Research Article

NEPAL LIVESTOCK FEED BALANCE AND STRATEGIES TO ADDRESS THE FEED DEFICIT

S. B. Singh[1*] and N. Singh[2]
[1]Freelance, Livestock Sector Development Specialist, Kathmandu, Nepal
[2]Department of Livestock Services, Kathmandu, Nepal

*Corresponding author: suryasingh1951@gmail.com

ABSTRACT

A study was done in 2019 with the objective of assessing the livestock feed balance in Nepal. The land use data generated by ICIMOD in 2010 was utilized to asses the land resources, and the Land Resource Mapping Project (LRMP) (1986) remained the main source of data to estimate the Total Digestible Nutrient (TDN) supplies from forests, shrub lands, grasslands, croplands (including weeds), and barren lands, plus kitchen wastes as animal feeds. Crop data of the Ministry of Agriculture and Livestock Development (MoALD) (2016/17) were utilized to estimate the TDN supply from crop residues and milling by-products and the livestock data to estimate livestock feed requirements. The findings revealed that there have been significant increases in livestock population and their TDN requirements since 80's, but greater increases could be observed in TDN supply from crop by-products and milling by-products due to increased food crop production. Consequently, the deficit feed balance (TDN) at national level has dropped from 30.9% in the 1980's to 20.05% in 2016/17. By ecological belt, the feed deficit was the highest in the mid hills (-24.09%) followed by terai (-18.91%). The feed situation in the high hills was not too poor (-3.56%). Province one, and three were at severe situation of feed deficit, at -30.48%, and -38.44%, respectively. Feed deficit in the remaining provinces ranged from -9.19% to -15.85%, but a positive balance exists in province six (+6.35%). Recommendations are made to improve livestock feed balance in the country.

Key words: Livestock Units, ecological belts, province, land leasing

INTRODUCTION

Livestock is increasingly valued for food security and rural youth employment in Nepal. There are 7.3 million cattle, 5.2 million buffalo and 0.048 million yak/Chauries, 10.99 million goats, 0.8 million sheep, 1.3 million pigs, 0.056 million equines, 68.63 million fowl and 0.392 million ducks (MoALD, 2017). A total of 2.53 million milking cattle and buffalo were producing 1.91 million t of fresh milk (65% buffalo milk). Buffalo also produced 180,080 t of meat annually. Small ruminants produced 70,420 t (95% goat) of meat annually. While the pigs produced 24,535 t of meat annually, poultry produced 57,509 t of meat (96% chicken) and 135 million eggs, annually.

The then Ministry of Livestock Development (2017) estimated that about 54.6% of the large ruminants were above three years, and one-third under one year of age. Animals between one and three years constituted only 12.3% of total population. The improved animals comprised only 3.4% in case of cattle, and about 4.3% in the case of buffalo. The sheep and goats above six months comprised of about 70% of total population. Improved animals comprised 2.7% in the case of goats and 0.5% in the case of sheep. Of total pig population, only 7.3% was improved. About 55% of pig population was above six months of age. Similarly, of 70 million fowl population, the commercial poultry accounted for 14.5 million.

While the ruminants and equines depend mostly on feeds available on private and common property resources, the rural poultry and pigs depend on scavenging, and the commercial stocks on concentrate feed mixes. Rajbhandary & Shah (1981) estimated that the feed deficit was about 30.9% in terms of Total Digestible Nutrients (TDN) during the 1980's. No systematic studies have taken place since then. Customarily, the national planners use the one-third feed deficit figure even today. However, there have been significant changes in land use pattern, livestock population and production and the farming system in Nepal since then. Therefore, this study was done to assess if there have been any changes in the livestock feed balance since 1980's, and to offer recommendations to manage the feed deficit.

MATERIAL AND METHODS

Estimation of feed availability

Estimation of feed availability from forests, grasslands, shrub lands, barren lands and cultivated lands involved two-stage analysis. The first stage involved the analysis of land use data generated by the International Centre for Integrated Mountain Development (ICIMOD) in 2010 (http://rds.icimod.org) by employing geographic object-based image analysis (GEOBIA) using Landsat images. The ICIMOD data were clipped by using ArcGIS 10.4 version. The same algorithm was utilized to estimate land use and land cover (LULC) of each district,

which were then congregated into provincial database. However, the above images did not provide data on feed productivity of any of these land resources, nor was there any detailed land productivity study carried out since LRMP studies.

Therefore, the second stage examination was undertaken which involved analysis of TDN production from these land resources. Miller (1993) reported an average productivity of 0.73 t/ha TDN for alpine pasturelands. Similarly, Devkota & Kolachhapati (2011) reported 0.64 t/ha TDN for pasturelands of Myagdi district. These two figures averaged out at 0.68t TDN/ha. However, there are no detailed studies of grasslands in the mid hills and the terai. Therefore, the pasturelands' productivity of 0.662, 0.235 and 0.103t TDN/ha in the high hills, mid hills and the terai, respectively, as reported by the Ministry of Forest and Soil Conservation (MFSC, 1989) was utilized in this study.

