GHG Platform INDIA

Major Emitting Sources from Livestock and Aggregate Sources and Non-CO2 Emissions from Land:

Trends in India and Mitigation Opportunities

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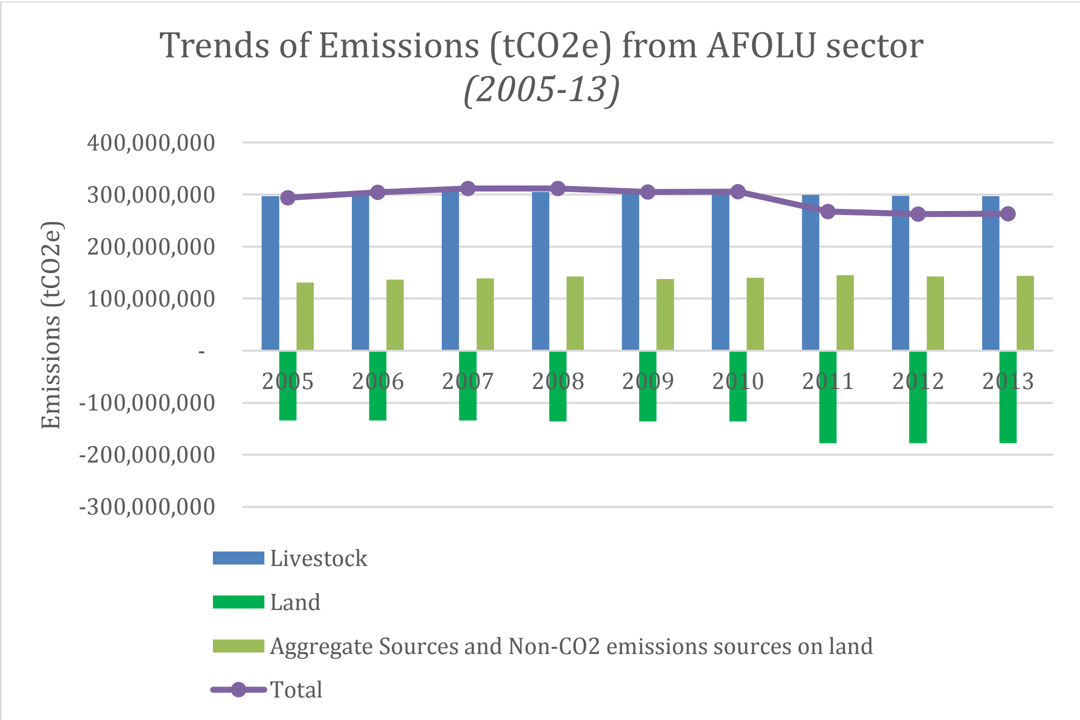
According to estimates of the GHG emissions from Agriculture, Forestry and Other Land Use (AFOLU) calculated by the GHG Platform – India from 2005 to 2013, the three major subsectors viz. Livestock, Aggregate Sources and Non-CO2 Emissions from Land, and Land had the following profile:

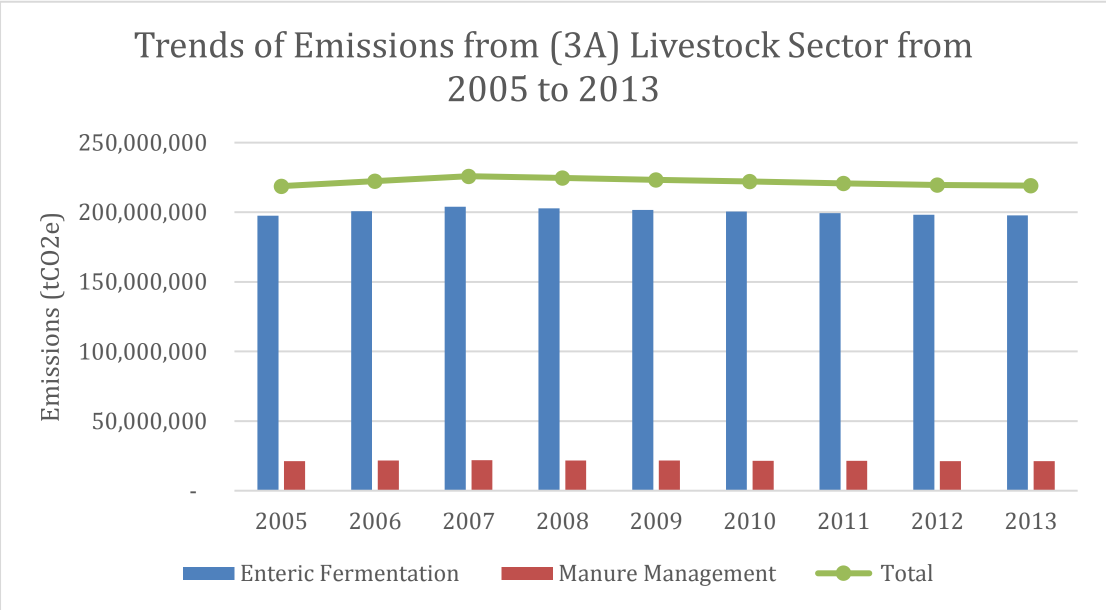
	2005 (GHG Emissions in CO2 equivalent GWP calculated as per AR2 in million tonnes)	2013 (GHG Emissions in CO2 equivalent GWP calculated as per AR2 in million tonnes)
Livestock	222.87	223.12
Aggregate Sources and Non-CO2 Emissions from Land	112.88	126.91
Land	-134.03	-177.73



