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India's Livestock Feed Demand: Estimates and Projections

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Abstract

The paper has estimated the feed consumption rates for different livestock species by age-group, sex, and function at the national level, and based on that the paper has generated demand for different types of feed by the year 2020. According to this study, by 2020 India would require a total 526 million tonnes (Mt) of dry matter, 855 Mt of green fodder, and 56 Mt of concentrate feed (comprising 27.4 Mt of cereals, 4.0 Mt of pulses, 20.6 Mt of oilseeds, oilcakes and meals, and 3.6 Mt of manufactured feed). In terms of nutrients, this translates into 738 Mt of dry matter, 379 Mt of total digestible nutrients and 32 Mt of digestible crude protein. The estimates of demand for different feeds will help the policymakers of the country in designing trade strategy to maximize benefits from livestock production.

Introduction

India has one of the largest livestock populations in the world[1], and one of its notable characteristics is that almost its entire feed[2] requirement is met from crop residues and byproducts; grasses, weeds and tree leaves gathered from cultivated and uncultivated lands; and grazing on common lands and harvested fields. Land allocation to cultivation of green fodder crops is limited and has hardly ever exceeded 5 per cent of the gross cropped area (GoI, 2009). Hence, the supply of feed has always remained short of normative requirement (GoI, 1976; Singh and Mujumdar, 1992; Ramachandra *et al*., 2007), restricting realization of the true production potential of livestock. For example, the actual milk yield of bovines is reported to be 26-51 per cent below the attainable yield under field conditions (Birthal and Jha, 2005), which otherwise could have been realized with better feeding, breeding and disease management. Birthal and Jha (2005) have found feed scarcity as the main limiting factor to improving livestock productivity.

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Reliable estimates of feed demand and supply are not available, though some attempts have been made in the past to estimate availability of different types of feed at the national level (GoI, 1974; Hazra and Rekib, 1991; Singh and Mujumdar, 1992; Pandey, 1995; Singh *et al*., 1997; Ramachandra *et al*., 2007). Most of these studies also generated estimates of nutritional requirement of livestock as to find the gap between feed availability and requirement. The availability of different feeds was assumed equal to their production; and production was assumed equal to actual consumption, thus enabling researchers to claim that the gap between availability and nutritional requirement is the gap between actual consumption and requirement. These assumptions, however, are unrealistic. First, availability of feed need not necessarily be equal to its production, as the availability may get affected by international trade, especially in the case of grains and oilcakes. Besides, feed availability is also affected by its non-feed uses. For instance, the paddy straw, otherwise a fodder for livestock, is used as packaging and thatching material, and as filler in particle boards. There is also an evidence of burning of paddy straw in some parts of the country (Sidhu *et al*., 1998; Gadde *et al*., 2009). Second, the actual consumption of feed could be equal to net availability (net of trade and non-feed uses), but after a time lag, as there are always

inventories or carry-over stocks from one year to the next year. Third, for official purposes, the Ministry of Agriculture assumes 5 per cent of the gross food grain production[3] as feed for livestock and poultry — a factor which is in use since the early-1950s when the country was facing acute food grain scarcity and agriculture was subsistence-oriented. Since then, Indian agriculture has grown tremendously. Food grain production has increased from 52 million tonnes (Mt) in 1951-52 to 230 Mt in 2006-07, and production of oilseeds from 5 Mt to 25 Mt. Livestock production has grown even faster; milk production has increased from 19 Mt to 100 Mt and the number of eggs from 1.9 billion to 47 billion. An allowance of 5 per cent of the gross production of food grains as feed, provides an estimate of 10.8 Mt for 2006-07, which given such a robust increase in livestock production, is obviously an underestimate.

With a few exceptions, no serious attempts have been made to estimate feed consumption rates at the household level, and to build from there an estimate of aggregate demand at the state, agro-ecological zone or country level. Amble *et al*. (1965) and Jain and Singh (1990) generated feed consumption rates for cattle and buffalo at the national level using data collected through pilot surveys by the Indian Agricultural Statistics Research Institute (IASRI) from mid-1950s to early-1980s. Their estimates, however, suffer from two weaknesses. First, the pilot surveys, from which the data was utilized, were not planned to estimate feed consumption rates at the national level. Second, these surveys were conducted at different points of time spread over a period of 30 years or so; hence feed consumption rates obtained by pooling data for such a long period are unlikely to represent neither the current nor the past feed situation unless the agricultural or livestock economy has remained static, which is unlikely.

In this paper, we have provided all-India estimates of feed consumption rates for different livestock species and their composition using data from a nationally representative household survey; and have built from there the estimates of demand for different types of feed. This study makes an important contribution towards understanding utilization of food grains as animal feed, the information on which is scarce and anecdotal. Further, these feed consumption rates can serve as benchmark for their periodic updating without recourse to regular surveys. The paper has been organized in six sections. The analytical approach, used to elicit information on feed consumption from households and generating feed consumption rates from these at the national level, is discussed in the next section. Estimates of all-India feed consumption rates, in terms of ingredients and nutrients, are provided in section 3. Section 4 provides estimates of total consumption of different types of feed, and the projected demands for different types of feed to 2020 are discussed in section 5. Concluding remarks are made in the last section.

2. Sampling Design and Analytical Approach

The paper made use of the data from a feed consumption survey undertaken as part of a larger project, '*India's livestock feed balance and its environmental implications*', funded by the Indian Council of Agricultural Research (ICAR) under the National Agricultural Technology Project (NATP), and carried out jointly by the National Centre for Agricultural Economics and Policy Research (NCAP) and the Society (now Centre) for Economic and Social Research (SESR), Delhi. The design of the feed consumption survey was developed at the SESR, which also carried out the survey. In the following paragraphs we have discussed sampling design and analytical approach followed in this study.

