes/year): NIL

Amhara

Cereal straws/stovers (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	31.46	2211.19	2242.65
Barley	92.23	695.63	787.86
Wheat	20.76	1509.01	1529.77
Maize	40.68	3062.18	3102.86
Sorghum	0	3608.66	3608.66
Finger millet	0	858.29	858.29
Oats/'Aja'	1.01	5.13	6.14
Rice	0	123.45	123.45

Total cereal straws/stovers = 12259.68 (x10^3 tonnes)/year

Cereal brans (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	2.0901	146.8972	148.9873
Barley	6.1270	46.21325	52.34027
Wheat	1.3792	100.2487	101.6279
Maize	1.9818	149.1832	151.1651
Sorghum	0	124.6628	124.6628
Finger millet	0	42.3572	42.3572
Oats/'Aja'	0.0670	0.3405	0.4076
Rice	0	8.2012	8.2012

Total cereal brans = 629.75 (x10^3 tonnes)/year

Pulse straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Horse beans	0	409.28	409.28
Field peas	4.70	56.38	61.08
Haricot beans	0	55.37	55.37
Chick-peas	22.24	246.33	268.57
Lentils	21.35	84.37	105.72
Grass pea	0	191.80	191.80
Fenugreek	0	26.78	26.78
Mung bean/"Masho"	49.03	37.27	86.31
Gibto	0	28.94	28.94

Total pulse straws = 1233.84 (x10^3 tonnes/year)

Oilseed straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Neug	0	141.82	141.82
Linseed	0	29.93	29.93
Groundnut	0	21.09	21.09
Sunflower	23.06	0	23.06
Safflower	0	12.25	12.25
Sesame	0	270.97	270.97
Rapeseed	0	54.65	54.65
Soyabeans	0	33.71	33.71

Total oilseed straws = 587.47 (x10^3 tonnes/year)

Vegetable plant aerial parts (x10^3 tonnes/year)

	Belg season	Meher season	Total
Head cabbage	0	1.88	1.88
Ethiopian cabbage	0.77	2.43	3.21
Tomatoes	0	2.73	2.73
Green pepper	0	3.73	3.73
Red pepper	0.21	34.84	35.05

Total vegetable plant aerial parts = 46.59 (x10^3 tonnes/year)

Root crops aerial parts (x10^3 tonnes/year)

	Belg season	Meher season	Total
Beetroot	0	0.40	0.40
Carrot	0	0.33	0.33
Onions	6.00	36.91	42.91
Potatoes	85.92	55.96	141.88
Yam	0	0.00	0.00
Garlic	0	12.94	12.94
Taro	0	0.00	0.00
Sweet potatoes	0	3.08	3.08

Total root crops aerial parts = 201.54 (x10^3 tonnes/year)

Permanent crops (10^3 tonnes/year)

Bananas peel	0.1007
Banana stems and leaves	10.843
Lemon peel	0.5007
Mango peel	0.1810
Mango kernel	0.4242
Orange peel	0.4347
Papaya skin	0.0917
Coffee hull	0.3849
Coffee pulp	0.8207
Sugar cane tops	22.8797
Sugar cane bagasse	25.6253

Oilseed cakes (x10^3 tonnes/year)

	Belg season	Meher season	Total
Noug/Niger	0	49.422	49.422
Linseed	0	9.982	9.982
Safflower	0	4.270	4.270
Sesame	0	80.938	80.938
Rapeseed	0	18.230	18.230
Groundnut	0	5.690	5.690
Sunflower	8.035	0	8.035
Soyabean	0	24.080	24.080

Total oilseed cakes = 200.65 (10^3 tonnes/year)

Oromia

Cereal straws/stovers (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	31.21	2830.02	2861.23
Barley	101.11	1251.47	1352.58
Wheat	62.02	3047.64	3109.66
Maize	745.15	6804.87	7550.02
Sorghum	6.35	4216.52	4222.87
Finger millet	0	313.53	313.53
Oats/'Aja'	10.71	50.48	61.19
Rice	0	15.80	15.80

Total cereal straws/stowers = 19486.89 (x10^3 tonnes)

Cereal brans (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	2.07	188.01	190.08
Barley	6.72	83.14	89.86
Wheat	4.12	202.47	206.59
Maize	36.30	331.52	367.82
Sorghum	0.22	145.66	145.88
Finger millet	0.00	15.47	15.47
Oats/'Aja'	0.71	3.35	4.07
Rice	0	1.05	1.05

Total cereal brans = 1020.82 (x10^3 tonnes/year)

Pulse straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Horse beans	2.44	651.88	654.32
Field peas	16.69	61.76	78.45
Haricot beans	107.97	158.03	266.00
Chick-peas	0.00	191.78	191.78
Lentils	2.84	82.74	85.58
Grass pea	0	109.37	109.37
Fenugreek	0.44	20.37	20.82
Mung bean/"Masho"	0.53	5.95	6.48

Total pulse straws = 1412.79 (x10^3 tonnes/year)

Oilseed straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Noug/Niger	0	386.88	386.88
Linseed	0.0389	118.18	118.22
Groundnut	0	130.04	130.04
Safflower	0	0.44	0.44
Sesame	1.6651	51.57	53.23
Rapeseed	0	21.89	21.89
Soyabean	0	20.92	20.92

