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Environmental value of dung in mixed crop-livestock systems*

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ABSTRACT

Dung is an important byproduct of livestock. It is used as manure, or is converted into dung cakes for use as fuel or mixed with clay for flooring and plastering of mud houses. Apart from these important uses of dung, it also has a great environmental value. Its contributions to environment could be positive as well as negative. From the negative side, methane emission from manure management is a negative environmental externality. The positive externality is the use of dung cake as domestic fuel, which can be seen as a substitution or replacement of the equivalent amount of thermal energy from fuel-wood or fossil-fuel. It is a great saving on fuel-wood by cutting down of standing forests and trees, and another is the saving of land that is required to produce replacement amount of fuel-wood for dung cake. In the present paper we have estimated the quantity of fuel-wood that would be required to replace dung-cake as domestic fuel, and the land area that would be required to produce or supply that amount of fuel-wood. At current feeding rates, India produces over 83 million tonnes of dry dung-cake, which is used annually by the rural households as domestic fuel for cooking and warming. If this amount of dung cake was to be replaced by fuel wood, the country will require producing an additional amount of 23.5 million tonnes of fuel-wood, and the additional land requirement for fuel-wood plantation will be about 2.35 million ha. From the perspective of food production, supposing that under traditional rainfed agriculture food grains yield ranges from 1.5 to 2 tonnes/ha, the land saved would produce 3.5 to 5 million tonnes of foodgrains.

Key words: Dung fuel, Environment, Land saving

India is endowed with huge livestock population. In 2003, it had over 464 million livestock heads. This vast number is deployed primarily to produce food (milk and meat), fibre (wool) and energy for work. However, in the process of food production some byproducts or joint products are also produced. These are urine and dung, and in ruminants, methane, a greenhouse gas from fermentation of feed in their rumen. There are several other residual products like hides and skins, bone, hair, horn and hoof, tallow and offals that have industrial uses.

Dung is an important byproduct of livestock. It is used as manure, or is converted into dung cakes for use as fuel or mixed with clay for flooring and plastering of mud houses. According to scientific studies on organic manures, dung used as manure contains on an average 0.35% nitrogen, 0.15% phosphoric acid and 0.20% potash (Anonymous 1966). More importantly, only about 35, 65 and 75% of the available N,P,K, respectively, from the manure are absorbed by the first crop after application (Garg *et al.* 1973), and the rest are available to subsequent crops as residual effects. A study on biomass energy makes known that in 1988–89 the total production of biomass energy was 24,438 PJ (Peta Joules), the share of agriculture, forestry and livestock to the total biomass energy were estimated to be 49, 34 and 17% respectively (www.iccept.ic.ac.uk).

Apart from these important uses of dung, it has a great environmental value. Its contributions towards environment are positive as well as negative. From the negative side, methane emission from manure management is an environmental externality. The positive externality is the use of dung cake as a domestic fuel which can be seen as a substitution or replacement of the equivalent amount of thermal energy from fuel-wood or fossil-fuel. It is a great saving on fuel-wood in terms of avoiding cutting of standing forests and trees, and another saving that is implicit is the saving in the land that is required to produce replacement amount of fuelwood. Many studies focused on production and utilization

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of the dung (Goel *et al*. 1973, Garg *et al*. 1971, CSO, 1993,1996). So far, the issue of environmental contribution of dung had not received any attention in the empirical studies. Some important studies are critically reviewed are as follows. The Central Statistical Organization (CSO) has its own state-wise dung evacuation rates per cattle and per buffalo and also dung utilization rates for manure and fuel. These rates in conjunction with the projected number of cattle and buffalo are used to calculate annual dung output and output values of manures and dung cake for purposes of estimating national income. The drawback with these estimates is that these rates are old, and do not include evacuation rates of livestock other than bovine species. Goel *et al.* (1972) estimated national dung production and its disposal for the year 1966, utilizing data collected through sample surveys for estimation of milk production, and found that dung evacuation and disposal rates vary from season to season and from state to state. The disposal rates of dung also depend upon climate, cultivation practices, availability of firewood, etc. and standards of living of rural population. The disposal rates of dung for dung cake were 13% in rainy season and 40% in winter. However, its utilization as manure was 85% during rainy season and 58% during winter. Mishra and Dikshit (2004) worked out national dung production for the year 1992. To get one figure they have estimated dung evacuation rates for different categories of bovines by taking care of feed fed per animal per day in terms of TDN.

There are some weaknesses of these evacuation rates. First, these are, based on the assumption that there is a same mean evacuation rate for both cattle and buffalo (Mishra and Dikshit 2004), hence there is a marginal overestimation of dung production from cattle and marginal underestimation for buffaloes. Further, most of these estimates relate only to bovines, excluding dung production from other animals. In the light of these observations, we planned to focus on estimation of dung production, utilization, and its environmental value in terms of resource saving i.e. fuel wood and land. This study is a part of a larger study 'India's Livestock Feed Balance' conducted by the authors. We carried out an all-India sample survey on livestock feed consumption rates, dung evacuation rates, dung utilization and several other characteristics during 2002–2003. The dung related statistics in conjunction with the population of ruminants and other supplementary information were utilized to estimate environmental impact of dung in India.