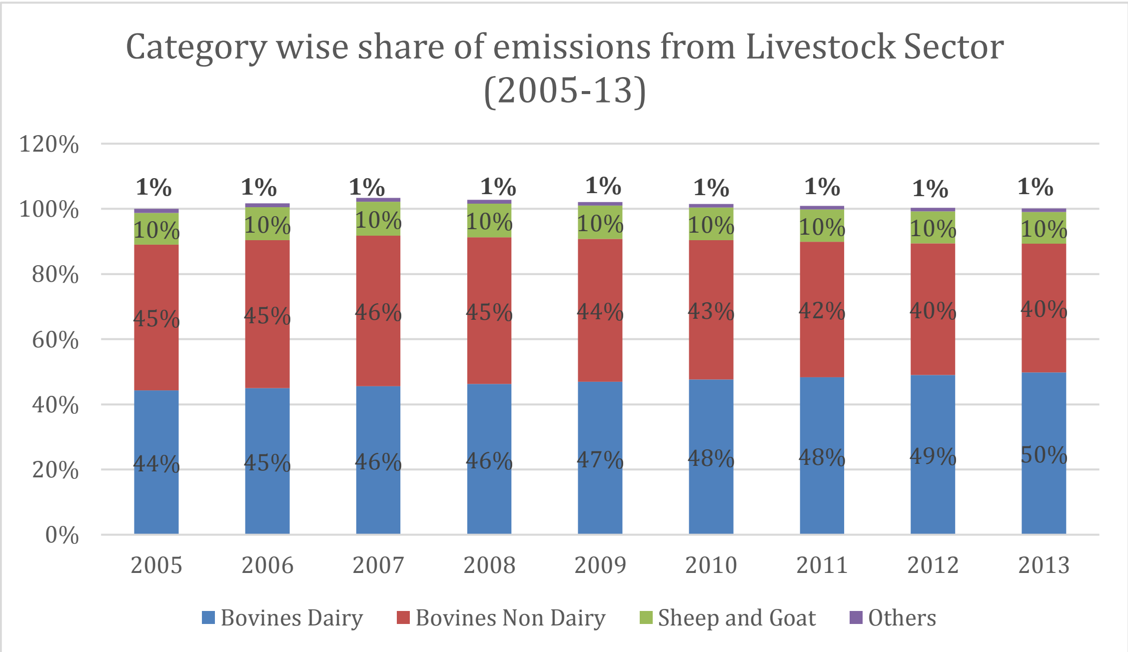
As can be seen, from the table and the accompanying graph, emissions from the livestock sub-sector contribute the maximum quantity of GHGs to the atmosphere. The contribution of this sub-sector was 223.12 million tonnes of CO2 equivalent in 2013. The other emitting sub-sector viz. Aggregate Sources and Non-CO2 Emissions from Land contributed around 50% of the emissions from the livestock sector i.e. 126.91 million tonnes of CO2 equivalent in 2013. The third sub-sector i.e. Land, is a net sink rather than a source of emissions, and was removing 177.73 million tonnes of CO2 from the atmosphere, amounting to around 51% of the positive emissions emanating from this sub-sector. In this discussion, we focus on the two major emitting sub-sectors of AFOLU, viz. Livestock and Aggregate Sources and Non-CO2 Emissions from Land.