Similarly, during 1980's when the community forestry program had just commenced, livestock were freely grazed in the forests. Now the community forest cover about 36% of the total forest area (Department of Forest 2018) and many community forests are restricted from grazing. Similarly, the increased tree canopy has reduced ground cover in the leasehold forests. Yet, fodder collection from both of these forests is still continued. However, there was no detailed study report available on feed availability from community or leasehold forests in the current scenario. Similarly, TDN productivity of forage obtained from cultivated lands was also lacking. Therefore, LRMP data (1986) were utilized for estimation of TDN supply from forests, grasslands, shrub lands, barren lands, and agricultural lands (weeds), including the kitchen wastes, with the assumption that no significant changes have occurred since then due to lack of any discernible technical interventions except under leasehold forestry programme.

To estimate the TDN supply from food crop residues, crop yields (production) data from MoALD statistics (2016/17) were used. These production figures were converted into crop residues (by using harvesting indices) and milling by-products (by using milling indices) as available livestock feeds based on review of national and international literatures and personal communications with the national experts[1]. However, it must be recognized that the conversion factors vary by crop variety, agro-ecological differences, method of harvest and processing, and the method of data collection. These are the common limitations of such studies.

The quantity of straw burnt in the field, and straw used for mushroom production were taken from the study findings of Bhandari and Kafle (2017) and PACE Nepal Pvt. Ltd. (2012), respectively. Data on use of grains and by-products, molasses and import of feed ingredients by feed industries were obtained from the Feed Industries Association of Nepal (2017).

Feed demand estimation

Estimates for feed requirements were based on MoALD (2017) data on livestock and livestock production. The livestock numbers were converted into Livestock Units (LUs) by using factors as agreed with the national experts[2]. One LU was considered for a 400kg livestock. Estimation of LU by breed was based on fitting the herd composition data from the then Ministry of Livestock Development (2017) into the same year's MoALD livestock population data.

The requirements for animals were based on NRC (2001) and Manitoba Goat Association (2008). TDN requirement for milk production was derived from Paul et.al. (2004) and for draft animals from Oli (1984), and Sen et al., (1978). The requirements for fish was estimated from total annual fish production, common feed ingredients used and feed conversion ratio of 2.0 under poly culture (Pradhan et al. 2012). The TDN requirement for pigs was estimated by the estimated amount of feed consumption by age for their digestible energy (DE) requirements and their conversion into TDN. Similarly, the TDN for poultry was estimated by converting the annual amount of feed ingredients used by the feed industries in 2016/17 (Feed Industries Association of Nepal, 2017) into TDN.

RESULTS AND DISCUSSION

1 Harvesting indices of buckwheat from Dr. Binayak Rajbhandary, HICAST; paddy from Mr. Bhola Man Singh Basnyat, Rice Production Expert; wheat, barley, millet from Dr. Madan Raj Bhatta, former National Wheat Production Coordinator; and pulse crops from Mr. Ram Krishna Neupane, ex-National Oil Seed Coordinator.

2 Dr. Megh Raj Tiwari, Director, NASRI/NARC, Dr. Krishna Prasad Paudel, Animal Health and Breeding Expert, and Prof. Dr. Naba Raj Devkota, Agriculture and Forestry University, Rampur, Chitwan.

Changes in llivestock population, and cereal and oilseed crop production since 1980

There have been significant changes in livestock population since 1980 when LRMP survey was undertaken (Table 1). Overall, the Livestock Unit has increased by 1.58 times with the increase in poultry population by 118 times, pig population by 3.6 times, sheep and goat population by 2.1 times and cattle and buffalo population by 1.3 times. These increases had intensified the livestock feed demand dramatically.

Table 1: Changes in livestock population and in 2016/17 over 1980

Species	Population, MoALD (2016/17)		Population in 1980 (FAO, 2005)	Changes over 1980 (multiple)
Cattle	7,302,511			
Buffalo	5,168,809	12,540,666	9,400,000	
Yak/Chauri	69,346			1.3
Goat	10,766,363	11,522,901	5,380,000	
Sheep	756,538			2.1
Pigs	1,341,584	1,341,584	375,000	3.6
Equine	55,808	55,808		
Fowl	68,941,223	69,322,039	586,000	
Duck	380,816			118.3
Total LU		8,495,536	5,372,000	1.58

Note: To make the LU compatible with the FAO data above, factors such as (i) 0.2 pigs =1 LU; and (ii) 0.01 poultry=1 LU were used, based on author's long time experience.

At the same time, crop production has increased at least by 2.15 times and the average crop yields by 1.49 times since 1986 (Table 2). Major changes could be observed in cereal and sugarcane production.