MATERIALS AND METHODS

To carry out surveys under this larger study on *India's Livestock feed Balance*, entire country was classified into 11 livestock regions on the basis of typography, climatic conditions and cropping pattern. This exercise was carried out with the help of a far more sophisticated exercise done by the National Bureau of Soil Survey (NBSS&LUP), Nagpur. In the present paper only all India estimates of dung production, its utilization and environmental impacts have been provided. No regional estimates have been included in this study.

Approach

Sample survey: The sampling for the survey was conducted by stratified multistage random sampling. Of 11 livestock regions, survey was conducted in 10 regions. Two districts were selected at random from each region for implementation of the survey. And, from each selected district, 2 villages were selected at random. From each selected village level, 24 households were selected at random with the proviso that the selected households must have one or another species of livestock. To capture seasonal variations each sample household was revisited at an interval of 15 days particularly for repeated measurement of feed fed to animals. To collect information on several other characteristics like bodyweight, dung production and its utilization, etc. the investigator visited sample households once in each season. All animals, irrespective of species, belonging to the sample household were covered in the survey.

Estimation procedure: For any characteristics, say dung production per animal per day belonging to a particular category, say buffalo-in-milk, was estimated for each of the 10 livestock regions in which the survey was carried out. And, its national average was obtained as a weighted average of the regional averages, the weights being the regional populations of the animals in the particular category, say population of buffalo-in-milk for example. The dung not collected in the households, i.e. evacuated out in grazing lands, on road-side or elsewhere, was excluded from the study, because this is not available to the households for use.

An *Environmental Model of Livestock Production System* (Mishra and Dikshit 2004) was used to assess environmental implications of dung. The impact is the resource (land) saving due to dung use as a domestic fuel. The model is a static one. All the variables and parameters involved relate to a point of time, a particular year. We have used livestock population as enumerated for the year 2003. The effect of gestation lag in the production of fuel-wood can be described as follows: The model assumes that the fuel wood is produced and used within the same year. This is apparently an unrealistic assumption. We all know that time is an essential feature of bio-mass growth. And, in reality more than one year's time is required to cover the whole process of fuel-wood tree plantation, growth and logging of trees, drying and use of cut-out wood as fuel. Suppose it takes 3 years to complete the process, before dry wood is made available for use at the end of the third or the beginning of the fourth year. This means that whereas the fuel wood made available can replace equivalent amount of energy from dung cake only in the fourth year, the necessary land area required for growing and harvesting of trees for making the fuel wood available will have to be kept locked up during the preceding 3 years. This implies that 3 times as much land will be required or saved if year's dung cake output was to be

replaced by fuel wood. This stock-flow conversion relationship is illustrated in Table 1,which was generated under the following assumption: (i) the gestation lag between planting and harvesting of fuel-wood is 3 years, (ii) the fuel-wood yield is 30 tonnes/ha given the fertility of land and density of planting.

RESULTS AND DISCUSSION

Estimates of production of dung: Information on the number of bovines and the per animal per day average dung production of animals (evacuation rates) was utilized to estimate total dung production from bovines in India. The national average per animal dung production (Table 1) was obtained as a weighted average of the regional averages, the weights being the regional populations of the animals in the particular category. Evacuation rates of bovines according to their age, sex and function are given in Table 1.

Dung evacuation rates (dung production per animal per day) varied considerably across species, age-groups and functional classification of bovines. Production of dung per animal per day largely depends upon quantity of feed intake and type of feed. Physiological and environmental factors also affect per animal per day dung production. Therefore, it is difficult to give any interpretation to the variation that exists in the evacuation rates shown in Table 1.

The total wet dung production for the year 2003 was estimated at about 562 million tonnes. Species-wise share in total dung production shows a contribution of 60% by the cattle, and obviously as cattle have a larger share in total bovine population. Share of buffaloes in total dung production is 40%. But, on individual basis, evacuation rate per day was higher for buffaloes than for cattle.

Utilization pattern of dung in India: In the absence of season-wise dung utilization statistics, we have dung utilization information from the Central Statistical Organization (CSO).

Table 1. Dung production by different categories of bovines, 2003

Categories	Evacuation rate (kg/day)	Population (million)	Dung production (million tonnes)	% Share in total dung produced
Cattle				
In-milk	6.63	35.80	86.63	25.78
Dry	6.58	22.30	53.56	15.94
Adult male	4.46	57.60	93.77	27.91
Young stock	4.43	63.10	102.03	30.37
Total		178.80	335.99	59.79
Buffalo				
In-milk	8.35	33.30	101.49	44.91
Dry	8.49	13.90	43.07	19.06
Adult male	6.65	6.70	16.26	7.20
Young stock	4.43	40.30	65.16	28.83
Total		94.20	225.99	40.21
Grand total		273.00	561.98	100.00