Total oilseed straws = 731.62 (x10^3 tonnes/year)

Vegetable plant aerial parts (x10^3 tonnes/year)

	Belg season	Meher season	Total
Lettuce	0	0.01	0.01
Head cabbage	0	6.57	6.57
Ethiopian cabbage	0.77	29.33	30.10
Tomatoes	3.77	3.53	7.30
Green pepper	2.79	9.44	12.24
Red pepper	0	43.59	43.59

Vegetable plant aerial parts = 99.81 (x10^3 tonnes/year)

Root crop aerial parts (x10^3 tonnes/year)

	Belg season	Meher season	Total
Beetroot	0.60	3.55	4.15
Carrot	0	1.18	1.18
Onions	10.09	20.67	30.76
Potatoes	114.99	88.98	203.96
Yam	0	0.00	0.00
Garlic	2.77	12.04	14.81
Taro	0.63	21.50	22.14
Sweet potatoes	7.90	214.02	221.92

Root crop aerial parts = 498.92 (x10^3 tonnes/year)

Permanent crops (x10^3 tonnes/year)

Avocado skin	0.508
Avocados seed	1.41
Bananas peel	3.23
Banana stems and leaves	113.19
Lemon peel	0.0647
Mangoe peel	1.281
Mango kernel	3.00
Orange peel	0.269
Papaya skin	0.196
Pineapple crown	0.00011
Coffee hulls	41.59
Coffee pulp	88.67
Sugarcane top	42.92
Sugarcane bagasse	48.07
Enset leaves and stems	166.63

Oilseed cakes (x10^3 tonnes/year)

	Belg season	Meher season	Total
Noug/Niger	0	134.82	134.82
Linseed	0.0129	39.42	39.43
Safflower	0	0.155	0.1547
Sesame	0.4973	15.40	15.90
Rapeseed	0	7.30	7.30
Groundnut	0	34.96	34.94
Soyabean	0	14.95	14.95

Total oilseed cakes = 247.52 (10^3 tonne/year)

Somali

Cereal straws/stovers (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	0.00	0.00	0.00
Barley	0.00	0.75	0.75
Wheat	0.00	9.22	9.22
Maize	8.15	80.49	88.64
Sorghum	0	177.48	177.48
Oats/'Aja'	0.00	0.02	0.02

Total cereal straws/stovers = 276.11 (x10^3 tonnes/year)

Cereal brans (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	0.00	0.00	0.00
Barley	0.00	0.05	0.05
Wheat	0.00	0.61	0.61
Maize	0.40	3.92	4.32
Sorghum	0.00	6.13	6.13

Total cereal brans = 11.11 (x10^3 tonnes/year)

Pulse straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Horse beans	0	0.00	0.00
Field peas	0.00	0.03	0.03
Haricot beans	0.918	0.17	1.09
Chick-peas	0.00	0.00	0.00
Lentils	0.00	0.00	0.00
Mung bean/"Masho"	0.00	0.00	0.00

Total pulse straws = 1.12 (x10^3 tonnes/year)

Oilseed straw (x10^3 tonnes/year)

	Belg season	Meher season	Total
Groundnut straw	0	7.71	7.71

Total oilseed straw = 7.71 (x10^3 tonnes/year)

Vegetable plant aerial parts (x10^3 tonnes/year)

	Belg season	Meher season	Total
Ethiopian cabbage	0	0.00	0.00
Tomatoes	0	0.32	0.32
Green	0	0.01	0.01

Total vegetable plant aerial parts = 0.33 (x10^3 tonnes/year)

Root crop aerial part (x10^3 tonnes/year)

	Belg season	Meher season	Total
Onions	0	3.32	3.32

Total root crop aerial part = 3.32 (x10^3 tonnes/year)

Permanent crops (x10^3 tonnes/year)

Bananas peel	0.1301
Banana stem and leaves	3.9000
Lemon peels	0.0295
Mango peels	0.0219
Mango kernels	0.0512
Orange peels	0.2188
Papaya skin	0.0533

Oilseed cake (x10^3 tonnes/year)

	Belg season	Meher season	Total
Groundnut	0	2.69	2.69

Benishangul-Gemuz (B-G)

Cereal straws/stovers (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	0.00	34.68	34.68
Barley	0.00	1.28	1.28
Wheat	0.00	5.60	5.60
Maize	5.33	294.03	299.36
Sorghum	0	312.78	312.78
Finger millet	0	83.85	83.85
Oats/'Aja'	0.00	0.05	0.05
Rice	0	6.22	6.22

Total cereal straws/stovers = 743.83 (x10^3 tonnes/year)

Cereal brans (x10^3 tonnes)

	Belg season	Meher season	Total
Teff	0.00	2.30	2.30
Barley	0.00	0.09	0.09
Wheat	0.00	0.37	0.37
Maize	0.00	14.32	14.32
Sorghum	0.00	10.81	10.81
Finger millet	0.00	4.14	4.14
Oats/'Aja'	0.00	0.0034	0.0034
Rice	0	0.41	0.41