Delineation of Livestock Regions

India has considerable heterogeneity in topography, soils, rainfall, irrigation, temperature, crops and livestock production systems. Hence, for any survey to qualify as a nationally representative survey, it must take into account this heterogeneity. To ensure that survey estimates are representative of the national feed situation, a multistage sampling framework was adopted to generate the required information. The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) — an offshoot of the Indian Council of Agricultural Research, has mapped India's territorial space into 20 agro-ecological zones with their further classification into 60 sub-zones. However, for implementation of the survey, we have taken into consideration the topography, climatic conditions and cropping pattern of 60 sub-zones, re-organized these into 11 broad regions which we have called as 'livestock regions'. In doing so, it was ensured that a livestock region was contiguous. These regions are: Western Himalaya, North-West Plain, Eastern Plain, Central

Highlands, Eastern Plateau and Highlands, Deccan Plateau and Hills, Rajasthan-Gujarat Plains, Eastern Ghats, Western Ghats, Assam-Bengal Plain, and North-Eastern Highlands. Details on the territorial spread of each of these regions are provided in Annex Table I.

Sampling Design

The survey was conducted in 10 livestock regions, excluding North-Eastern Highlands. The sampling approach adopted was that of stratified multistage random sampling. From each livestock region, two districts[4] (one from some regions) were selected at random; and from each selected district, two villages were selected, again at random. A livestock census was conducted in each selected village as to know the ownership pattern of different livestock species. Having enumerated livestock-keeping households, a random sample of 20-25 livestock-keeping households was drawn from each village as to make up a total sample size of around 1000 households. Excluding un-surveyed zone, a total of 864 households were covered in the survey. In this paper, we could not utilize information from all the 864 households, because some households had to be dropped from the analysis due to incomplete and incorrect information. The data was collceted during 2001 and 2002.

Information related to the households and livestock holdings was collected from the heads of the households. Information that required measurement, e.g. amount of different types of feed to be fed to different categories of animals, by age-group, sex and function; and animal characteristics, e.g. body weight[5] was generated by investigators at the household premises. Investigators were required to weigh and record types of feed being fed to the animals twice a day, in the morning and evening, for one full year as to capture seasonality in feed consumption rates and their composition which is likely to vary because of the seasonality in production of different types of feed and also because of seasonal differences in the uses of livestock or their outputs. Considering that it was difficult to weigh and record different feeds every day, each household was revisited every fortnight for one year to collect this information.

Estimation Procedure

For generating information on feed consumption and other characteristics of livestock, all animals in the sample households were covered in the survey. The quantity of any type of feed fed per day per animal belonging to a particular category, say buffalo in-milk was estimated for the sample households.

Household level feed consumption provides a base to estimate feed consumption rates at the national level. The feed consumption rates at the national level were estimated applying scale-up factors at the levels of village, district and region. From the survey, we collected information on (i) number of sample households having livestock, say buffalo in-milk, (ii) number of buffaloes in-milk observed, and (iii) amount of feed fed per day to these buffaloes in-milk. Then, the problem was to scale-up (ii) and (iii) to the successive higher levels, that is to village, district, region and country levels. The procedure of scaling-up is described below, choosing in-milk buffalo as an illustration.

Village-level Aggregation

From the livestock census of each village, we had the total number of households having buffaloes in-milk. We obtained a scale-up factor for each village by dividing the total number of households having buffaloes in-milk by the number of sample households having buffaloes in-milk. We applied this factor to its sample estimates of (ii) and (iii) for each village.

District-level Aggregation

Scaling-up factor for the district was obtained by dividing the total number of villages in the district by the number of sample villages from that district. Consider any of the sample districts in a region. For sample villages falling within it, we had already generated aggregate estimates of (ii) and (iii), respectively. We summed up estimates of (ii) for the sample villages and multiplied this sum by the scale-up factor of that district to get district level aggregate of (ii). In the same way, we obtained district level aggregate of (iii). Likewise, we worked out aggregate estimates of (ii) and (iii) for the other sample districts in the region.

Region-level Aggregation

The scale-up factor for a region was obtained by dividing the number of districts in the region by the number of sample districts from that region. To obtain region-level aggregate estimates of (ii) and (iii), we

followed the same procedure as described for district-level aggregation. The district-level aggregates of (ii) for the sample districts were summed up; and this sum was multiplied by the scale-up factor to obtain region-level aggregate estimate of (ii). Likewise, by multiplying the sum of (iii), by the scale-up factor we obtained the regional aggregate estimate of (iii).

Estimation of Per Day Animal Feed Consumption

Region-level feed consumption rate for our illustrative animal category, buffaloes in-milk, was obtained by dividing the region's aggregate estimate of (iii) by the aggregate estimate of (ii). Note that (iii) stands for the quantity of feed fed per day and (ii) for the number of buffaloes in-milk. Buffalo in-milk is just an example animal, chosen for illustration. The procedure applies for any livestock category, any type of feed or any type of livestock output. Having estimated feed consumption rate for a livestock category at the regional level, the national level feed consumption rate was obtained as the weighted average of the regional feed consumption rates; the weight being region's population of that livestock category. The regional populations of different animal categories are aggregates of their district level populations for 2003 obtained from the 17th Livestock Census (GoI, 2005).

The above procedure estimates the feed consumption rate, excluding intake through grazing, for any livestock category. Direct estimation of feed intake through grazing is information-intensive and is difficult. Hence, to estimate feed consumption through grazing we followed a normative approach that specifies nutritional requirement of a livestock category in terms of dry matter (DM) as per its average body weight. All types of feed fed to an animal at the household premises were converted into dry matter equivalents, and then were summed up to obtain a single feed consumption rate. Using information on animal characteristics from the surveys and using Shaeffer's formula (as provided in Sastry *et al*., 1982), the body weight of different livestock categories was estimated to find their dry matter requirement for maintenance, production and reproduction (ICAR, 1997). For an animal of a specific body weight, the difference between its normative requirement of DM and the amount of DM intake at the household premises is the amount of DM coming through grazing. The dry matter intake through grazing was reconverted into green fodder equivalent.