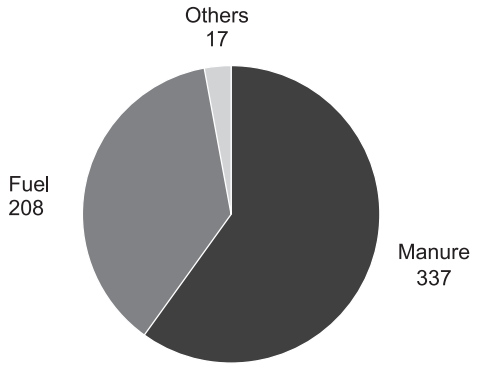

Fig. 1. Utilization pattern of dung in India, 2003 (million tonnes)

About 37% of the total wet dung production in country is utilized for fuel. The rest about 60% is being utilized as manure and roughly 3% is used for other purposes like plastering of mud houses etc. (Fig. 2). About 337 million tonnes dung is used as manure, and about 208 million tonnes dung is used as domestic fuel in the form of dung cakes. A little quantity of bovine dung, about 17 million tonnes goes for other uses of the households.

Environmental value of dung: Land saving: In the present section, environmental value of bovine dung has been estimated in terms of natural resource saving that is tree resources and land. The rate of weight loss in the process of drying dung cake was taken from CSO statistics on dung output. The other relevant parameters are furnished in Table 2.

Fuel-wood yield from fuel-wood plantation and harvesting are given in Table 3. These are based on the actual experience of some specific projects in Gujarat (Patel 1985). Patel (1985) reported that the yield was over 100 tonnes/ha under what he calls 'green revolution condition'. What he meant was intensive plantation practices with close planting, irrigation and application of high doses of chemical fertilizers. Under rainfed conditions without fertilizers the yield was estimated as 30 tonnes/ha. The gestation period in both cases was 3 years. We

Table 2. Dung output and relevant parameter values

Particulars	Values
Total production of wet dung (million tonnes) in 2003	562.0
The proportion of wet dung utilized for fuel (%)	36.81
Rate of weight loss during drying of dung cake (%)	39.99
Replacement rate of fuel wood for dung cake in terms of thermal energy	1: 3.539
Yield of fuel wood (tonnes/ha)	30
Gestation lag between planting and harvesting of fuel wood tree (years)	3

Source: Central Statistical Organization for the proportion of wet dung utilized for fuel (%) and the rate of weight loss during drying of dung cake. Khadi and Village Industries Commission (1983) for replacement rate of fuel wood for dung cake in terms of thermal energy. Patel (1985) for yield of fuel wood and gestation lag.

Table 3. Land saving due to dung use as domestic fuel

Particulars	Values
Dry dung cake output (million tonnes)	83
Fuel-wood required to replace dung cake (million tonnes)	23.5
Land area required to produce fuel-wood with 3 year gestation lag (million ha)	2.35

accumulation,' whose environmental value cannot be gauged in economic terms. Looked at from an economic angle, and supposing that under traditional rainfed agriculture foodgrains yield ranges from 1.5 to 2 tonnes/ha, land saved would account for about 3.5 to 5 million tonnes of foodgrains output.

India's livestock sector, being one of the largest in the world, has increasingly come under international scrutiny for its greenhouse gases emission. Nonetheless, livestock also

Table 4. Land required for annual fuel wood flow tree plantation

	Time period							
Items	T-3	T-2	T-1	T0	T1	T2	T3	T4
Land planted by fuel wood saplings (ha)	1	1	1					
		1	1	1				
	–	–	1	1	1			
	–	–	–	1	1	1		
	–	–	–	–	1	1	1	
	–	–	–	–	–	1	1	1
Total land occupied during any year (ha)	1	2	3	3	3	3	3	3
Annual flow of fuel wood output (metric tonnes)	0	0	0	30	30	30	30	30

have used yield under rainfed conditions since this is what corresponds with normal farming practices in the country.

Farmers generally grow fuel wood trees under rainfed conditions along field boundaries and on lands not suitable for intensive cultivation. The equivalence ratio between dung-cake and fuel wood in terms of thermal energy is taken from Khadi and Village Industries Commission (KVIC 1983). According to this 3.539 kg of dung cake is required to replace 1.0 kg of firewood.

Using the parameter values given in Table 2 we have computed, the quantity of fuel-wood that would be required to replace dung-cake as domestic fuel, and the land area that would be required to produce or supply that much fuel-wood (Table 3).

At the current rates of feeding and the feed composition, India produces over 83 million tonnes of dry dung-cake, which is used annually by rural households as domestic fuel for cooking and warming. If this amount of dung-cake was to be replaced by fuel-wood, India is required to produce an additional amount of about 23.5 million tonnes of fuel-wood, and additional land requirement for fuel-wood plantation will be 2.35 million ha.

For India, with increasing population pressure on the almost fixed supply of arable land, this is indeed a great saving. This land must be an important source of 'natural bio-mass capital generates positive externalities to the environment such as land saving due to dung used as domestic fuel; or for that matter, land saving that may be due to recycling of agricultural by-products as animal feed, or greenhouse gases emission prevented by use of manure in place of chemical fertilizers, besides conservation of soil-born microorganisms.

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