Total cereal brans = 32.44 (x10^3 tonnes)/year

Pulse straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Horse beans	0	2.66	2.66
Field peas	0.00	4.25	4.25
Haricot beans	3.96	5.39	9.35
Chick-peas	0.00	0.39	0.39
Lentils	0.00	0.02	0.02
Grass pea	0	0.00	0.00
Fenugreek	0	0.01	0.01
Mung bean/"Masho"	0.00	1.60	1.60

Total pulse straws = 18.29 (x10^3 tonnes/year)

Oilseed straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Noug/Niger	0	15.13	15.13
Linseed	0	0.45	0.45
Groundnut	0	72.04	72.04
Safflower	0	1.56	1.56
Sesame	0	41.88	41.88
Rapeseed	0	0.53	0.53
Soyabeans	0	30.86	30.86

Total oilseed straws = 162.45 (x10^3 tonnes/year)

Vegetable plant aerial parts (x10^3 tonnes/year)

	Belg season	Meher season	Total
Head cabbage	0.00151	0.05	0.05
Ethiopian cabbage	0.4541	0.04	0.50
Tomatoes	0.0799	0.01	0.09
Green pepper	0.0247	0.03	0.05
Red pepper	0	1.60	1.60

Total vegetable plant aerial parts = 2.29 (x10^3 tonnes/year)

Root crop aerial parts (x10^3 tonnes/year)

	Belg season	Meher season	Total
Beetroot	0	0.01	0.01
Carrot	0	0.00024	0.00024
Onions	0.0210	0.24	0.25
Potatoes	0.5409	2.00	2.54
Taro	0	0.29	0.29
Sweet potatoes	0	1.65	1.65

Total root crop aerial parts = 4.75 (x10^3 tonnes/year)

Permanent crops (10^3 tonnes/year)

Bananas peel	0.17532
Banana stems and leaves	5.24088
Lemon peel	0.03019
Mango peel	0.25444
Mangoe kernel	0.59634
Orange peel	0.01733
Papaya skin	0.01092
Coffee hulls	0.06191
Coffee pulp	0.13200
Sugarcane tops	0.32894
Sugarcane bagasse	0.36841

Oilseed cakes (x10^3 tonnes/year)

	Belg season	Meher season	Total
Noug/Niger	0	5.27	5.27
Linseed	0	0.151	0.151
Safflower	0	0.543	0.543
Sesame	0	12.51	12.51
Rapeseed	0	0.177	0.177
Groundnut	0	19.37	19.37
Soyabean	0	22.05	22.05

Total oilseed cakes = 60.07 (10^3 tonne/year)

SNNPR

Cereal straws/stovers (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	51.57	390.40	441.97
Barley	33.15	173.32	206.47
Wheat	1.43	376.10	377.53
Maize	780.25	1693.73	2473.99
Sorghum	60.91	477.17	538.07
Finger millet	0	8.70	8.70
Oats/'Aja'	0.00	0.42	0.42
Rice	0	8.48	8.48

Total cereal straws/stovers = 4055.62 (x10^3 tonnes/year)

Cereal brans (x10^3 tonnes/year)

	Belg season	Meher season	Total
Teff	3.43	25.94	29.36
Barley	2.20	11.51	13.72
Wheat	0.09	24.99	25.08
Maize	38.01	82.52	120.53
Sorghum	2.10	16.48	18.59
Finger millet	0.00	0.43	0.43
Oats/'Aja'	0.00	0.03	0.03
Rice	0	0.56	0.56

Total brans = 208.30 (x10^3 tonnes/year)

Pulse straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Horse beans	2.76	206.65	209.41
Field peas	1.21	7.62	8.83
Haricot beans	173.55	155.09	328.64
Chick-peas	0.00	19.41	19.41
Lentils	0.00	0.56	0.56
Grass pea	0	1.53	1.53
Fenugreek	0	0.42	0.42
Mung bean/"Masho"	0.00	0.50	0.50

Total pulse straws = 569.32 (x10^3 tonnes/year)

Oilseed straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Noug/Niger	0	1.25	1.25
Linseed	0.0294	1.36	1.39
Groundnut	17.2714	1.63	18.90
Sunflower	0.3232	0	0.32
Safflower	0	0.44	0.44
Sesame	0	0.71	0.71
Rapeseed	0	3.07	3.07
Soya beans	0	0.28	0.28

Total oilseed straws/stovers = 26.37 (x10^3 tonnes/year)

Vegetable plant aerial residues (x10^3 tonnes/year)

	Belg season	Meher season	Total
Head cabbage	0	2.89	2.89
Ethiopian	98.62	74.07	172.67
Tomatoes	0	0.32	0.32
Green pepper	1.185	4.29	5.47
Red pepper	0	17.86	17.86

Total vegetable plant aerial parts = 199.22 (x10^3 tonnes/year)

Root crop straws (x10^3 tonnes/year)

	Belg season	Meher season	Total
Beetroot	1.010	1.11	2.12
Carrot	0.410	0.26	0.67
Onions	5.595	3.47	9.07
Potatoes	336.750	36.34	373.09
Yam	5.3692	101.93	107.30
Garlic	5.3746	1.88	7.25
Taro	10.966	221.79	232.76
Sweet potatoes	44.536	168.97	213.51