3. Feed Consumption Rates

Conventionally, livestock feed is classified into roughages (green and dry fodders) and concentrates. Green fodder may come from (i) cultivated fodder crops, (ii) grasses, weeds and tree leaves gleaned and gathered from cultivated and uncultivated lands, and (iii) grazing on common lands and harvested fields. Similarly, dry fodder includes crop residues, most of which are cereal straws. Pulses and other legume crops like groundnut also contribute to dry fodder. Sources of dry fodder may include (i) cultivated crops, and (ii) roughages gathered from different sources. Concentrate feed includes (i) food grains and their preparations, such as flour and bread; and byproducts of milling and household processing, like husk, bran, khuddi/chunni (minutiae of broken grains not fit for human consumption), (ii) oilseeds, oil cakes and meals, and (iii) manufactured feeds.

Table 1 presents all-India feed consumption rates of different types of feed fed to different categories of livestock at the household premises. Per day mean consumption of green fodder was 5.96 kg for a buffalo in-milk, 5.44 kg for a dry buffalo, 4.06 kg for an adult male buffalo and 2.29 kg for a young one, average for heifers and calves. Corresponding consumption rate of dry fodder was 6.34 kg for a buffalo in-milk, 4.95 kg for a dry buffalo, 7.47 kg for an adult male buffalo and 2.22 kg for young stock. Consumption rate of concentrate feed, which is essential for animal's growth and production, was estimated as 1.05 kg for a buffalo in-milk, 0.52 kg for a dry buffalo, 0.36 kg for an adult male buffalo and 0.19 kg for a young one. These consumption rates, for any kind of feed, were lower for their counterpart categories of cattle, and the difference is larger in the case of in-milk and dry animals, especially for concentrate feed. There was hardly any difference in the feeding rates of young stock of buffalo and cattle. Feed consumption rates of different feeds were slightly higher for goats than for sheep.

Different types of feed contain different amounts of moisture, nutrients and energy contents; hence the feed consumption rates as raw material do not provide any definite indication regarding their appropriateness from the perspective of animal nutrition, and also their comparison across species and categories. Nutrient-equivalent rates are a composite measure of feed intake,

Table 1. Quantities of feed fed to different species within household premises: 2001-02

(kg/animal/day)

Animal category	Feed types			Nutrients		
	Green fodder*	Dry fodder	Concentrates	Dry matter (DM)	Total digestible nutrients (TDN)	Digestible crude protein (DCP)
Cattle						
In-milk	4.75	5.50	0.64	6.71	3.44	0.27
Dry	3.40	4.02	0.40	4.83	2.46	0.18
Adult male	4.06	6.03	0.33	6.74	3.36	0.21
Young stock	2.18	2.13	0.18	2.62	1.33	0.10
Buffalo						
In-milk	5.96	6.34	1.05	8.14	4.25	0.37
Dry	5.44	4.95	0.52	6.28	3.21	0.25
Adult male	4.04	7.47	0.36	8.06	3.99	0.24
Young stock	2.29	2.22	0.19	2.74	1.39	0.10
Goat	1.04	0.20	0.06	0.49	0.27	0.03
Sheep	1.01	0.20	0.04	0.46	0.24	0.03
Others**	2.35	6.72	0.49	7.08	3.54	0.22

Source: NATP project database

Notes: * includes cultivated fodder and the fodder gleaned and gathered from cultivated and uncultivated lands.
** includes camel, horse, donkey and mule.

and are comparable across species or their categories. Hence, dry fodder, green fodder and concentrate feed were converted into their nutrient equivalents as dry matter (DM), digestible crude protein (DCP) and total digestible nutrients (TDN) using their respective conversion factors (ICAR, 1997)[6].

The last three columns of Table 1 present consumption rates of DM, TDN and DCP for different livestock categories. Per day dry matter (DM) intake by a buffalo in-milk and a dry buffalo was estimated as 8.14 kg and 6.22 kg, respectively, which was higher by 21 per cent and 30 per cent over their respective counterparts of cattle. Intake of TDN and DCP was also higher in the case of in-milk and dry buffaloes. Also, the consumption rates of these nutrients were higher for adult male buffaloes than for adult male cattle. For adult males and in-milk cattle, consumption rates of all nutrients were almost similar. For adult buffalo males, these rates were lower than for in-milk buffaloes, but higher than those for dry buffaloes. Nutrient consumption rates for young stock of cattle and buffalo were almost the same. Note that, these consumption rates do not include nutrient intake through grazing.

Intake of feed through grazing, estimated by applying the procedure outlined in the previous section, is given in Table 2. DM requirement of different animal categories varied from 2.1 per cent to 2.7 per cent of their body weights. For every livestock category, DM required was more than that consumed at the household premises, and the difference between the two was the contribution of grazing. Accordingly, 5-15 per cent of the total DM intake in the case of large ruminants (except young stock of buffalo), and 19-26 per cent in the case of small ruminants was through grazing. Note that contribution of grazing to the total DM intake was the lowest for in-milk animals.

The feed consumption rates re-estimated after accounting for the intake through grazing, are presented in Table 3. The dry matter intake by an animal category is equal to its normative requirement at a specific body weight. Consumption rates of TDN and DCP also rose after taking into account the contribution of grazing. On raw material basis, the changes occurred in the consumption rates of green fodder. After accounting for intake through grazing, the per day per animal consumption of green fodder increased by 25-82 per cent in the case of cattle, and 49-166 per cent in the case of buffalo; the smallest increase being for in-milk animals and the largest for young stock. The contribution of grazing was substantial in the case of small ruminants and other livestock species.