Table 2. Changes in crop production since LRMP (1986)

Year	Crop production and yields					Changes over past years (multiple)	
	Details by Year			2016/17			
	Crop	Production (t)	Yield (kg/ha)	Production (t)	Yield (kg/ha)	Production (t)	Yield (kg/ha)
1984/85	Paddy	2,709,430	1.97	5,230,327	3.37	1.93	1.71
1984/85	Maize	819,850	1.42	2,300,121	2.55	2.81	1.80
1984/85	Millet	124,430	0.93	306,704	1.16	2.46	1.26
1984/85	Wheat	533,720	1.18	1,879,191	2.55	3.52	2.16
1984/85	Barley	23,460	0.86	30,510	1.11	1.30	1.30
1984/85	Oil seed	84,030	0.66	214,451	1.03	2.55	1.57
1984/85	Sugarcane	408,260	23.36	3,219,560	45.47	7.89	1.95
2000/01	Lentil	143,084	0.88	254,308	1.23	1.78	1.39
2000/01	Chick pea	12,148	0.83	10,969	1.10	0.90	1.33
2000/01	Pigeon pea	20,936	0.87	16,497	0.97	0.79	1.11
2000/01	Black gram	21,599	0.71	19,499	0.83	0.90	1.17
2000/01	Grass pea	6,796	0.78	9,354	1.16	1.38	1.49
2000/01	Horse gram	5,241	0.62	5,690	0.90	1.09	1.44
2000/01	Soybean	17,470	0.84	29,061	1.23	1.66	1.46
2000/01	Other legumes	15,969	0.77	32,817	1.07	2.06	1.39
2010/11	Buckwheat	8,841	0.86	12,039	1.09	1.36	1.27
					Average changes	**2.15**	**1.49**

Source: MoALD Annual Statistics. Information on Nepalese Agriculture published in various years

Changes in land use

There have been significant changes in land use pattern in Nepal since 1990 (Table 3). The most significant change could be observed in increased built up area and barren land by 65.5% and 52.5%, respectively, compared to 1990. The grassland area has reduced by 26.8% and forest area by 7% with concurrent increase in agricultural land by 7.6% and shrub land by 4.5% (Table 3). The increased areas of agricultural and barren lands significantly increased the feed supply to the livestock compared to 1990 and before.

Table 3. Changes in land use pattern in Nepal

Land category	1990	2000	2010	Change over 1990
		Area, ha		
Forest	6,668,336	6,148,401	6,202,809	-7.0%
Shrub land	328,142	346,930	342,986	4.5%
Grassland	1,728,561	1,379,485	1,264,552	-26.8%
Agriculture area	3,753,933	4,096,968	4,039,820	7.6%
Barren area	1,006,831	1,702,002	1,535,851	52.5%
Water body	81,052	73,051	72,685	-10.3%
Snow/glacier	1,168,741	974,176	1,255,347	7.4%
Built-up area	32,916	47,499	54,462	65.5%
Total	**14,768,512**	**14,768,512**	**14,768,512**	

Source: (Kabir et.al. (2018)

Sources of Total Digestible Nutrients (TDN)

Major sources of livestock feeds were the crop residues and milling by-products, forest, and weeds and grasses from farmlands, each contributing 44%, 20.5% and 15.1% of total TDN supply. Rest of the sources contributed less than 5% of the total supply (Table 4). Improved forage and pasture contributed only about 7% of total supply. In aggregate, available TDN is estimated at 10.1 million t, which is 1.5 times greater than the estimate (6.58 million t) of the MFSC (1989), under optimistic (moderate) scenario.

Table 4. Available TDN (MT) by source

Sources of feed	Total area (ha)	Available TDN (t)	Percent share
Forest	6,176,984	2,070,334	20.5%
Shrub land	341,809	177,021	1.8%
Grassland	1,253,349	255,528	2.5%
Crop residues and milling by-products	NA	4,443,642	44.0%
Farm weeds (seasonal forages) etc.	4,017,873	1,526,792	15.1%
Improved forages and pasture/grasses	67,061	694,749	6.9%
Barren area	1,534,681	92,081	0.9%
Commercial silage @40 t/day, 70% TDN	≅ 250	4,380	0.043%
Kitchen wastes*		359,000	3.6%
Grain supplementation @5% of total TDN requirements in general		481,176	4.8%
Total TDN supply		**10,104,703**	**100%**

Source: Author's estimates.

* At 225g/day/HH (LRMP, 1986), Rural HH in 2017 was 4,430,458

There was also an increased use of silage, especially by the commercial dairy farmers. About 40 t of silage was produced and marketed daily in Nepal (personal communication S. G. Cattle Fodder Industry in Ranighat, Birgunj, May 10, 2019). There were also reports that some dairy farmers used a significant quantity of Indian silage. However, lack of import data restricted its inclusion as feed source in preparation of the present feed balance sheet.