Total root crop aerial parts = 945.76 (x10^3 tonnes/year)

Permanent crops (10^3 tonnes/year)

Avocado skin	1.116
Avocado seed	4.503
Bananas peel	14.103
Banana leaves and stems	365.917
Lemon peel	0.153
Mango peel	1.592
Mango kernel	3.731
Orange peel	0.6302
Papaya skin	0.4768
Pineapple crown	0.1020
Coffee hull	19.44
Coffee pulp	41.46
Sugarcane top	110.16
Sugarcane bagasse	123.38
Enset leaves and stems	377.91

Oilseed cakes (x10^3 tonnes/year)

	Belg season	Meher season	Total
Noug/Niger	0	0.4355	0.4355
Linseed	0.0098	0.4544	0.4642
Safflower	0	0.1541	0.1541
Sesame	0	0.2135	0.2135
Rapeseed	0	1.0243	1.0242
Groundnut	4.6431	0.44	5.08
Sunflower	0.1126	0	0.11
Soyabean	0	0.13	0.13

Total oilseed cakes = 7.61 (x10^3 tonnes/year)

Gambela

Cereal, pulse, oilseed and vegetable residues (x10^3 tonnes/year)

	Belg season	Meher season	Total
Cereal straws/stovers			
Teff	0	0.023	0.023
Barley	0	0.06	0.06
Maize	15.42	14.27	29.69
Sorghum	0	13.57	13.57
Rice	0	0.33	0.33
Cereal brans			
Maize	0.75	0.70	1.45
Sorghum	0.00	0.47	0.47
Rice	0	0.022	0.022
Pulse straw			
Haricot beans	0.062	0.06	0.122
Oilseed straws			
Noug/Niger	0	0.12	0.12
Sesame	0.35	0.00	0.35
Vegetable plant aerial parts			
Ethiopian cabbage	0.046	0.00	0.046
Oilseed cake			
Sesame	0.1036	0.0011	0.1047

1, concentrate, rest are forages

Total cereal straws/stovers = 43.67 (x10^3 tonnes/year)

Total cereal brans = 1.942 (x10^3 tonnes/year)

Total pulse straws/stovers = 0.122 (x10^3 tonnes/year)

Total oilseed straws = 0.47 (x10^3 tonnes/year)

Total vegetable plant aerial parts = 0.046 (x10^3 tonnes/year)

Total oilseed cakes = 0.1047 (x10^3 tonnes/year)

Permanent crops: NIL

Harari

Cereal, pulse, oilseed and vegetable residues (x10^3 tonnes/year)

	Belg season	Meher season	Total
Cereal straws/stovers			
Wheat	0.00	0.20	0.20
Maize	0.25	5.21	5.46
Sorghum	0	28.72	28.72
Cereal brans			
Wheat	0.00	0.01	0.01
Maize	0.01	0.25	0.27
Sorghum	0	0.99	0.99
Pulse straws			
Field peas	0	0.01	0.01
Haricot beans	0	0.0036	0.0036
Oilseed straw			
Groundnut	0	5.22	5.22
Vegetable plant aerial parts			
Sweet potatoes	0	0.23	0.23
Oilseed cakes			
Sesame	0	0.06834	0.06834
Groundnut	0	0.23	0.23

Total cereal straws/stovers = 34.37 (x10^3 tonnes/year)
Total cereal brans = 1.27 (x10^3 tonnes/year)
Total pulse straws = 0.0136 (x10^3 tonnes/year)
Total oilseed straws = 5.22 (x10^3 tonnes/year)
Total vegetable plant aerial parts = 0.23 (x10^3 tonnes/year)
Total oilseed cakes = 0.29834 (x10^3 tonnes/year)

Permanent crops (10^3 tonnes/year)

Bananas peel	0.00307
Banana leaves and stems	0.4062
Mango skin	0.0012
Mango kernel	0.0028
Papaya crown	0.0124

Dire Dawa

Cereal, pulse, oilseed and vegetable residues (x10^3 tonnes/year)

	Belg season	Meher season	Total
Cereal straws/stovers			
Maize stover	0.06	0.78	0.84
Sorghum stover	0	45.96	45.96
Cereal Bran			
Maize	0.00	0.04	0.04
Sorghum	0.00	1.59	1.59
Pulse straw			
Field peas	0	0.51	0.51
Haricot beans	0	0.62	0.62
Oilseed straw			
Groundnut	0	0.33	0.33
Vegetable plant aerial parts			
Tomato	0.0235	0.08	0.1035
Oilseed cakes			
Sesame	0	0.022	0.022
Groundnut	0	0.11	0.11

Total cereal straws/stovers = 46.84 (x10^3 tonnes/year)
Total cereal brans = 1.63 (x10^3 tonnes/year)
Total pulse straws = 1.13 (x10^3 tonnes/year)
Total oilseed straws = 0.33 (x10^3 tonnes/year)
Total vegetable plant aerial parts = 0.1035 (x10^3 tonnes/year)
Total oilseed cakes = 0.132 (x10^3 tonnes/year)

Permanent crops (10^3 tonnes/year)

Coffee hull	0.00166
Coffee pulp	0.00355

Lowland grazing area as percent of the total grazing area

A substantial part of total grazing area in Afar, Somali, Benshangul-Gumuz, SNNPR, Gamela, Harari and Dire Dawa is in lowlands, which provides a bulk of feed for the grazing animals and form the core support system for the pastoralist system in these regions in Ethiopia.