Table 2. Estimated consumption of green roughages through grazing: 2001-02

(kg/animal/day)

Animal category	Average body weight (kg)	DM required as % body weight	Stall-fed DM as % of body weight	Quantity of DM received through grazing (kg)	Quantity of green fodder from grazing (kg)
Cattle					
In-milk	280	2.5	2.39	0.30	1.18
Dry	245	2.1	1.97	0.32	1.27
Adult male	278	2.7	2.42	0.77	3.07
Young stock	118	2.6	2.22	0.44	1.78
Buffalo					
In-milk	355	2.5	2.29	0.73	2.94
Dry	350	2.1	1.79	1.07	4.28
Adult male	327	2.7	2.46	0.77	3.09
Young stock	142	2.6	1.93	0.95	3.81
Goat	21	2.9	2.35	0.12	0.46
Sheep	23	2.7	2.00	0.16	0.65
Others	385	2.7	1.84	3.32	13.27

Source: NATP project database and authors' estimates

Table 3. Feed consumption rates including intake through grazing: 2001-02

(kg/animal/day)

Animal category	Nutrient			Feed types		
	Dry matter (DM)	Total digestible nutrients (TDN)	Digestible crude protein (DCP)	Green fodder	Dry fodder	Concentrates
Cattle						
In-milk	7.01	3.59	0.29	5.92	5.50	0.64
Dry	5.15	2.63	0.21	4.66	4.02	0.40
Adult male	7.50	3.76	0.27	7.12	6.03	0.33
Young stock	3.07	1.57	0.13	3.95	2.13	0.18
Buffalo						
In-milk	8.87	4.64	0.42	8.90	6.34	1.05
Dry	7.35	3.78	0.33	9.72	4.95	0.52
Adult male	8.82	4.40	0.30	7.11	7.47	0.36
Young stock	3.69	1.90	0.17	6.10	2.22	0.19
Goat	0.61	0.33	0.04	1.50	0.20	0.06
Sheep	0.61	0.32	0.04	1.65	0.19	0.04
Others	10.40	5.31	0.46	15.65	6.72	0.49

Source: NATP project database

This pattern of feed consumption was as expected. Feed consumption is influenced by animal's age, sex and function. Higher feeding rates for in-milk animals are because of their requirement of additional energy for production of milk and reproduction. Similarly, higher feeding rates for adult males are because they are used for strenuous agricultural operations like ploughing, sowing and transportation; and for breeding, which require more energy.

4. Demand for Feed

The estimated feed consumption rates though appeared to be small, total quantity of each type of feed when estimated for country's entire livestock

population turned out to be enormous. In 2003, India had 185 million cattle, 98 million buffaloes, 124 million goats and 62 million sheep, besides sizeable populations of other species. On multiplying the estimated feed consumption rates for different species (reported in Table 3) by their respective populations we arrived at a total consumption of 757 Mt of green fodder, 466 Mt of dry fodder and 47 Mt of concentrate feed in 2003 (Table 4).

Bulk of the feed, as expected, was consumed by bovines. Cattle accounted for around half of the green fodder and concentrate feed, and 62 per cent of the dry fodder. Of the total quantities fed to cattle, milch cows (in-milk and dry) accounted for around 35 per cent of the green fodder, 39 per cent of the dry fodder and 53 per cent of the concentrate feed. Buffaloes consumed about 37 per cent of the green roughages, 34 per cent of the dry fodder and 42 per cent of the concentrate feed. Over 61 per cent of the green fodder, 70 per cent of the dry fodder and 81 per cent of the concentrate feed that went into buffalo production system were consumed by milch buffaloes. Share of small ruminants was 14 per cent in green fodder, 3 per cent in dry fodder and 8 per cent in concentrate feed.

Table 4. Total consumption of feeds and fodders in India: 2003

(in Mt)

Animal category	Population (million)	Green fodder	Dry fodder	Concentrates
Cattle				
In-milk	35.8	77.4	71.9	8.4
Dry	28.7	48.8	42.1	4.2
Adult male	57.6	149.7	126.8	6.9
Young stock	63.1	91.0	49.1	4.1
Total	185.2	366.8	289.8	23.6
Buffalo				
In-milk	33.3	108.2	77.1	12.8
Dry	17.6	62.4	31.8	3.3
Adult male	6.7	17.4	18.3	0.9
Young stock	40.3	89.7	32.7	2.8
Total	97.9	277.7	159.8	19.8
Goat	124.4	68.1	9.1	2.7
Sheep	61.5	37.0	4.3	0.9
Others	1.2	6.9	2.9	0.2
Grand total	**470.2**	**756.6**	**465.9**	**47.3**

Source: Estimated using information in Table 3

Households obtained feed supplies from different sources. Almost the entire quantity of dry fodder came from the cultivated crops, mainly from cereals as straws. Gathered dry fodder comprised only 2 per cent of the total. Of the 757 Mt of green fodder consumed by livestock, about 40 per cent (302 Mt) came from grazing, and the rest from cultivated fodder crops (27%), and grasses, weeds and tree leaves gleaned and gathered from cultivated fields and uncultivated lands such as pastures, public lands, wastelands, fallows and forests (33%).

Table 5 shows the demand for different types of concentrate feed, viz. (i) cereals and cereal preparations, (ii) pulses and pulses preparations, (iii) oilseeds, oilcakes and meals; and (iv) manufactured feed. Of the total 47.3 Mt of concentrate feed consumed by livestock, cereals comprised 22.8 Mt, pulses 3.9 Mt and oilseeds, oilcakes and meals 17.6 Mt. Manufactured feed comprised 2.9 Mt.

Table 5 also shows the composition of concentrate feed fed by livestock species. Cattle shared approximately half of the total concentrate feed, and buffaloes 42 per cent. Such information is important from the perspective of animal nutrition, and also for planning production/supply of different feed ingredients.