Livestock

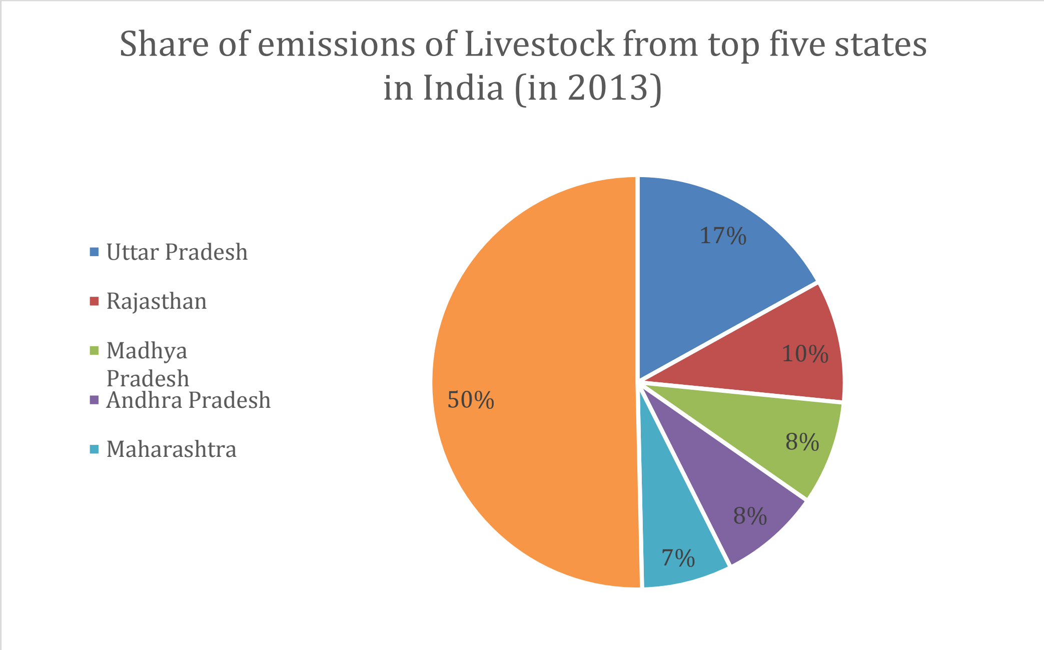
Within the Livestock sub-sector, the two categories of emissions are enteric fermentation and manure management. Of the two, enteric fermentation is by far the dominant contributor of GHG emissions, accounting for around 90% of the emissions from this sub-sector. In 2013, for instance, of the total GHG emissions of 223.13 million tonnes CO2 equivalent from livestock, 201.91 million tonnes of CO2 equivalent arose due to enteric fermentation. The graph placed below shows the trends of emissions from the livestock sector from 2005 to 2013.



Further, within enteric fermentation, the relative share of bovines, both dairy and non-dairy animals to the overall emissions emanating from the livestock sub-sector is around 90% of all emissions from this sub-sector, as shown in the graph below.

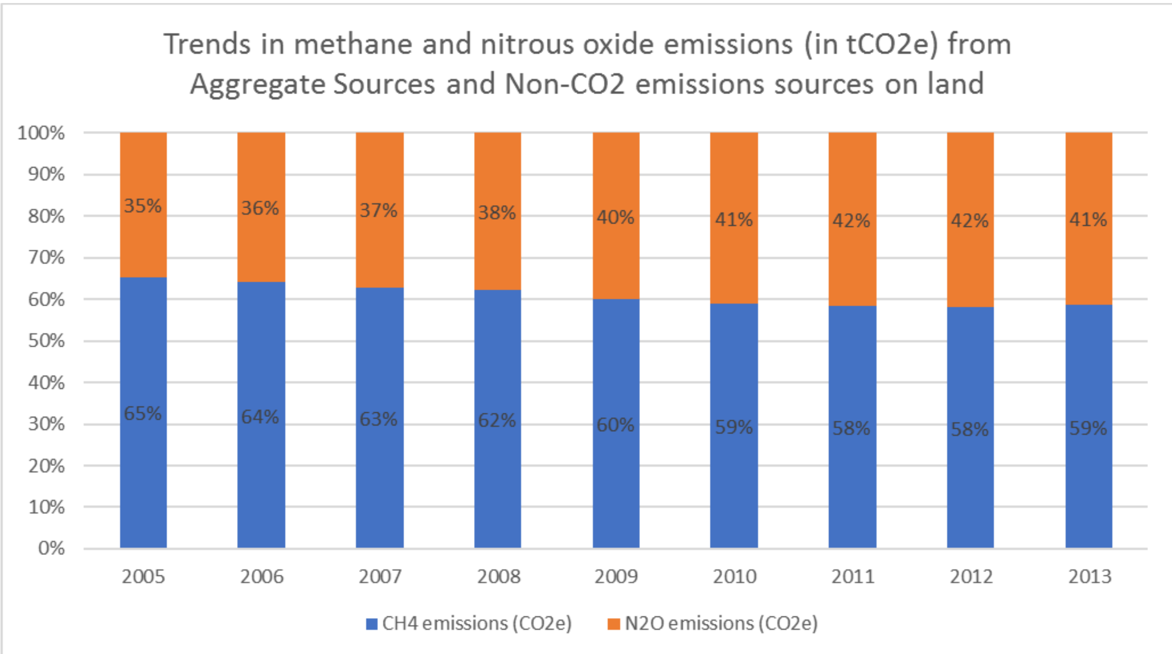


Spatially, the top 5 contributors among states to emissions from the Livestock sector account for 50% of India's emissions, as is shown in the graph below:

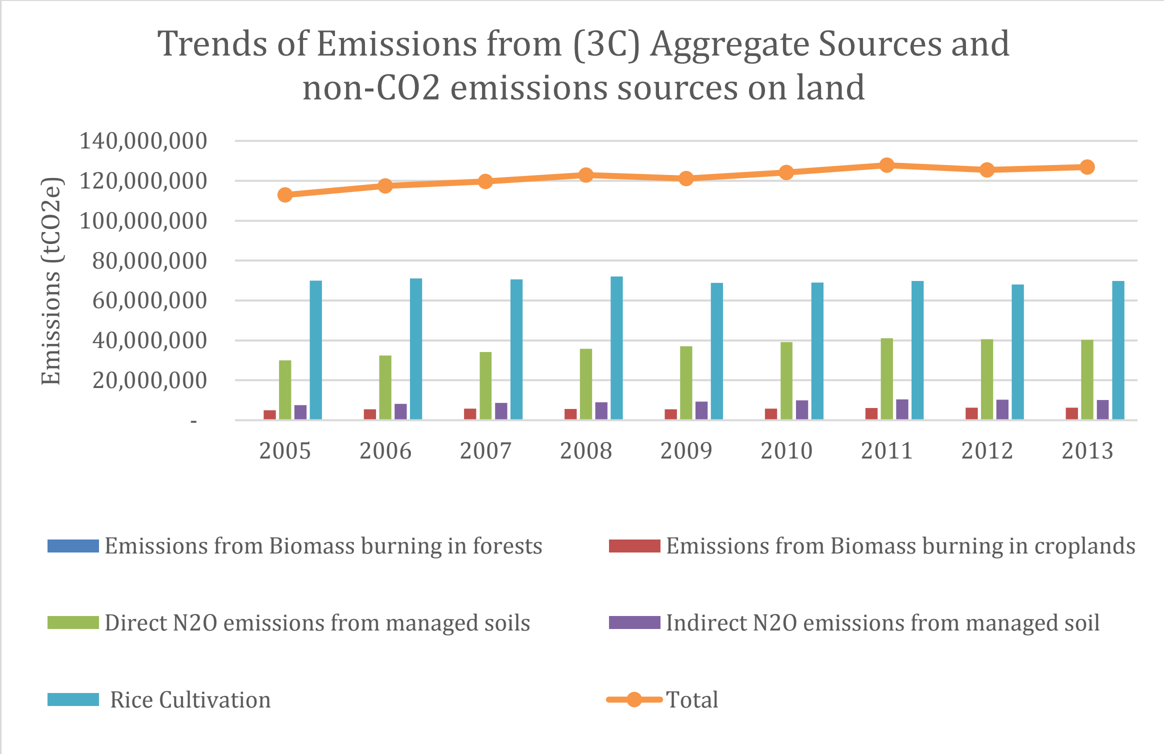


Aggregate Sources and Non-CO2 Emissions from Land

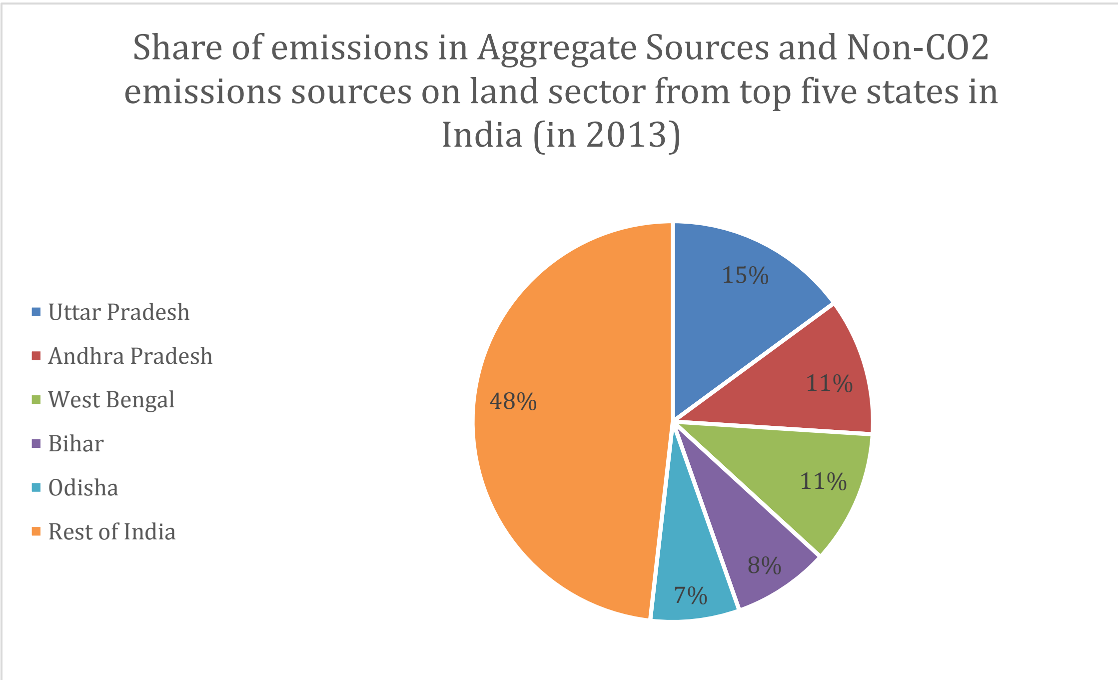
Emissions from this sector are primarily of methane and nitrous oxide. Their relative shares, in carbon dioxide equivalent emissions are shown in the graph below:



Methane emissions are a major constituent of emissions from this sector, primarily due to rice cultivation. However, the relative contribution of