Share of straw in TDN supply by crop: Total TDN available from crop and milling by-products in the country was estimated at 4.44 million t (Table 5). On an average, straws contributed 65% of TDN supply. This figure is much higher than reported by Sah et., al (2018), as these authors reported that straw contributed 50% of

total dry matter of buffalo diet in Chitwan, Gorkha and Tanahu districts. This difference could be associated with the differences in the type of animals considered, cropping systems and the season of study. Sah et., al (2018) based their study on assessment of the feeding management of milking animals during the winter season, whereas we, in this study considered the total national herds covering a complete calendar year. Milking animals are certainly fed better than other stocks in the herds.

Table 5. TDN available by crop and share of straw/ Stover

Crops	Total TDN, t	Share of Straw, t	TDN share by crop (%)	Share of straws to total available TDN (%)
Paddy	2,099,420	1,643,858	51.01%	78.3%
Maize	908,778	721,088	22.38%	79.3%
Wheat	849,158	423,633	13.15%	49.9%
Sugarcane	153,694	145,562	4.52%	94.7%
Millet	127,589	127,589	3.96%	100.0%
Lentil	98,411	65,158	2.02%	66.2%
Mustard	84,967	25,235	0.78%	29.7%
Other legumes	14,375	14,375	0.45%	100.0%
Barley	10,638	9,013	0.28%	84.7%
Black gram	8,553	8,553	0.27%	100.0%
Soybean	24,844	5,562	0.17%	22.4%
Pigeon pea	8,516	4,703	0.15%	55.2%
Sunflower	11,713	4,405	0.14%	37.6%
Buckwheat	5,736	4,298	0.13%	74.9%
Linseed	10,811	3,838	0.12%	35.5%
Groundnut	3,327	3,327	0.10%	100.0%
Grass pea	3,713	2,488	0.08%	67.0%
Chickpea	4,088	2,322	0.07%	56.8%
Sesame	3,739	2,137	0.07%	57.1%
Horse gram	1,945	1,945	0.06%	100.0%
Sarson	5,992	1,780	0.06%	29.7%
Niger	1,849	915	0.03%	49.5%
Rayo	1,785	530	0.02%	29.7%
Overall	**4,443,642**	**3,222,316**	**100.0%**	**65.1%**

Source: Derived from MoALD Statistical Information on Nepalese Agriculture (2017) and expert consultation for conversion factors from grain to crop residues and milling by-products

In addition, at one hand, straw makes up the major livestock diet (80%) during the winter and the summer, little effort is put to conserve the surplus green forage available during the rainy season on the other hand. Therefore the animals are over supplied with green feed during the rainy season in general (though not in terms of balanced nutrition), and undersupplied during the winter and summer. During the later periods, the animals are in very poor nutritional condition, which compels them to under perform. Drake et al., (2002) reported that the inclusion of rice straw beyond 25% in dairy animal ration and 50% in the dry cow ration limits intake and hence animal production performance. It is good to learn that while in the terai about 30% of straws (wheat and rice) are burnt in the fields due to the use of combine harvester, there is increasing use of rice straw by the paper industries and the growing mushroom industries, particularly in the hills.

Likewise almost entire sugarcane bagasses are used as fuel in sugar and paper industries. They are also the major sources of fuel even during jiggery (*gur*) making in the rural Nepal. Similarly, most of the molasses is used for spirit manufacturing. And molasses are not the choice of the feed industries as the sugar industries usually store them in open pits.

Import of cereals and their by-products: In 2016/17, the poultry industries in Nepal used 745,429 t of feed ingredients, of which 75% yellow maize, 99% of soybean, 90% each of sesame and mustard cakes, and 30% de-oiled rice bran were imported (Feed Industries Association of Nepal, 2017). While the import of de-oiled rice bran and oil cakes were mainly due to short supplies in the country, the import of maize grain[3] was mainly due to the poor quality of local products. Most of local maize are harvested during pre-monsoon to monsoon when farmers are engaged in other farm businesses. At the same time, there are no facilities at local level for proper post harvest management, such as drying and maintaining minimum moisture level. The local maize grains are low in quality for poultry feeding and are also suspected for high level of infestation with aflatoxin, generally *Aspergillus flavus* (Pokhrel, 2016). Therefore, the feed industries used the imported high quality maize even if they were more expensive than the local maize. Total TDN value of these imported ingredients was about 381,735 t.

Estimated feed (TDN) demand

Total TDN demand of livestock in 2016/17 is estimated at 12.257 million t (Table 6). This demand is 1.3 times higher than 9.461 million t as reported by Rajbhandary & Pradhan (1991). The large ruminants occupied about 83% of total TDN requirements in the country. Of the large ruminants, the share of cattle was the highest followed by buffalo. The share of small ruminants was only 6.6%, of which goat occupied 94% and the rest by sheep. Pig and poultry each occupied below 5% of total demand.