Feed intake in terms of nutrients is presented in Table 6. In 2003, a total of 651 Mt of dry matter (DM) went into India's livestock production system, of which 64 per cent came from dry fodder, 29 per cent from green fodder and 7 per cent from concentrates. Consumption of total digestible nutrients (TDN) was estimated at 334 Mt, of which 60 per cent was derived from dry fodder, 30 per cent from green fodder and the rest from concentrates. Consumption of digestible crude protein (DCP) was 28 Mt, to which green fodder contributed 49 per cent, dry fodder 24 per cent and rest came from concentrates.

How credible are our estimates of feed demand? In 2003, India produced 88.1 Mt of milk, 5.9 Mt of meat and 2.2 Mt of eggs. For producing such a huge amount, the feed requirement would have also been huge; hence our estimates of feed demand appear to be reasonable. Unlike other researchers who estimated the availability of feed based on assumptions of grain to straw ratios, crop yields and fixed proportion of food grain production as feed, our estimates of feed demand have been built upon the actual feed consumption rates

Table 5. Composition of concentrate feed: 2003

(in Mt)

Species	Cereals	Pulses[1]	Oilseeds and oilcakes[2]	Manufactured feed[3]	Total
Cattle	11.64	1.71	8.74	1.55	23.64
Buffalo	7.82	2.10	8.54	1.31	19.78
Goat	2.24	0.11	0.37	0.01	2.72
Sheep	0.90	0.00	0.00	0.00	0.90
Others	0.19	0.00	0.00	0.02	0.21
Total	22.79	3.92	17.65	2.89	47.25

Source: NATP project database

Notes: [1]Also include guar and guar products

[2]Also include cakes of other than 9 major oilseeds for which statistics was officially recorded, and meal of rice bran.

[3]Includes feeds from both organized and unorganized sectors.

Table 6. Feed demand in terms of dry matter and nutrients: 2003

Nutrient	Total (Mt)	Percentage share of		
		Green fodder	Dry fodder	Concentrates
Dry matter (DM)	650.8	29.1 (11.6)	64.4	6.5
Total digestible nutrients (TDN)	333.7	30.3 (12.1)	59.8	9.9
Digestible crude protein (DCP)	28.2	49.0 (19.6)	23.8	27.2

Note: Figures within the parentheses are shares of grazing in total nutrient consumption.
Source: Authors' estimates

derived from nationally representative household surveys. To provide further credence, we examined the feed consumption estimates, mainly for food grains, and their estimation procedures from some other studies.

In order to estimate the net availability of food grains for human consumption, the Ministry of Agriculture, Government of India deducts 12.5 per cent from the gross food grain production, which comprises 5 per cent for seed, 5 per cent for feed and 2.5 per cent for wastage. These norms have not been revised since these were first employed in the early-1950s. As per this norm, an estimated 10.3 Mt of food grains went into livestock production in 2003. Note that, Indian agriculture has grown significantly during the past six decades and this has definitely contributed towards increased availability of food grains as animal feed. Industrial uses of food grains too appear to have increased, which are not accounted for in the overall allowance of 12.5 per cent assumed for official purposes. With these considerations, the National Commission on Agriculture has recommended raising of the overall allowance of food grains to 19 per cent (GoI, 1976).

Chand (2007) and Kumar *et al*. (2009) have estimated demand for food grains, as food and non-food (seed, feed, wastages and industrial uses). Taking a fraction of 9.5 per cent of the production of rice, 13.5 per cent of wheat, 41 per cent of coarse cereals and 16.9 per cent of pulses, Kumar *et al*. (2009) have estimated the non-food demand for food grains at 34 Mt in 2004-05 — 31.7 Mt of cereals and 2.3 Mt of pulses. On the other hand, Chand (2007) has estimated non-food demand for food grains as residual after deducting the household demand from the total supply, and has put it at 45.5 Mt — 41.1 Mt of cereals and 4.4 Mt of pulses. These studies have provided the estimate of aggregate demand for food grains for non-food purposes without segregating it as seed, feed, wastage and industrial uses.

Coarse cereals are used for food as well as feed. Their demand as food, however, has declined considerably during the past two decades, reaching 13.7 Mt in 2004-05 (Kumar *et al*., 2009). During 2003-05,

India produced on an average 35.5 Mt of coarse cereals, and had a net trade surplus of 0.8 Mt. On adjusting for food demand, trade and seed (0.4 Mt), we were left with 21 Mt of coarse cereals available for use as feed and other purposes (Annex Table 2). It may be noted that industrial uses of coarse cereals, except maize, are limited. Hence, we may infer that a sizable proportion of coarse cereals are utilized as feed in livestock and poultry production. Besides, other food grains and their byproducts such as bran, khuddi/chunni, etc. are also used as animal feed.

Sarma and Gandhi (1990) have estimated the demand for food grains as livestock feed using a feed conversion ratio — defined as the amount of feed required to produce one unit of livestock output. Having converted different outputs into 'livestock output units' assuming one-tenth of the milk output as equal to one unit of meat or eggs, and a feed conversion ratio of 2.4:1, they have projected feed demand to 2000 to range from 21.8 Mt to 34.5 Mt under different income growth assumptions. These estimates of feed demand, however, suffer from an important weakness that is, these were estimated only for the animals that were utilized for producing milk, meat and eggs, and ignored the feed consumption by the adult males and young stock. Note that, India has over 64 million adult males and 103 million young stocks of cattle and buffalo, whose feed requirement is huge.

In 2003, India produced 5.9 Mt of meat (including 1.7 Mt of poultry meat), 2.2 Mt of eggs and 88.1 Mt of milk, which are equivalent to 17 Mt of 'livestock output units', as defined by Sarma and Gandhi (1990). Using the same feed conversion ratio (2.4:1) as used by Sarma and Gandhi, we estimated a total consumption of 40.7 Mt of food grains for use as animal feed. On deducting 9.2 Mt of feed for poultry (meat and eggs) from this, the balance 31.5 Mt are used by livestock alone; and note that this amount does not include feed consumption by draught animals and young stock which we have estimated at 15 Mt in this paper. Adding feed consumed by draught animals and young stock to the total feed consumed by milch and meat animals estimated using feed conversion approach, provided a total feed demand of 46.5 Mt, which is very close to our survey-based estimate of 47.3 Mt.