	Total Grazing land (ha)			Lowland Grazing (ha)			Lowland, % of total		
Total	Forest area	Grassland area	Wetland Area	Forest area	Grass-land area	Wetland area	Forest area	Grazing area	Wetland area
Tigray	443426	3070649	19828	145939	1302285	11371	32.91	42.41	57.35
Afar	299431	1117249	264860	284055	1030644	263955	94.86	92.25	99.66
Amhara	1875150	7179510	374100	145939	2315318	49705	7.78	32.25	13.29
Oromia	8749607	12384610	248907	2255737	9108606	87005	25.78	73.55	34.95
Somali	964933	26577304	91438	880744	26127460	90765	91.28	98.31	99.26
B-G	1064838	3279071	27607	922023	3073731	27199	86.59	93.74	98.52
SNNPR	4160207	3467283	150845	1635963	2963466	137214	39.32	85.47	90.96
Gambela	942626	2024733	46832	845597	2022666	2915042	89.71	99.90	99.89
Harari	5875	7480	2.119	1547	2894.671	2.1187	26.33	38.70	100
Dire Dawa	23095	25072	2.380	15679	22343.82	2.3796	67.89	89.12	100

Annex 2. Competitive uses of crop residues

A questionnaire was developed to capture the information from the field. The inputs were gathered by the FAO Field Coordination Offices from six regions: Afar, Amhara, Oromia, SNNPR, Somali and Tigrai. The field offices collected the information from woreda offices, extension and development workers, and Regional Agriculture and Pastoralists Bureaus. The inputs from the remaining four regions could not be obtained. Based on the expert consultations, the pattern of use of crop residues for B-G, Harari and Gambela was taken as the same as for Oromia; and for Dire Dawa, the crop use pattern for Somali was taken. The main reason for using this approach was their close proximity to the regions for which the crop use patter was collected from the field by the FAO Field Offices.

The filled-out questionnaire received for the six regions from the FAO Field Offices are reproduced below:

Afar

PERCENT USE							
	Used for Livestock Production (including grazing)	Left on the field (as mulch or incorporated into the soil)	Used for roof and/or wall making	Burned on the Field/Dumped on land	Used for other purposes (i.e. mushroom, paper, board, matrices, bedding, handicraft, compost etc.)	Remarks, if any	TOTAL %
Cereals							
Teff straw	100					Only in Zone 2	100
	70		30			Only in Argoba in Zone 3	100
Barley straw	100					Only in Zone 2	100
Wheat straw	100						100
Maize stover	100					In Zone 1,2, 3, 5	100
Sorghum stover	100					Only in Zone 2 and Argoba Zone 3	100
Finger millet straw							100
Oats/'Aja' straw							100
Rice straw							100
Pulses							
Horse beans straw	100						100
Field peas straw	100						100
Haricot beans white straw							100
Chick-peas straw							100
Lentils straw							100
Vetch straw							100
Fenugreek straw							100
Mung bean/"Masho" straw	100					In Argoba in Zone 3 and Semurobi in Zone 5	100

Gibto straw							100
Oilseeds							
Neug straw							100
Linseed straw							100
Groundnut straw							100
Sunflower straw							100
Safflower straw							100
Sesame straw		100					100
Rapeseed straw							100
Soyabean straw							100
Vegetables							
Lettuce waste							100
Head Cabbage leaves							100
Ethiopian Cabbage leaves							100
Tomatoes aerial part		100					100
Green pepper leaves and stalks		100					100
Red pepper leaves and stalks		100					100
Swiss chard waste							100
Root Crops							
Beetroot aerial part							100
Carrot aerial part							100
Onion aerial part							100
Potato aerial part							100
Yam/'Boye' aerial part							100
Garlic aerial part							100
Taro/'Godere' aerial part							100

Sweet potato aerial part							100
Permanent Crops							
Avocado peel							100
Avocado seed							100
Banana peel	100	-				All zones but insignificant amount	100
Banana leaves	100	-				All zones but insignificant amount	100
Banana stems						All zones but insignificant amount	100
Guavas peels							100
Guava pulp							100
Lemons peels							100
Mangoes peels							100
Mango kernels							100
Orange peels		100				Zone 1,2, 3, 5 but insignificant amount	100
Orange pulp		100				Zone 1,2 3, 5 but insignificant amount	100
Papaya peels		100				Zone 1, 2, 3, 5 but insignificant amount	100
Pineapple peels							100
Pineapple pulp							100
Pineapple crown							100
Chat waste							100
Coffee husk							100
Coffee pulp							100
Hops (Gesho) waste							100
Sugar cane tops	100					Only from Kesem Sugar Factory-temporary	100

						arrangement with FARM Africa	
Sugarcane bagasse	100					Only from Kesem Sugar Factory-temporary arrangement with FARM Africa	100
Enset leaves							100
Enset stems							100
Fiber crops							
Cotton aftermath	100					Fed on the field in Zone 3	100