Table 6. Estimated TDN demand by livestock species in the year 2016/17

Livestock species	Total population	LU	TDN required, t	Percent share
Cattle, including bullocks	7,302,808	4,236,873	4,780,656	39.0%
Buffalo, including bullock/bull	5,168,809	2,560,020	2,804,792	22.9%
For volume of milk production	NA	NA	2,496,166	20.4%
Yak/Nak	69346	49,456	54,154	0.4%
Goat	10,986,114	687,971	753,328	6.1%
Sheep	800,658	45,766	50,113	0.4%
Horse	68711	68,874	75,417	0.6%
Pig	1,291,308	NA	584,984	4.8%
Poultry	68,630,638	NA	551,529	4.5%
Duck	392,255	NA	8,018	0.1%
Fish	56,575	NA	97,725	0.8%
Total			**12,256,882**	**100%**

Source: Authors' estimate; NA= Not applicable

Feed balance at national level

TDN requirements for livestock exceeded the supply by 20.05% (Table 7). This deficit figure was much lower than the estimates (-30.9% to -34%) made by the previous authors (Rajbhandary & Sah, 1981; Rajbhandary & Pradhan, 1991). These differences are associated mainly with the change on land use pattern and livestock population and production, and the considerable increase in cereal and oil seed crop production since the previous authors undertook the studies. The table below also shows that the feed industries import about 70% of the total TDN required by the commercial poultry sector.

Table 7. Feed (TDN) balance

TDN Requirements (t)	12,256,882
TDN equivalent import by feed industries (t)	381,735
Total TDN requirements (t)	12,638,617
Local TDN Supply (t)	10,104,703
Balance (+/-) (t)	-2,533,914
Percent deficit, overall	-20.05%
TDN deficit in commercial poultry sector	-69.7%

3 Total import of maize grain is about 13% of total national maize production of 2,300,121 t)

Feed balance by ecological belts

Available TDN by source: While crop residues and milling by-products were the dominant sources of feeds in the terai and mid-hills, forest and grasslands were dominant in the high hills (Table 8). Forests were important also in the mid hills. Of the available TDN in the country, mid-hills and terai, each shared about 45% and the high hills only about 10%.

Table 8. Available TDN by sources and eco-zone

Sources of feeds	High-hills		Mid-hills		Terai		Total
	Available TDN (t)	Percent share	Available TDN (t)	Percent share	Available TDN (t)	Percent share	
Forest	295,981	28.4%	1,249,404	27.5%	524,949	11.6%	2,070,334
Shrub land	64,365	6.2%	92,561	2.0%	20,095	0.4%	177,021
Grassland	146,658	14.1%	39,733	0.9%	69,136	1.5%	255,528
Cultivated fields (weeds/ forage)	145,441	13.9%	734,121	16.2%	647,229	14.3%	1,526,792
Barren lands	63,077	6.0%	26,352	0.6%	2,652	0.1%	92,081
Crop and milling by-products	220,195	21.1%	1,766,423	38.9%	2,457,026	54.3%	4,443,645
Improved forages and pasture/grasses	31,398	3.0%	252,724	5.6%	410,626	9.1%	694,749
Commercial silage @40 t/day, 70% TDN					4,380	0.1%	4,380
Kitchen wastes	28,767	2.8%	171,590	3.8%	185,295	4.1%	385,653
Grain use @5% of total requirements	46,906	4.5%	204,080	4.5%	203,536	4.5%	454,522
Total	1,042,789	100.0%	4,536,989	100.0%	4,524,925	100.0%	10,104,705
% TDN supply	**10.03%**		**44.9%**		**44.8%**		

Source: Authors' estimate

TDN Requirements by Eco-zone: TDN requirements in the mid-hills was the highest (47.6%) followed by the terai (43.6%), and the high-hills (8.8%) (Table 9). Cattle population was the major consumer of feeds across the eco-zone, followed by buffalo and for total volume of milk production.

Table 9. TDN requirements by eco-zone

Livestock species	TDN requirements (t)			Total
	High-hills	Mid-hills	Terai	
Cattle	493,385	2,201,262	2,086,008	4,780,656
Buffalo	182,138	1,423,380	1,199,274	2,804,792
Yak/Nak	45,816	8,339	-	54,154
For volume of milk production	152,380	1,224,432	1,119,354	2,496,166
Goat	81,233	398,935	273,160	753,328
Sheep	20,239	21,286	8,588	50,113
Horse	36,695	33,775	4,947	75,417
Pig	49,770	315,087	220,127	584,984
Poultry	11,467	204,657	335,405	551,529
Duck	243	2,328	5,446	8,018
Fish	46	2,113	95,566	97,725
Total	**1,073,414**	**5,835,593**	**5,347,875**	**12,256,882**
TDN Share by Eco-zone	8.8%	47.6%	43.6%	100.0%

Source: Authors' estimate

Feed balance by Eco-zone: Information on table (8 and 9 above) could be summarized as below in table 10. Accordingly, the feed (TDN) deficit is the highest in the mid hills (-24.09%), followed by terai (-18.91%). The feed situation in the high-hills is more or less balanced. These findings differed from those by Maharjan (2003), as the author reported that the feed deficit was about 15% in the high hills, 40% in the mid hills, and 19% in the terai. These differences could be associated with the changes in land use pattern, livestock population and production, and crop production.