Sarma and Gandhi (1990) have projected the demand for feed grains to 2000 under different income growth assumptions, that is 1.6 per cent, 3.1 per cent, 3.8 per cent and 5.1 per cent per annum. During 1990-91 to 2003-04, India's per capita income grew at an annual rate of 4.0 per cent, which is slightly higher than the assumed growth rate of 3.8 per cent by Sarma and Gandhi. At this rate of growth, they projected feed grain demand at 29.1 Mt for the year 2000, while our estimates of demand for concentrate feed for 2003 were 47.3 Mt, comprising 22.8 Mt of cereals, 3.9 Mt of pulses, 17.6 Mt of oilseeds, oilcakes and meals and 2.9 Mt of manufactured feed.

The purpose of looking at the estimates of feed demand reported by others is to show that hardly there exists any credible estimate of feed demand. These vary widely according to the assumptions made; and lack a sound empirical basis. Our estimates of feed demand are built upon the actual feed consumption rates obtained from a nationally representative household survey; hence are more credible and can serve an important input in agricultural and livestock policy. These provide an empirical basis for (i) understanding input-output relationships in livestock production, (ii) planning livestock development commensurate with feed availability, (iii) generating estimates of income from livestock for national accounts statistics, and (iv) preparing national food balance sheet more accurately.

5. Feed Demand to 2020

There are two main approaches to project future estimates of feed demand. First, the feed conversion approach as used by Sarma and Gandhi and discussed in the previous section. This approach, however, is information-intensive. It requires projected demand for livestock products, and feed conversion ratios for each type of livestock product. Multiplying the projected demand for livestock products by their respective feed conversion ratios yields the amount of feed required to produce the projected demand for these products. In India, livestock are raised on crop residues and byproducts, and feed conversion ratio for each type of feed and product is difficult to get. Further, livestock are multi-functional, used not only to produce food but also to provide draught services. This approach is suitable for estimation of feed demand for animals that produce food, and ignore feed consumption by animals that are used for providing services. Estimation difficulties also arise in using this approach because of

non-differentiation of livestock production systems by the type of function. For example, buffaloes are primarily valued for milk, but young males and unproductive she-buffaloes are also utilized for meat production.

The second approach is to project populations of different categories of animals and multiply the projected populations with their respective base year feed consumption rates to obtain the total consumption of different types of feed. A major weakness of this approach is its strong assumption of unvarying feed consumption rates and their composition over time, which is unlikely to hold in the long-run. In the short-run, feed consumption rates and their composition may not change much; hence short-run demand projections can be built upon using base year feed consumption rates. We have used this approach to project feed demand to 2020, and have tried to overcome 'the assumption of static feeding rates' using the following procedure. First, we have projected populations of different categories of livestock to 2020 using their past trends[7] for the period 1982-2003 (Table 7). Then, by multiplying the projected populations of different animal categories with their respective feeding rates we have obtained future demand for different types of feed. Accordingly, by 2020 India would require 494 Mt of dry fodder, 825 Mt of green fodder and 54 Mt of concentrate feed.

The past sources of growth in livestock production indicate that while growth in milk production came from both increases in the number of animals as well as their yield, growth in meat production was mainly number-driven (Birthal *et al*., 2006). Thus, we expected a change in the projected feed demand by dairy animals. Through number-driven growth we got an estimated 122 Mt of milk production by 2020. Note that the demand for milk by 2020 has ben estimated as 135-156 Mt (Delgado *et al*., 2001; Parthasarathy Rao and Birthal, 2008). Nonetheless, if the past milk production trends were to continue, India will produce 137 Mt of milk by 2020, which is sufficient to meet the minimum of the projected demand. This is about 15 Mt more than that estimated through number-driven approach. This additional quantity of milk will come from yield improvements and not from the increase in numbers.

To estimate the quantity of feed required to produce additional 15 Mt of milk through yield improvements, we assigned this amount to cows and buffaloes in proportion of their share in total milk produced in 2003. Accordingly, 6.5 Mt of additional milk supply will come from cows and the rest from buffaloes. TDN and DCP requirement to produce one kg of cow milk with 4 per cent fat is 0.315 kg and 0.045 kg, respectively. For producing one kg buffalo milk of 6 per cent fat, the TDN and DCP requirements are 0.410 kg and 0.057 kg, respectively. Thus, to produce 15 Mt of milk, India will require additional 5.4 Mt of TDN and 0.8 Mt of DCP. Assuming that feed composition will remain unchanged in future, the additional amount of TDN and DCP was converted into their raw material equivalents that is green fodder, dry fodder and concentrate feed. Adding these quantities to the quantities obtained through the number-driven growth, we got the total demand for different types of feed. Thus, by 2020, India would require a total 526 Mt of dry fodder, 855 Mt of green fodder, and 56 Mt of concentrate feed — comprising 27.4 Mt of cereals, 4.0 Mt of pulses, 20.6 Mt of oilseeds, oilcakes

Table 7. India's livestock feed demand to 2020

(in Mt)

Animal category	Population (million)	Green fodder	Dry fodder	Concentrates
Cattle				
In-milk	42.9	103.4	98.1	10.7
		(11.0)	(12.1)	(0.7)
Dry	27.0	46.3	39.6	3.9
Adult male	44.5	115.3	97.9	5.4
Young stock	71.2	104.0	55.4	4.7
Total	185.6	369.0	291.0	24.7
Buffalo				
In-milk	45.0	164.8	124.6	18.4
		(18.7)	(20.4)	(1.1)
Dry	21.6	76.5	39.0	4.1
Adult male	6.9	17.9	18.8	0.9
Young stock	40	89.1	32.4	2.8
Total	113.5	348.2	214.8	26.2
Goat	156.6	85.7	11.4	3.4
Sheep	73.8	43.1	5.1	1.1
Others*	1.6	9.1	3.9	0.3
Total	**531.2**	**855.1**	**526.3**	**55.7**
		(29.7)	**(32.5)**	**(1.8)**

Notes: Figures within the parentheses are quantities of feed required to produce additional milk through yield improvements.