Gibto grains:

a) Percent for human consumption:
b) Percent used for alcohol production

Amhara

PERCENT USE							
	Used for Livestock Production (including grazing)	Left on the field (as mulch or incorporated into the soil)	Used for roof and/or wall making	Burned on the Field/Dumped on land	Used for other purposes (i.e. mushroom, paper, board, matrices, bedding, handicraft, compost etc.)	Remarks, if any Fire wood	TOTAL %
<u>Cereals</u>							
Teff straw	70		30				100
Barley straw	70		30				100
Wheat straw	70		30				100
Maize stover	90					10	100
Sorghum stover	85		10			5	100
Finger millet straw	100						100
Oats/'Aja' straw	100						100
Rice straw	95		5				100
<u>Pulses</u>							
Horse beans straw	100						100
Field peas straw	100						100
Haricot beans white straw	100						100
Chick-peas straw	100						100
Lentils straw	100						100
Vetch straw	100						100

Fenugreek straw	100						100
Mung bean/"Masho" straw	100						100
Gibto straw	100						100
Oilseeds							
Neug straw	80			20			100
Linseed straw	30			70			100
Groundnut straw	100						100
Sunflower straw	80						100
Safflower straw	60						100
Sesame straw	80			20			100
Rapeseed straw	60						100
Soyabean straw	100						100
Vegetables							
Lettuce waste	100						100
Head Cabbage leaves	100						100
Ethiopian Cabbage leaves	100						100
Tomatoes aerial part	-						100
Green pepper leaves and stalks -							100
Red pepper leaves and stalks -							100
Swiss chard waste	100						100
Root Crops							
Beetroot aerial part	100						100

Carrot aerial part	100						100
Onion aerial part	-						100
Potato aerial part	100						100
Yam/'Boye' aerial part	-						100
Garlic aerial part	-						100
Taro/'Godere' aerial part	-						100
Sweet potato aerial part	100						100
Permanent Crops							
Avocado peel	100						100
Avocado seed	-						100
Banana peel	100						100
Banana leaves	50						100
Banana stems	50						100
Guavas peels	-						100
Guava pulp	-						100
Lemons peels	-						100
Mangoes peels	100						100
Mango kernels	-						100
Orange peels	-						100
Orange pulp	-						100
Papaya peels	-						100

Pineapple peels	-						100
Pineapple pulp	-						100
Pineapple crown	-						100
Chat waste	-						100
Coffee husk	0			100			100
Coffee pulp	0						100
Hops (Gesho) waste	-						100
Sugar cane tops	60						100
Sugarcane bagasse	5						100
Enset leaves /Falsebanana/	100						100
Enset stems /Falsebanana/	100						100

Gibto grains:

a) Percent for human consumption: 70
b) Percent used for alcohol production: 30

SNNPR

PERCENT USE							
	Used for Livestock Production (including grazing)	Left on the field (as mulch or incorporated into the soil)	Used for roof and/or wall making	Burned on the Field/Dumped on land	Used for other purposes (i.e. mushroom, paper, board, matrices, bedding, handicraft, compost etc.)	Remarks, if any Use for fire wood	TOTAL %
<u>Cereals</u>							
Teff straw	70		20		10 For mattresses; some as cash income (marketed)		100
Barley straw	60	15					100
Wheat straw	60	20			10	In parts of the main producing North-East part of the region nowadays they rent combiner for harvest and the straw is not properly collected. Although animals are let to graze on it the wastage is high	100
Maize stover	90 (high wastage during feeding, less chopping					10	100
Sorghum stover	80		15			5	100
Finger millet straw	100						100
Oats/'Aja' straw	100						
Rice straw	80			20		No significant produvtion	
<u>Pulses</u>							

Horse beans straw	100						100
Field peas straw	100						100
Haricot beans white straw	80				20% as cash source		100
Chick-peas straw	100						100
Lentils straw	100						100
Vetch straw	100						100
Fenugreek straw	90			10			100
Mung bean/"Masho" straw	100						100
Gibto straw	-						
Oilseeds							
Neug straw	100						
Linseed straw							100
Groundnut straw	100						100
Sunflower straw	-						100
Safflower straw	-						100
Sesame straw	80			20			100
Rapeseed straw	-						100
Soyabean straw							100
Vegetables							
Lettuce waste	100						100
Head Cabbage leaves	100						100

Ethiopian Cabbage leaves	100						100
Tomatoes aerial part	100						100
Green pepper leaves and stalks -		100					100
Red pepper leaves and stalks -		100					100
Swiss chard waste	100						100
Root Crops							
Beetroot aerial part							100
Carrot aerial part	100						100
Onion aerial part	100						100
Potato aerial part	100						100
Yam/'Boye' aerial part	100						100
Garlic aerial part	100						100
Taro/'Godere' aerial part	0					Due to oxalic acid content it irritates tongue	
Sweet potato aerial part	100						100
Permanent Crops							
Avocado peel	100						100
Avocado seed	-						100
Banana peel	100						100
Banana leaves	90				10		100
Banana stems	100						100