nitrous oxide emissions has been gradually increasing because of growing fertilizer use.



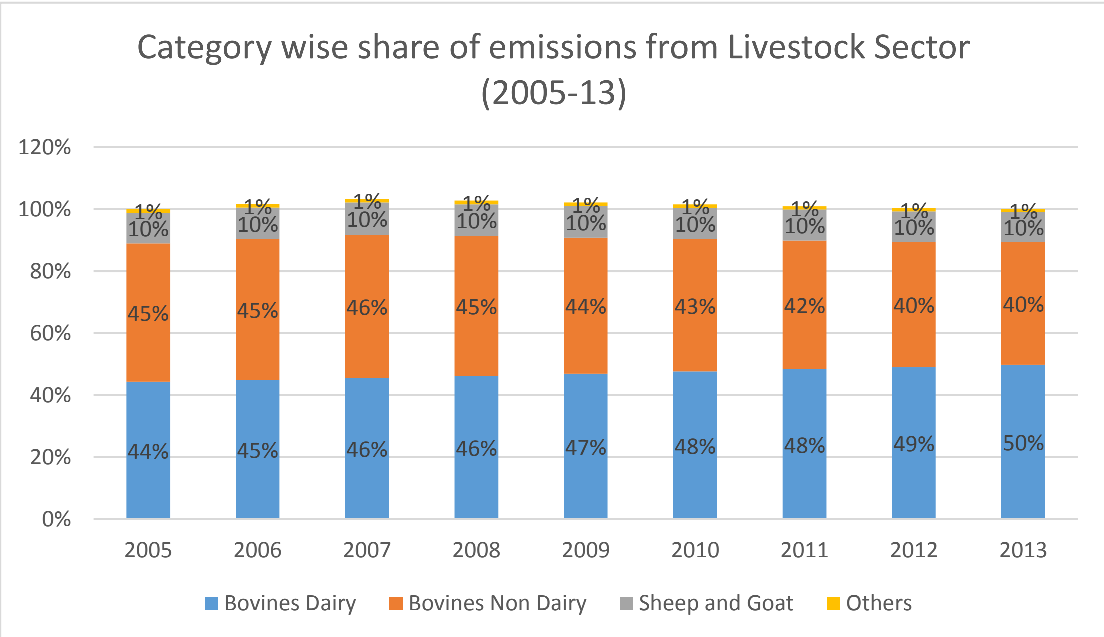
Spatially, the states that had a major contribution to emissions from this sector in 2013, primarily due to widespread cultivation of rice are Uttar Pradesh, Andhra Pradesh, West Bengal, Bihar and Odisha as shown in graph given below. Together these states combine to account for 52% of emissions from these sources.