Source: Authors' estimates

and meals, and 3.6 Mt of manufactured feed. In terms of nutrients, this translates into 738 Mt of dry matter, 379 Mt of total digestible nutrients and 32 Mt of digestible crude protein.

6. Conclusions and Implications

In this paper, we have estimated the feed consumption rates for different livestock species by age-group, sex and function at the national level, and based on that we have generated demand for different types of feed. In 2003, India's livestock consumed 757 Mt of green fodder, 466 Mt of dry fodder and 47 Mt of concentrates. Since there is hardly any reliable information on feed consumption rates and feed demand, these estimates can serve an important input into policy making. For official purposes, 5 per cent of the gross production of food grains is set aside as animal feed while estimating their net availability for human consumption. In the present times, this allowance appears to be an underestimate given the level of food grain production as well as of livestock production in the country.

The results of this study can be of considerable importance to policymakers. First, the estimates of demand can help resolve the controversy regarding utilization of food grain used as feed, which vary widely, depending on the assumptions made. These estimates will provide a sound basis for determining the input-output relations for the livestock sector, which can be used by the Central Statistical Organization (CSO) for estimation of the Gross Domestic Product (GDP) from the livestock sector. It may be noted that at present the CSO uses feed availability rather than actual consumption for the purpose of estimating income from livestock sector. Second, India's livestock sector being one of the largests in the world has come under scrutiny of the international environmental agencies for its greenhouse gas emissions. Available estimates of greenhouse gas emission for India's livestock are based on default rates, as provided by the Inter-Governmental Panel on Climate Change (IPCC). The emission of greenhouse gases depends on the quantity and quality of feed consumed. In this study, we have generated feed consumption rates, which can be used to estimate greenhouse gas emissions in a more scientific manner. Third, trade in concentrate feed like maize and soybean has assumed a greater importance. Estimates of demand for different feeds will help the policymakers in designing trade strategy to maximize benefits from livestock production. Fourth, given the current policy emphasis on use of grains as bio-fuel, outputs of crops like maize, rapeseed and soybean are likely to be diverted towards production of bio-fuels, and hence availability of credible estimates of feed demand can help policymakers plan their production and utilization accordingly. Finally, the feeding practices do not change in the short-run, and the estimated feeding rates can serve as benchmark which can be updated periodically to estimate the feed demand without recourse to annual surveys.

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End Notes

[1] According to the FAO estimates, India in 2007 had 16.6 per cent of world's large ruminants (277 million), 9.9 per cent small ruminants (190 million), 3.0 per cent poultry (560 million) and 1.5 per cent pigs (14 million).

[2] We have used the word 'feed' in a broad sense to represent roughages and concentrates.

[3] In order to derive net availability of food grains for human consumption, the Ministry of Agriculture, Government of India, keeps aside 12.5 per cent of the gross foodgrain production as seed, feed and wastage. This comprises 5 per cent for seed, 5 per cent for feed and 2.5 per cent for wastage. These allowances were estimated in 1951 and have not been revised since then.

[4] In the Central Highlands and Assam-Bengal Plains, the survey was conducted in one district only.

[5] To estimate body weight, we obtained information on animal's girth and length, which were then fitted into Shaeffer's formula to generate average body weight of the animals. The formula is: $W= (L G^2)/300$; where, W is the weight in pounds, and G and L are the girth and length of the animal in inches, respectively.

[6] Green fodder, dry fodder and concentrate feed were converted into dry matter (DM) applying a factor of 0.25 for green fodder and 0.90 for dry fodder and concentrate feed. The factors for conversion of DM from each source into TDN were taken as 0.534 for green fodder, 0.476 for dry fodder and 0.780 for concentrate feed. The factors for conversion of DM from each source into DCP were 0.073, 0.016 and 0.180 for green fodder, dry fodder and concentrate feed, respectively. These fractions are the weighted averages of their contents in different types of feeds and fodders.

[7] Livestock population was projected using linear and log-linear trends depending on their best fit.

References

Amble, V.N., Murty, V.V.R., Sathe, K.V. and Goel, B.B.P.S. (1965) Milk production of bovines in India and their feed availability. *Indian Journal of Veterinary Science*, **35**(3): 221-238.

Birthal, P.S. and Jha, A.K. (2005) Economic losses due to various constraints in dairy production in India. *Indian Journal of Animal Sciences*, **75**: 1476-1480.

Birthal, P.S., Taneja, V.K. and Thorpe, W. (Eds) (2006) *Smallholder Livestock Production in India: Opportunities and Challenges*. National Centre for Agricultural Economics and Policy Research, New Delhi, India and International Livestock Research Institute, Nairobi, Kenya.

Chand, R. (2007) Demand for food grains. *Economic and Political Weekly*, **42**(52): 10-13.

Delgado, C., Rosegrant, M.W. and Meijer, S. (2001) Livestock to 2020: The revolution continues. Paper presented at the *Annual Meeting of the International Trade Research Consortium (IARTC)*, Auckland, New Zealand, 18-19 January. Available at http://www.ilri.org/ILRI_Dev/misc-pdf/delgado.pdf.

FAOSTAT: http://faostat.fao.org/default.aspx. Food and Agriculture Organization, Rome.

Gadde, B., Bonnet, S., Menke, C. and Garivait, S. (2009) Air pollutant emissions from rice straw open field burning in India, Thailand and the Philippines. *Environmental Pollution*, **157**(5): 1554-1558.

