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Reducing methane emission through management of cattle population and grass land—A case study in different regions of Maharashtra

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ABSTRACT

Agriculture contributes about 20% of global greenhouse gases (GHGs). Among the agricultural processes, ruminant livestock emits the highest amount (59%) of GHG through enteric fermentation which needs reduction through maintaining optimum size of animal population as per carrying capacity of the grazing land (GLS) available in the region, apart from endeavoring development of concentrated feed stock. While estimating the emission potential of the animal population of Maharashtra, mathematical model for computing desired level of animal population at carrying of presently available GLS of regions namely Konkan, western Maharashtra, Marathwada and Vidarbha, has been developed. The high correlation coefficient of the developed models will help to estimate optimum size of ruminants in different regions as per carrying capacity of GLS at different methane emission level. The result also indicates that the highest GHG emission (5176.44 lakh kg/annum) occurs in Western Maharashtra, followed by Vidarbha and Marathwada. Although Vidarbha ranks second highest in methane emission, the need for reduction of animal population in percentage terms is the lowest due to non-over saturation of carrying capacity of GLS. The highest percentage reduction (60%) is needed for western Maharashtra as the area of the available GLS is less to support the present over size of ruminants.

Key words: Grazing land, Methane emission, Modeling

Agricultural sector contributes 20% of global GHGs emission. The land use changes play important role in emission of GHG (Lal 2001). Sources in agricultural sector for GHG emission are low-land rice cultivation, livestock, and burning of residue, soil organic and inorganic carbon loss. Livestock mainly ruminants, emit methane and nitrous oxide. GHGs emission occur in 2 ways (i) through enteric fermentation of ruminants as the ruminant animal possesses fore-stomach which is used for digestion of cellulosic and other roughages.Fermentation of green matter in ruminant animals, under anaerobic condition results in production of hydrogen, which is taken up by methanogenic bacteria to reduce carbon dioxide into methane. The process of manufacturing organic manure using cow dung under anaerobic condition generates significant quantity of methane,(ii) the nitrous oxide from animal waste is formed when urine is stored in pot holes and nitrified and denitrified in the ranged land or in stables. The major GHGs emission sector from enteric fermentation is estimated to be about 59 per cent. The emission of nitrous oxide as compared to the methane gas is in the ratio of 9 : 1 (Swamy and Bhattacharaya 2006).Therefore, in computing GHGs emission only methane emission is considered. In India, GHG contribution comes from crossbred cattle, indigenous cattle, buffalos, goats and sheep and other livestock (mule, yak, camel, donkey, pigs, mithun, horse and pony) to the tune of 4.6, 48.5, 3.9, 4.7, 1.8 and 1.4 respectively. Among the states, Uttar Pradesh followed by Madhya Pradesh and Bihar contribute the most of the GHGs emitted from animal sources (Singhal *et al.* 2005).

In Maharashtra, according to the livestock census 2003, there are 16.07 lakh cattle, 5.74 lakh buffalo, 3.12 lakh sheep and 10.27 lakh goats, which are contributing substantial quantity of GHGs in the atmosphere. Many attempts have been made to estimate the methane emission from livestock in various parts of the country (Singh1998, Garg and Shukla 2002). But attempt has not been made to estimate the spatial variation of methane emission from ruminants in different regions of Maharashtra namely Konkan, Western Maharashtra, Marathwada and Vidarbha. The present study is an attempt to estimate the desired number of ruminants to be maintained as per the carrying capacity of the grazing land in different regions of Maharashtra. This is required for assessing the reduction in total methane emission. If the numbers of ruminants in different regions of the state are

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brought down to the level as recommended by the carrying capacity of the grazing land, then there is considerable scope to reduce the methane emission from the ruminants. This will also help to develop mathematical models for each region to estimate the optimum number of ruminant population based on the carrying capacity of the available GLS.

MATERIALS AND METHODS

On the basis of fodder consumption, the Forest Department of Rajasthan, while preparing its action plan for the period 1996–2016, has done computation of livestock in terms of cow unit by adopting the following conversion factors 1 camel = 4 cows; 1 buffalo = 2 cows; 1 horse/pony/donkey/mule = 1 cow; and 1 sheep/goat = 0.25 cows

Based on the above criteria, all the animals as per 2003 livestock census of Maharashtra are converted into equivalent cow units and total cow units for districts occurring in each region have been estimated for feed availability as well as for methane emission from anaerobic fermentation in digestion.