Guavas peels	-						100
Guava pulp	-						100
Lemons peels	-						100
Mangoes peels	100						100
Mango kernels	-						100
Orange peels	100						100
Orange pulp	100						100
Papaya peels	100						100
Pineapple peels	-						100
Pineapple pulp	-						100
Pineapple crown	-						100
Chat waste	-						100
Coffee husk	40				Remaining as organic fertilizer; discarded		100
Coffee pulp	40				Sold for tea making		100
Hops (Gesho) waste	-						100
Sugar cane tops	70			30			100
Sugarcane bagasse	0						100
Enset leaves /Falsebanana/	60				Leaves marketed as wrapping material; handicraft (rope)		100
Enset stems /Falsebanana/	100						100

Tigrai

PERCENT USE							
	Used for Livestock Production (including grazing)	Left on the field (as mulch or incorporated into the soil)	Used for roof and/or wall making	Burned on the Field/Dumped on land	Used for other purposes (i.e. mushroom, paper, board, matrices, bedding, handicraft, compost etc.)	Remarks, if any	TOTAL %
Cereals							
Teff straw	96	2.5	0.5	-	1		100
Barley straw	95	3	0.6	-	1.4		100
Wheat straw	95.5	2	0.7	-	1.8		100
Maize stover	90	5	-	4	1		100
Sorghum stover	89	6	2	2	1		100
Finger millet straw	95	3	-	-	2		100
Oats/'Aja' straw	-	-	-	-	-		100
Rice straw	80	-	-	10	10		100
Pulses							
Horse beans straw	84	10	-	4	2		100
Field peas straw	98	1	-	-	1		100
Haricot beans white straw	90	5	-	1	4		100
Chick-peas straw	98	1	-	0.5	0.5		100

Lentils straw	85	10	-	4	1		100
Vetch straw	99	1	-	-	-		100
Fenugreek straw	80	10	-	5	5		100
Mung bean/"Masho" straw	98	1	-	-	1		100
Gibto straw							100
Oilseeds							
Neug straw	60	20	-	10	10		100
Linseed straw	55	15	-	15	15		100
Groundnut straw	70	10	-	10	10		100
Sunflower straw	65	20		10	5		100
Safflower straw	60	25		10	5		100
Sesame straw	45	30	-	20	5		100
Rapeseed straw	60	30		10	0		100
Soyabean straw	97	2	-	1	-		100
Vegetables							
Lettuce waste	70	15	-	10	5		100
Head Cabbage leaves	65	5	-	20	10		100
Ethiopian Cabbage leaves	75	5		10	10		100
Tomatoes aerial part	85	8	-	5	2		100

Green pepper leaves and stalks (40)		30	-	15	15		100
Red pepper leaves and stalks (40)		30		15	15		100
Swiss chard waste	85	10	-	3	2		100
Root Crops							
Beetroot aerial part	90	5	-	5	-		100
Carrot aerial part	86	5	-	5	4		100
Onion aerial part	50	30	-	8	12		100
Potato aerial part	90	4	-	5	1		100
Yam/'Boye' aerial part	-	-	-	-	-		100
Garlic aerial part	60	20	-	7	3		100
Taro/'Godere' aerial part	-	-	-	-	-		100
Sweet potato aerial part	75	10	-	8	7		100
Permanent Crops							
Avocado peel	92	3	-	3	2		100
Avocado seed	-	-	-	-	-		100
Banana peel	97	1	-	1	1		100
Banana leaves	85	5	-	5	4		100
Banana stems	87	4	-	4	5		100
Guavas peels	85	5	-	5	5		100
Guava pulp	96	2	-	1	1		100

Lemons peels	-	-	-	-	-		100
Mangoes peels	93	3	-	3	1		100
Mango kernels	-	-	-	-	-		100
Orange peels	-	-	-	-	-		100
Orange pulp	-	-	-	-	-		100
Papaya peels	85	5	-	5	5		100
Pineapple peels	85	4	-	6	5		100
Pineapple pulp	93	1	-	3	3		100
Pineapple crown	85	5	-	6	4		100
Chat waste	-	-	-	-	-		100
Coffee husk	-	-	-	-	-		100
Coffee pulp	-	-	-	-	-		100
Hops (Gesho) waste	-	-	-	-	-		100
Sugar cane tops	90	2	-	5	3		100
Sugarcane bagasse	-	-	-	-	-		
Enset leaves	-	-	-	-	-		
Enset stems	-	-	-	-	-		

Gibto grains:

a) Percent for human consumption:
b) Percent used for alcohol production

Oromia

PERCENT USE							
	Used for Livestock Production (including grazing)	Left on the field (as mulch or incorporated into the soil)	Used for roof and/or wall making	Burned on the Field/Dumped on land	Used for other purposes (i.e. mushroom, paper, board, matrices, bedding, handicraft, compost etc.)	Remarks, if any	TOTAL %
<u>Cereals</u>							
Teff straw	70		30				100
Barley straw	60	10	30				100
Wheat straw	50	10	40				100
Maize stover	60				40 (fuel)	For fuelwood	100
Sorghum stover	50		10		40 (fuel)		100
Finger millet straw	70		30				100
Oats/'Aja' straw	50	10	40				100
Rice straw	50	10			40 (fuel)		100
<u>Pulses</u>							
Horse beans straw	60	40					100
Field peas straw	60	40					100
Haricot beans white straw	70	30					100
Chick-peas straw	80	20					100
Lentils straw	80	20					100
Vetch straw	80	20					100