Table 10. Feed balance by Eco-zone

Feed balance	High-hills	Mid-hills	Terai	Total
TDN Demand (t)	1,073,414	5,835,593	5,347,875	12,256,882
TDN equivalent import by feed industries (t)	7,896	141,437	232,402	381,735
Total TDN requirements (t)	1,081,310	5,977,030	5,580,277	12,638,617
TDN Available (t)	1,042,789	4,536,989	4,524,925	10,104,703
Feed demand supply (balance)	-38,521	-1,440,041	-1,055,352	-2,533,914
Percent feed deficit	**-3.56%**	**-24.09%**	**-18.91%**	**-20.05%**

Source: Authors' estimate

Feed balance by Province

TDN available by province: The share of the province to the national TDN supply ranged from 9.3% from Province Six to 19% from Province One. Province Two and Three each had TDN share of about 15%, and Province Four and Seven each shared about 12% (Table 11). The crop by-products and milling by-products remained dominant TDN contributors across the provinces. Forest was the second dominant source of feeds in Province Six and Seven. The third source was the cultivated fields, offering green feeds from crop weeding and forage harvests. In Province six, both grasslands and shrub lands were important sources of livestock feeds.

Table 11. TDN available by Province ('000 t)

Sources of feeds	Province							
	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN	Total
Forest	376	101	366	243	351	279	354	2,070
Shrub land	32	6	11	40	18	45	26	177
Grassland	21	25	16	51	28	89	25	256
Cultivated fields	290	231	207	157	304	154	184	1,527
Barren lands	13	1	10	20	4	32	13	92
Crop & milling by-products	897	909	583	464	875	242	474	4,444
Improved forages and pasture/ grasses	134	136	177	111	75	29	32	695
Commercial silage @40t/ day, 70% TDN	-	4	-	-	-	-	-	4
Kitchen wastes	72	70	83	38	62	25	36	386
Grain @5% of total TDN requirements	86	70	68	54	81	42	54	455
Total	1,922	1,552	1,521	1,176	1,799	937	1,198	10,105
Percent share	19.0%	15.4%	15.1%	11.6%	17.8%	9.3%	11.9%	100%

Source: Authors' estimate

TDN Requirements by province: The TDN demand of livestock species including milk production is given in Table 12. The TDN demand was the highest in Province One followed by Province Three and Five. By demander, cattle was the largest demander followed buffalo and quantity of milk produced. The TDN demand of pig was the highest in Province One, and the highest poultry demand was in Province Three.

Table 12. TDN Requirements ('000 t) by species and by Province

Species	Province							
	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN	Total
Cattle	1,280	681	733	345	697	400	646	4,781
Buffalo	466	424	496	365	605	166	282	2,805
Yak / Nak	17	-	9	12	-	15	1	54
For volume of milk production	496	357	470	338	441	123	270	2,496
Goat	156	97	146	78	134	69	74	753
Sheep	5	0.4	5	7	9	18	6	50
Horse	8	0.3	1	6	5	49	6	75
Pig	258	44	82	42	102	30	27	585
Poultry	38	57	309	59	71	6	11	552
Duck	2	2	1	1	1	0.2	0.3	8
Fish	12	55	5	1	22	0.1	2	98
Total	**2,739**	**1,717**	**2,257**	**1,254**	**2,088**	**876**	**1,326**	**12,257**
% share	**22.30**	**14.00**	**18.40**	**10.20**	**17.00**	**7.20**	**10.80**	**100.00**

Source: Author's estimate

The feed balance by Province: The above analyses indicated that the Province Three and One were at severe feed deficit situation (38.4% and 30.5%, respectively) compared to other provinces (Table 13). Province Six seemed at positive balance (+6.4%). The deficit in other provinces ranged from -9.2% in Province Four to -15.9% in Province Five.