GoI (Government of India) (1974) *Report of the Committee on Livestock Feed and Fodder*. Ministry of Agriculture, New Delhi.

GoI (1976) *Report of the National Commission on Agriculture*. Part 3, *Demand and Supply*. Controller of Publications, New Delhi.

GoI (2005) *Seventeenth Livestock Census, 2003*. Ministry of Agriculture, New Delhi.

GoI (2006) *Level and Pattern of Consumer Expenditure, 2004-05*. Report No. 508(61/1.0/1). National Sample Survey Organization, Ministry of Statistics and Program Implementation, New Delhi.

GoI (2008) *Agricultural Statistics at a Glance.* Ministry of Agriculture, New Delhi

GoI (2009) *Year-wise Area under Crops — All India*. Available at: http://dacnet.nic.in/eands/LUS-2006-07/Summary/tb3.13.pdf.

Hazra, C.R. and Rekib, A. (1991) A forage production scenario in the country — A national perspective in technology development and transfer. *Agricultural Situation in India*, **46**(7): 581-588.

ICAR (Indian Council of Agricultural Research) (1997) *Nutrient Requirement of Livestock and Poultry*. 2nd edition. Indian Council of Agricultural Research, New Delhi.

Jain, J.P. and Singh, S. (1990) Qualitative and quantitative insufficiency of livestock feed by 2001 AD and possibilities of bridging gap. *Indian Journal of Animal Science*, **60**(10): 1224-1229.

Kumar, P., Joshi, P.K. and Birthal, P.S. (2009) Demand projections for food grains in India. *Agricultural Economics Research Review*, **22**: 237-243.

Pandey, U.K. (1995) The livestock economy of India: A profile. *Indian Journal of Agricultural Economics*, **50**(3): 264-282.

Parthasarathy Rao, P. and Birthal, P.S. (2008) *Livestock in Mixed Farming Systems in South Asia*. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India; National Centre for Agricultural Economics and Policy Research, New Delhi, India, and International Livestock Research Institute, Nairobi, Kenya

Ramachandra, K.S., Taneja, V.K., Sampath, K.T., Anandan, S. and Angadi, U.B. (2007) *Livestock Feed Resources in Different Agro-ecosystems of India: Availability, Requirement and their Management*. National Institute of Animal Nutrition and Physiology, Bangalore.

Sarma, J.S. and Gandhi, V. (1990) *Consumption and Production of Food grains in India. Implications of Accelerated Economic Growth and Poverty Alleviation*. Research report No. 81. International Food Policy Research Institute, Washington DC.

Sastry, N.S.R., Thomas, C.K. and Singh, R.A. (1982) *Farm Animal Management and Poultry Production*, Fifth edition. Vikas Publishing House, New Delhi.

Sidhu, B.S., Rupela, O.P., Beri, V. and Joshi, P.K. (1998) Sustainability implications of burning rice and wheat straw in Punjab. *Economic and Political Weekly*, **33** (39): A163-A168.

Singh, K., Habib, G., Siddiqui, M.M. and Ibrahim, M.N.M. (1997) Dynamics of feed resources in mixed farming systems of South Asia. In: *Crop Residues in Sustainable Mixed Crop/Livestock Farming Systems*, Ed: C. Renard. CAB International, Wallingford, UK/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Patancheru, India/ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 113–130.

Singh, P. and Mujumdar, A.B. (1992) Current status of feed and forage management of livestock in India. *Agriculture Situation in India*, **47**(5): 375-382.

Annex Table 1

Livestock regions delineated for implementation of the surveys

Sl No.	Name of the region	Name of the states or their parts covered
1	Western Himalaya	Jammu & Kashmir, Himachal Pradesh and Uttarakhand
2	North-West Plain	Punjab, Haryana and Western parts of Ganga-Yamuna Plains
3	Eastern Plain	North Bihar and part of South Bihar, Northern part of Awadh Plains (Eastern and Central Uttar Pradesh)
4	Central Highlands	Part of Madhya Pradesh, part of Maharashtra and part of Uttar Pradesh (Bundelkhand)
5	Eastern Plateau and High Lands	Part of Madhya Pradesh, part of Bihar, part of Andhra Pradesh, Orissa, part of Maharashtra, Mirzapur district of Uttar Pradesh, part of West Bengal
6	Deccan Plateau and Hills	Karnataka, Tamil Nadu, part of Andhra Pradesh
7	Rajasthan- Gujarat Plains	Rajasthan, Gujarat, excluding southern part
8	Eastern Ghats	Part of Tamil Nadu, part of Andhra Pradesh, part of Orissa, part of Pondichery, part of West Bengal
9	Western Ghats	Kerala, southern part of Gujarat, adjoining districts of Karnataka, adjoining districts of Maharashtra, Nilgiri district of Tamil Nadu, Daman and Diu, Andaman & Nicobar, Goa and part of Pondichery
10	Assam-Bengal Plain	Assam, part of West Bengal
11	North-Eastern Highlands	Sikkim, Arunanchal Pradesh, Nagaland, Meghalaya, Manipur, Mizoram and Tripura

Annex Table II

Utilization pattern of coarse cereals in India: 2003-05

Crop	Supply			Utilization		
	Production[1]	Net trade[2]	Total supply	Food[3] 2004-05	Seed[4]	Other uses, mainly feed
Sorghum	6.96	0.02	6.94	4.86	0.09	1.99
Pearl millet	10.02	0.08	9.94	4.07	0.04	5.83
Maize	14.58	0.71	13.87	3.02	0.15	10.70
Other coarse cereals	3.98	0.00	3.98	1.71	0.09	2.19
Total coarse cereals	35.54	0.81	34.73	13.65	0.36	20.72

Sources: [1]GoI(2008); [2]FAOSTAT; [3]GoI(2006); [4]Estimated using a seed rate of 10kg/ha for sorghum, 4kg/ha for pearl-millet, 20kg/ha for maize and 25 kg/ha for other coarse cereals.