Fenugreek straw	60	40					100
Mung bean/"Masho" straw	70	30					100
Gibto straw							100
Oilseeds							
Neug straw	60	40					100
Linseed straw	50	50					100
Groundnut straw	0	100					100
Sunflower straw							100
Safflower straw	40	60					100
Sesame straw	10				90 (burnt in field)		100
Rapeseed straw	0	70			30	Fuelwood	100
Soyabean straw	40	60					100
Vegetables							
Lettuce waste							100
Head Cabbage leaves		100					100
Ethiopian Cabbage leaves							100
Tomatoes aerial part		100					100
Green pepper leaves and stalks		100					100
Red pepper leaves and stalks		100					100
Swiss chard waste							100
Root Crops							
Beetroot aerial part		100					100

Carrot aerial part		100					100
Onion aerial part		100					100
Potato aerial part		100					100
Yam/'Boye' aerial part							100
Garlic aerial part		100					100
Taro/'Godere' aerial part							100
Sweet potato aerial part							100
<u>Permanent Crops</u>							
Avocado peel	-						100
Avocado seed	-						100
Banana peel	-						100
Banana leaves	50	50					100
Banana stems	40	60					100
Guavas peels	-						100
Guava pulp	-						100
Lemons peels	-						100
Mangoes peels	-						100
Mango kernels	-						100
Orange peels	-						100
Orange pulp	-						100
Papaya peels	-						100

Pineapple peels	-						100
Pineapple pulp	-						100
Pineapple crown	-						100
Chat waste	50	30			20	Fuel wood	100
Coffee husk	0			100			100
Coffee pulp	-						100
Hops (Gesho) waste	-						100
Sugar cane tops	70			30			100
Sugarcane bagasse	10			90			100
Enset leaves							100
Enset stems							100

Somali

PERCENT USE							
	Used for Livestock Production (including grazing)	Left on the field (as mulch or incorporated into the soil)	Used for roof and/or wall making	Burned on the Field/Dumped on land	Used for other purposes (i.e. mushroom, paper, board, matrices, bedding, handicraft, compost etc.)	Remarks, if any	TOTAL %
Cereals							
Teff straw	-	-	-	-	-		100
Barley straw	80	20		0	0		100
Wheat straw	80	20					100
Maize stover	83	12	5	0	0		100
Sorghum stover	83	12	5	0	0		100
Finger millet straw	70	20	10	0			100
Oats/'Aja' straw	-	-	-	-	100		100
Rice straw	80	20					100
Pulses							
Horse beans straw	-	-	-	-	-		100
Field peas straw	70	30	-	-	-		100
Haricot beans white straw	50	30	-	-	20 (making shades)		100
Chick-peas straw	-	-	-	-	-		100
Lentils straw			-	-	-		100
Vetch straw	-	-	-	-	-		100

Fenugreek straw							100
Mung bean/"Masho" straw							100
Gibto straw							100
Oilseeds							
Neug straw	-	-	-				100
Linseed straw	-	-	-				100
Groundnut straw	-	100	-				100
Sunflower straw	-	-	-				100
Safflower straw	-	-	-	-			100
Sesame straw	-	90	10	-			100
Rapeseed straw	-	-	-	-			100
Soyabean straw	-	-	-	-			100
Vegetables							
Lettuce waste	-	-	-	-			100
Head Cabbage leaves	-	100	-	-			100
Ethiopian Cabbage leaves	-	100	-	-			100
Tomatoes aerial part		100	-	-			100
Green pepper leaves and stalks		100	-				100
Red pepper leaves and stalks		100	-				100
Swiss chard waste		-		-			100
Root Crops							-
Beetroot aerial part		100	-	-			100

Carrot aerial part		100	-	-			100
Onion aerial part		100	-	-			100
Potato aerial part		100	-	-			100
Yam/'Boye' aerial part							100
Garlic aerial part							100
Taro/'Godere' aerial part							100
Sweet potato aerial part		100					100
<u>Permanent Crops</u>							
Avocado peel	60	40					100
Avocado seed	0	0	0	0	0		100
Banana peel	-	100	-	-	-		100
Banana leaves	40	40	20-	-	-		100
Banana stems	0	60	40	-	-		100
Guavas peels	30	-	70	-	-		100
Guava pulp	-	-	100	-	-		100
Lemons peels	-	-	100	-	-		100
Mangoes peels	-	-	100	-	-		100
Mango kernels	10	-	90	-	-		100
Orange peels	-	-	100	-	-		100
Orange pulp	-	-	100	-	-		100
Papaya peels	20	-	80	-	-		100

Pineapple peels	-	-	-	-	-		100
Pineapple pulp	-	-	-	-	-		100
Pineapple crown	-	-	-	-	-		100
Chat waste	20	-	40	-	40 (cooking)		100
Coffee husk	-	-	-	-	-		100
Coffee pulp	-	-	-	-	-		100
Hops (Gesho) waste	-	-	-	-	-		100
Sugar cane tops	-	-	-	-	-		100
Sugarcane bagasse							100
Enset leaves							100
Enset stems							100

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Saving livelihoods saves lives

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