Table 13. Feed balance by province ('000 t)

Feed balance ('000 t)	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN	Total
TDN Demand	2,739	1,717	2,257	1,254	2,088	876	1,326	12,257
Import (TDN equivalent)	26	39	214	41	49	4	8	382
TDN requirements	2,765	1,756	2,470	1,295	2,138	881	1,333	12,639
Available TDN	1,922	1,552	1,521	1,176	1,799	937	1,198	10,105
Feed balance	(843)	(205)	(950)	(119)	(339)	56	(135)	(2,534)
Feed deficit (%)	-30.5	-11.6	-38.4	-9.2	-15.9	6.4	-10.1	-20.1

Source: Authors' estimate

The near future feed balance

Estimation of near future TDN demand: With assumption that increase or decrease in livestock population will result in corresponding changes in feed demand, the compound annual growth rate for TDN demand for the next ten years will average about 6% plus for buffalo, goats, pigs and milk production from buffalo, and 3.8% for cow milk production. The demand for poultry and fish will grow at an average rate of 9% per annum. Overall, the TDN requirements for livestock will reach 1.27 times in 2021/22 and 1.54 times in 2026/27 compared to the requirements for the base year 2016/17.

Table 14. TDN requirements projection for the next 10 years

Livestock species	TDN requirements (t)/Year			Annual compound growth rate (%)
	2016/17	2021/22	2026/27	
Cattle	4,780,656	5,020,750	5,253,252	0.9%
Buffalo	2,804,792	4,009,909	5,084,300	6.1%
Sheep	50,113	44,568	40,105	-2.2%
Goat	753,328	1,130,804	1,500,910	7.1%
Pig	584,984	833,737	1,074,608	6.3%
Yak/Nak	54,154	54,154	54,154	0.0%
Equine	75,417	75,417	75,417	0.0%
Fowl	551,529	890,116	1,298,499	8.9%
Duck	8,018	7,335	6,813	-1.6%
Cow milk, t	801,668	990,583	1,167,100	3.8%
Buffalo milk, t	1,694,497	2,389,770	3,105,757	6.2%
Fish, t	97,725	150,806	241,061	9.4%
Total	**12,256,882**	**15,597,950**	**18,901,976**	**3.8%**
Increase in TDN demand		**1.27**	**1.54**	

Source: Authors' estimate

Estimated near-future TDN supply: Estimates for TDN supply for the near future revealed that if the growth rate in crop production could be maintained as achieved during 2006/07 to 2016/17, the growth rate in TDN supply from crops will average at about 7% per annum (Table 15).

Table 15. TDN supply growth associated with advances in crop production

Major crop (supply in t)	TDN factor	2016/17	2021/22	2026/27	Compound annual growth rate
Paddy	0.415	2,169,683	3,777,258	5,384,184	9.5%
Maize	0.395	908,778	1,384,079	1,858,393	7.4%
Millet	0.416	127,589	151,317	174,083	3.2%
Wheat	0.452	849,157	1,267,748	1,679,011	7.1%
Barley	0.349	10,638	12,668	14,601	3.2%
Oilseed	0.532	114,088	219,080	323,872	11.0%
Total		**4,179,932**	**6,812,150**	**9,434,144**	6.9%

Source: Authors' estimate

With regard to TDN supply from forests, shrub lands, grass lands and barren lands, it is uncertain if the present land use pattern of the country will remain the same in the near future. Neither can we predict whether there will be any significant interventions on these lands for increased forage supply. In fact, accessibility to forests may even decrease due to closing of community and leasehold forests for animal grazing, or restriction on fodder collection. Therefore, for the present purpose of estimating the gaps and defining forage interventions, we assumed that the TDN supply from these resources will remain unchanged.

With regard to TDN supply from forage produced on-farm, the trend analysis of DLS fodder development data (2002/03 and 2016/17) indicated that the growth in TDN supply from cultivated fodder would average out at 6.1% per annum. Based on this, the future contribution of improved fodder and pasture in the total TDN supply may reach 12,198,850 t in 2021/22 and 14,642,212 t in 2026/27 (Table 16). This corresponds to about 1.5 times more TDN supply in 2026/27 than in the base year 2016/17.

Table 16. TDN supply projection by source

Sources of feed	Available TDN (t)		
	2016/17	2021/22	2026/27
Forest	2,070,334	2,070,334	2,070,334
Shrub land	177,021	177,021	177,021
Grassland	255,528	255,528	255,528
Crop and milling by-products	4,443,642	6,812,150	9,434,144
Farm forages/fodder (weeds)	1,526,792	1,526,792	1,526,792
Improved forages and pasture	694,749	695,280	695,810
Commercial silage	4,380	7,008	11,914
Barren area	92,081	92,081	92,081
Kitchen wastes*	359,000	287,200	57,440
Grain supplementation @2.5% of total TDN requirements in general	481,176	275,456	321,148
Total	**10,104,703**	**12,198,850**	**14,642,212**

Source: Authors' estimate

Estimated future feed balance: The summarization of data from Table 15&16 above indicates that TDN deficit would rise to 24.76% by 2021/22 and 26.05% by 2026/27. Minimization of these deficits is crucial for the livestock sector to play a role as one of the engines of social and economic growth in Nepal.