Important Sources of GHG Emissions: Enteric Fermentation and Rice Cultivation

The two sub-sectors being discussed here had a combined total emission of 349.68 million tonnes of CO2 equivalent for the year 2013. Emissions emanating from enteric fermentation were 201.91 million tonnes of CO2 equivalent or 57.74% of the combined emissions from livestock and Aggregate Sources and Non-CO2 Emissions from Land in 2013. Rice cultivation accounted for 69.43 million tonnes of CO2 equivalent, or 19.86% of the combined emissions of these two subsectors in 2013. Thus, together, these two activities alone are responsible for 77.6% of all the emissions emanating from this subsector. It is for this reason, that we discuss mitigation options for these two activities. However, mitigation options in both these cases cannot be pursued from a purely emissions reduction perspective due to their importance as activities that form an important part of the rural economy as well as from the perspective of India's food security. There are, however, co-benefits that accompany many of the possible mitigation strategies that can realistically be pursued to reduce emissions from both these human activities

Possibilities of GHG reductions from Enteric Fermentation within the livestock sector



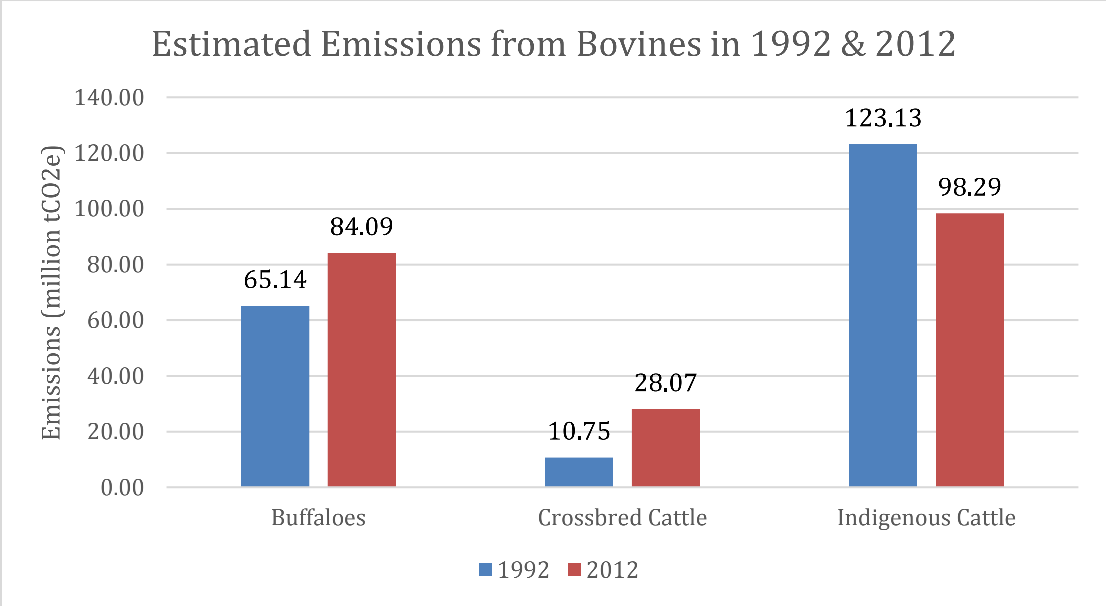
In order to identify mitigation potentials from enteric fermentation, it is illustrative to have a look at which animals are the principal sources of such emissions. The graph below illustrates that the population of indigenous cattle, crossbred cattle and buffaloes mainly drives emissions from the livestock sector. Thus, it is enteric fermentation emanating from cattle and buffaloes that needs to be addressed in order to make substantive mitigation gains.

Among the cattle population, the three categories are crossbred cattle, indigenous cattle and buffaloes. Between 2005 - 2013, the population of indigenous cattle has gone down by around 9%, while the overall cattle population increased by around 6.5%. Of the three categories of cattle, indigenous cattle population is around 49% of the total cattle population. Hence, if this trend holds and indigenous cattle populations continue to decline, autonomous mitigation would in any case take place without any specific interventions for GHG mitigation. To put it differently, if the population of indigenous cattle in the country had not declined, but remained at the same level as in 2005, the total emissions from enteric fermentation would have been 213.05 million tonnes of CO2 equivalent in 2013 or 5% higher than they actually were found to be for that year. Some long-term trends in the population of cattle are shown below to better illustrate the secular trend in reducing number of indigenous cattle.