Department of Animal Husbandry and Dairying, Ministry of Agriculture, Government of India, in its report on National Commission on Cattle (July, 2002) has estimated the carrying capacity of cattle unit as per the above conversion unit for different types of grazing lands as mentioned below.

i.	Permanent posture and grazing lands	2 cow units/ha
ii.	Land under tree crops and groves	1 cow unit/ha
iii.	Land under fodder crops such as *jowar*, *bajra* etc	3 cow units/ha
iv.	Forest land suitable for grazing (excluding 25% core area)	1 cow unit/ha
v.	Land under foodgrain crops- wheat, barley, paddy etc.	½ cow unit/ha

Using above criteria the optimum number of cow units for each region has been estimated as per the carrying capacity of grazing lands.

Considering the average methane emission @ 35.97 kg/cow unit/year for indigenous breed (Singhal *et al.* 2005), the total methane emission from the cattle units for each region was computed. Only 70% of the total population of young animals of cattle and buffaloes (in the age group of 0–1 year) was considered in young calves (0–3 months) due to non-functioning of rumen (Singhal *et al.* 2005). Similarly, kids of lambs (0–2 months old) also do not produce methane. However, total population of other categories of livestock was taken for methane emission estimation.

RESULTS AND DISCUSSION

GLS and ruminant livestock density: GLS and livestock density per hectare of GLS in different regions of Maharashtra (Table 1) indicated that in 1982 the ruminant livestock density per hectare of GLS was the highest (1.86 animal/ha) in the Konkan region, followed by 1.40 in western Maharashtra. The ruminant livestock density in 2003 was insignificantly reduced from 1.86 to 1.83 in Konkan region, whereas in all other regions the livestock density in 2003 increased as compared to 1982. In both the periods, the livestock density is the lowest in Vidarbha region, indicating the sign of income diversification from sole agriculture.

Present and optimum cattle population: Present and optimum cattle population as per the carrying capacity of the grazing land for different regions is shown in Table 2. The highest cattle population (143.91 lakh) in cow unit equivalent was in the Western Maharashtra, followed by 74.22 lakh in Vidarbha. The highest optimum cattle population in cow unit equivalent of 56.93 lakh as per carrying capacity of grazing land was in the Western Maharashtra, followed by Vidarbha with 56.37 lakh cattle population.The present cattle population in all the regions was higher than the estimated optimum cattle population as per the carrying capacity of the grazing land. It is worth noticing that the present cattle population in cow unit equivalent in all the regions are higher from 24.05% in Vidarbha to as high as 60.44% in Western Maharashtra.

Methane emission from present and optimum cattle unit: Methane emission from the present and optimum cattle population in cow unit equivalent for the regions of Maharashtra is presented in Table 3. Present methane emission from the cattle population of the Konkan, Western

Table 1. Grazing land, and ruminant livestock per ha of grazing land in different regions of Maharashtra in 1982 and 2003

Regions	1982			2003		
	Grazing land (lakh ha)	Ruminant livestock (lakh)	Ruminant livestock density per ha of grazing land	Grazing land (lakh ha)	Ruminant livestock (lakh)	Ruminant livestock density per ha of grazing land
Konkan	14.56(6.11)	27.02(8.84)	1.86	14.49(6.37)	26.58(7.53)	1.83
Western Maharashtra	91.61(38.42)	127.99(41.88)	1.40	91.25(40.11)	167.49(47.44)	1.84
Marathwada	53.16(22.29)	64.45(21.09)	1.21	45.64(20.06)	74.73(21.17)	1.64
Vidarbha	79.14(33.18)	86.12(28.19)	1.09	76.14(33.46)	84.26(23.86)	1.11
Maharashtra	238.47(100.00)	305.58(100.00)	1.28	227.52(100.00)	353.06(100.00)	1.55

* Data in parenthesis indicate percentage of total land and livestock taking Maharashtra as 100.