Table 17. TDN balance by Year

Details	2016/17	2021/22	2026/27
TDN Requirement (t)	12,256,882	15,597,950	18,901,976
TDN equivalent import by feed industries (t)	381,735	616,084	898,742
Total TDN requirements (t)	12,638,617	16,214,034	19,800,718
TDN Available (t)	10,104,703	12,198,850	14,642,212
Net deficit	-2,533,914	-4,015,184	-5,158,506
Overall Deficit (%)	-20.05%	-24.76%	-26.05%

CONCLUSION AND RECOMMENDATION

The above findings and discussion indicate that livestock are under-fed across the eco-zones and across the provinces, except Province Six. Over all TDN deficit stands at 20.05 %(-). By ecological belts, high hills seemed fairly in comfort zone in terms of TDN balance, and the mid hills at high feed pressure. Similarly, while Province Six is at positive balance, Province One and Three are at severe feed stress. This is a clear indication that the livestock feeds in Nepal are highly imbalanced. Livestock are under supplied during the winter, and the dry summer, irrespective of quality. In view of these observations, the following actions are recommended:

Prioritize the fodder and pasture crops:

There is a long array of fodder crops being promoted in the country. Giving equal emphasis to all fodder crops takes away not only the scarce resources, but also produces little outputs and impacts. The priority fodder crops could be the selected silage making crops, and winter growing with high productivity and high nutritional value.

Promote double and or triple fodder cropping:

The current practice of fodder cultivation are limited to Napier, Mulato II hybrid, teosinte, stylosanthes, and sorghum/sudan grass in the summer/rainy season, and oats, vetch, field peas and berseem in the winter, with their potentials to mix with legumes. Given the small landholding and shortage of feeds, particularly, during the winter and dry summer, there is a need of promoting double or triple fodder cropping systems for increased nutrient production per unit of land area. NARC and the universities should be working together to identify such fodder crops and develop cropping systems suitable for the hills and the terai.

Promote land leasing system:

Land is the limiting factor for fodder production. Therefore, the related stakeholders in the livestock sector should facilitate land leasing system for feed development. This could be achieved by working with the dairy farmers, their organizations and the local municipality through awareness raising on the value of balanced feeding e.g., (a) the value of green forage; and (b) limitations on the use of straws to dairy animals.

Implement massive forage/fodder production program in partnership with the silage making company/s and farmers' organizations:

Making silage at individual level may not be economical due to small farm sizes. Therefore, the development agencies engaged in livestock sector should support the private sector in order to develop feed marketing chains with an emphasis on silage production and marketing. While the silage making company would be important for taking responsibility of procurement of fodder from farmers and processing into silage and their marketing, the farmer associations, or dairy cooperatives can take responsibility of extension and marketing of silage.

Develop "fodder tree blocks" in the barren or uncultivated lands:

Fodder trees play crucial role in green matter supply during the winter and the dry summer months. Small landholders cannot plant fodder trees on their farmlands as they wish. However, the increasing area under private barren/ uncultivated lands is an opportunity for forage/fodder production intervention, particularly under dry land condition. These lands could be utilized under lease for fodder blocks development. Fodder trees could be planted in large blocks (more than 10 ropani=0.5ha) with priority to individual ownership.

Pasture development in the high hills should be accompanied with investment projects in the livestock sector:

The high-hills keep the highest potential for livestock production in the country due to its endowment with large tracks of rangelands. The carrying capacity of these rangelands could be further enhanced through appropriate management practices. For example, Grela (1990) reported that white clover could produce up to 9.5 t/ha (≈7.6 t TDN/ha) under good management system. Similarly, Pasture and Fodder Research Station Rasuwa (2016) reported that DM production from cocksfoot and perennial rye grass averaged 4.7 t/ha (≈2.77 tTDN/ha) and 4.58 t DM/ha (≈3.2 t TDN/ha), respectively, in the year 2015/16. These figures are significantly higher than the average production figure of 0.68 t TDN/ha in natural pasture. Therefore, it is possible to increase the pasture yields in the high hills significantly.

Support maize and soybean producers for increased production and productivity:

Since maize and soybean are the two major feed ingredients used by the feed industries largely by import, the government should promote quality production of these crops by support in: (a) variety selection/introduction; (b) promoting mechanization for the activities right from cultivation to harvesting and processing, and (c) development of storage facilities at cluster level. This is important in order to build national accounts and save foreign exchange at one hand, and ensuring sustainability of the industrial poultry sector in the other.

Emphasize on commercialization of smallholders

Replacement of local with improved breeds of cattle is an option to increase productivity in a climate smart way. This will require: (i) farmer education in livestock farm business management; (ii) community level infrastructure development (irrigation, farm roads, power supply, mechanization); (iii) quality milk products development and marketing; (iv) linking the smallholder dairy processors with ISO certified dairy industries; and (v) expanded quality technical services.

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