Table 2. Present and optimum cattle population in cow unit equivalent as per carrying capacity of grazing land in different regions of Maharashtra

(Lakh)

Region	Present cattle population	Optimum cattle population	% reduction required
Konkan	28.47(9.18)	11.49(7.46)	59.64
Western Maharashtra	143.91(46.42)	56.93(36.96)	60.44
Marathwada	63.40(20.45)	29.25(18.99)	53.86
Vidarbha	74.22(23.94)	56.37(36.59)	24.05
Maharashtra	310.00(100.00)	154.04(100.00)	50.31

Table 3. Methane emission from present and optimum cattle population in different regions of Maharashtra

(Lakh kg)

Region	Present cattle population	Optimum cattle population	% reduction required
Konkan	1024.07	413.30	59.6
Western Maharashtra	5176.44	2043.80	60.4
Marathwada	2280.50	1050.09	53.8
Vidarbha	2669.69	2023.69	24.0
Maharashtra	11150.70	5540.85	50.31

Maharashtra, Marathwada and Vidarbha was estimated to be 1024.07, 5176.44, 2280.50 and 2669.69 lakh kg, respectively. The estimated methane emission from the optimum cattle population as per the carrying capacity of grazing land for different regions is much lower than the methane emission from the present cattle population in cow unit equivalent. The problem of methane emission is more severe in Western Maharashtra, Konkan and Marathwada as the methane emission from the present cattle population is higher by 60.44, 59.64 and 53.86% than the methane emission from the optimum cattle population estimated as per the carrying capacity of the grazing land.

The mathematical relations between the carrying capacity of GLS and the present cattle population in cow unit equivalent of all the 4 regions of Maharashtra are shown in the Table 4. The data indicates that non- linear relationship is obtained for optimum cattle population at carrying capacity and present cattle population with high correlation co-efficient of 1.0 for Konkan region followed by western Maharashtra, Vidarbha and Marathwada with R^2 values of 0.864, 0.751 and 0.737 respectively. These relationships will help in maintaining optimum cattle population as per available GLS.

Reduction in cattle population for environmental management: The above analysis revealed that there is a need for drastic reduction ranging from 24.05% to 60.44% in the present cattle population in different regions of Maharashtra to bring it to optimum level as per carrying capacity of the grazing land to maintain methane emission level at a sustainable limit. It is not possible for such drastic reduction in cattle population within a short span as it may have severe economic consequences. There is a need to formulate a long-term strategy for periodical reduction of cattle population in the different regions to maintain the methane level at a controllable limit in the atmosphere. There may be a thought of the long term strategy of reducing 10% of present cattle

Table 4. Cattle population at different methane emission reduction level

Region	Present cattle population in cow unit equivalent (lakh)	Reduction in methane emission (%)				
		10%	20%	30%	40%	50%
Western Maharashtra	28.47	25.62	22.78	19.93	17.08	14.24
Marathwada	143.91	129.52	115.13	100.74	86.35	71.96
Vidarbha	63.40	56.44	50.72	44.38	38.04	31.70
Maharashtra	74.22	66.80	59.38	51.95	44.53	37.11
Maharashtra	310.00	278.38	248.01	217.00	186.00	155.01

Table 5. Mathematical models

Regions of Maharashtra	Proposed models X=ruminant nos. at present.Y= ruminant nos. at carrying capacity level of available GLS	Regression coefficient (R^2)
Konkan	$Y= 21.139–11.558X+1.902X^2–0.087X^3$	1.00
Western Maharashtra	$Y=610086–19818X+2555.6X^2–63.72X^3+5.211X^4–0.066X^5$	0.864
Marathwada	$Y= –98.011+35.93X–4.688X^2+0.271X^3–0058X^4$	0.737
Vidarbha	$Y=17800–143226X+4642.2X^2–792.01X^3+74.604X^4–3.6837X^5+0.0746X^6$	0.7512

population in every decade. The estimated cattle population at a reduction level at 10, 20, 30, 40 and 50% reduction within a span of next 50 years in different regions is shown in Table 5. It is seen that by reducing the cattle population by 10% in every 10 years, it is possible to bring down the cattle population to optimum level within the next 50 years, i.e. by 2060. Such a long term strategy if followed may not have any adverse affect on the economy as there will be sufficient time for long-term planning to compensate the milk, and meat production loss and economic loss to ancillary industries accrued due to the reduction in the number of cattle population.

Methane emission from livestock population in cow unit equivalent was 11150.70 lakh kg from enteric fermentation in the calendar year 2003. Amongst, the different regions, methane emission was the highest in Western Maharashtra, followed by Vidarbha and Marathwada due to the large cattle population. As per the carrying capacity of grazing land, the optimum cattle population should be around one-third of the present population in the different regions. If the present population can be brought down to the level of estimated optimum cattle population, estimated as per the carrying capacity of grazing land by following long term strategy, methane emission can be reduced substantially in the environment. The mathematical relations between the optimum cattle population as per the carrying capacity of grazing land will have a radical effect in bringing down GHGs, for better environment.

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