Year of Cattle Census[1]	Total Population of Indigenous Cattle (in thousands)	Total Population of Crossbred Cattle (in thousands)	Total Population of Buffaloes (in thousands)
1992	189,369	15,215	84,206
1997	178,782	20,099	89,918
2003	160,495	24,686	97,922
2007	166,015	33,060	85,745
2012	151,172	39,732	108,702

The population of indigenous cattle steadily dropped from 189,369 thousand heads to 151,172 heads of cattle. That is a 1.12% decrease, compounded annually over 20 years. In terms of the avoided emissions due to this trend, assuming that the indigenous cattle population had remained steady at the 1992 levels, India is avoiding 24.83 million tonnes of CO2 equivalent simply due to this decline in the population of indigenous cattle in 2012. Further, these avoided emissions are offsetting the cumulative annual increase in emissions of enteric fermentation from buffaloes between 1992 and 2012 that are 19.96 million tonnes of CO2 equivalent. Thus, improving productivity of cattle, especially indigenous cattle while at the same time reducing their numbers would be an important aspect of mitigation that would also have important environmental as well as socio-economic benefits.

[1] http://dahd.nic.in/documents/statistics/livestock-census



Aside from controlling the population of livestock, however, there are additional mitigation opportunities that are available in the Indian context, especially for dealing with enteric fermentation from cattle. The three broad strategies that have been found to be suitable for pursuing mitigation in the livestock sector in the Indian context are:

1. **Dietary manipulation**, through supplementing of green fodder intake and/or concentrated feeding. This could reportedly result in decline of methane emissions due to enteric fermentation in a range between 5% to 32%[2]
2. **Feed additives**, primarily Monensin, could result in decline of methane emissions due to enteric fermentation in a range between 14% to 32%[3]
3. **Strategic feed supplementation,** through adding Urea Molasses Mineral Block to cattle feeds. This could reportedly result in decline of methane emissions due to enteric fermentation in a range between 9% to 15%[4]

Assuming that in pursuit of all these strategies, even if the lower range of emission reduction could be achieved, India could reduce emissions of methane from cattle by around 25%. This would amount to around 45.07 million tonnes of CO2 equivalent not being released into the atmosphere, or 20.19% reduction of emissions from the livestock sector[5] overall.

However, there are, primarily 2 sorts of barriers that inhibit the pursuit of such emissions reductions. These are:

1. Livestock sector is dominated by the unorganized sector with millions of individuals having small flocks. Further, these individuals often do not rear cattle for producing marketable products, but do so for subsistence. Thus, the incentives for increasing the productivity of cattle are limited.

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[2] Sirohi, Smita and Michaelowa, Axel, "Implementing CDM for the Indian Dairy Sector: Prospects and Issues", published in Climate Policy 7 (2007) 62-74
[3] Ibid
[4] Ibid
[5] Calculation is based on GHG emissions estimates for 2013

2. While pursuing emission reduction from cattle would result in higher productivity of the animals due to improvements in their diet, the additional costs incurred in pursuing such strategies would not be completely offset by increased productivity. In a sector, which is perhaps already depressed due to relatively low prices of its commodities, expecting India's animal husbandry sector to absorb the additional costs of emission reduction would be impractical[6].

Possibilities of GHG reductions from Rice Cultivation

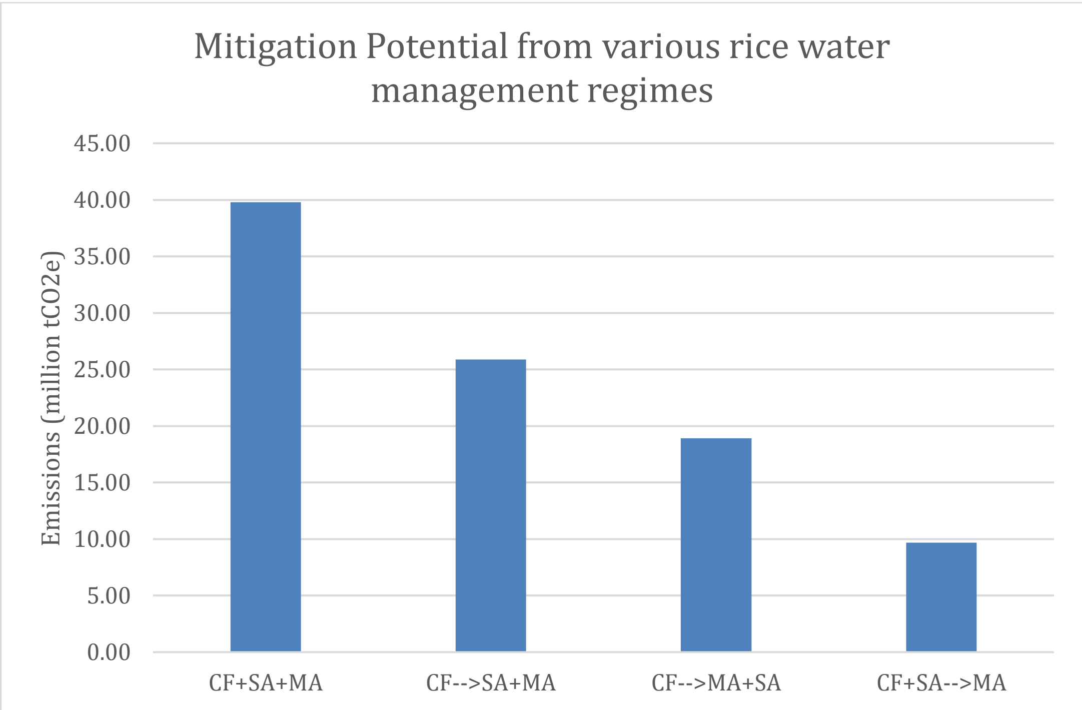
The total area under rice cultivation in India was 43.79 million hectares in 2013. Of this, the various rice ecosystems under which rice in India is grown, along with the associated emission factors and total emissions from rice were:

	Area Under Rice Cultivation (million hectares)	Emission factors for various rice ecosystems (kg per hectare, methane)	Total Emissions Estimates from rice cultivation (million tonnes CO2 equivalent)
Continuous Flooding (irrigated)	6.90	162	23.47
Single Aeration (irrigated)	9.15	66	12.68
Multiple Aeration (irrigated)	9.59	18	3.63
Rain fed/ flood prone (unirrigated)	3.19	190	12.73
Rain fed/ drought prone (unirrigated)	8.58	66	11.89
Deepwater	1.32	190	5.27
Upland (unirrigated)	5.28	0	0
Total	44.02		69.79

Of the above, possibilities of mitigation in the unirrigated categories of land are minimal. For example, little could be done with deepwater rice or rain fed flood prone rice, unless huge investments are made on infrastructure to drain away the excess water in the areas where such rice is grown. Further, unless huge investments for irrigation are made for rain fed areas that are drought prone, little could be done for reducing emissions from rice cultivation in these parts.

[6] Sirohi Samita, Michaelowa Axel, and Sirohi S.K., "Mitigation Options for Enteric Methane Emissions from Dairy Animals: An Evaluation for Potential CDM Projects in India", published in Mitigation and Adaptation Strategies for Global Change (2005)

The potential for mitigation thus exists in irrigated areas where rice is being grown under continuous flooded or single aeration ecosystems. To illustrate, if the areas where rice is being grown under continuous flooded ecosystems were to switch to single aeration ecosystems, the total emissions saved would amount to 13.91 million tonnes of CO2 equivalent or approximately 10% of the total emissions from Aggregate Sources and Non-CO2 Emissions from Land. There could be further emissions savings if all cultivation of rice in irrigated areas could be brought under the multiple aeration ecosystem. The additional savings of emissions from such a switch, over and above the switch from continuous flooded to multiple aeration ecosystems would amount to an additional 20.87 million tonnes of CO2 equivalent or additional 12.5% of the total emissions from Aggregate Sources and Non-CO2 Emissions from Land. Thus, switching over completely to multiple aeration ecosystem rice cultivation in all the irrigated areas of India could reduce a total of 30.09 million tonnes of CO2 equivalent emissions or 23.71% of the emissions from Aggregate Sources and Non-CO2 Emissions from Land. Such a switch over would also have associated environmental benefits such as conserving water, especially ground water as many of the rice growing areas rely on groundwater for irrigation, as well as economic benefits since such a switch over would also result in higher yields and gains in productivity of rice itself as well as of the other crops associated with rice growing ecosystems[7].



[7] Mahesh K. Gathala, Virender Kumara, P.C. Sharma, Yashpal S. Saharawat, H.S. Jat, Mainpal Singh, Amit Kumar, M.L. Jat, E. Humphreys, D.K. Sharma, Sheetal Sharma, and J.K. Ladha, "Optimizing intensive cereal-based cropping systems addressing current and future drivers of agricultural change in the northwestern Indo-Gangetic Plains of India", published in Agriculture, Ecosystems and Environment 177 (2013) 85– 97, ELSEVIER

It goes without saying that if rice was substituted with maize or millets, then the entire 69.73 million tonnes of CO_2 equivalent could be avoided. However, in order to do so, massive interventions would be required in changing people's tastes and preferences over a long period of time, without any guarantees of success

An additional aspect of a switch from continuous flooding rice ecosystems to multiple aeration rice cultivation is the benefits, both in terms of productivity as well as farm incomes. Thus, for example, a switch from continuous flooded rice cultivation followed by wheat, which is typical of the cropping pattern practiced in many irrigated areas of India, especially in the north, to multiple aeration cultivation of rice, followed by wheat and then mungbean, could result in higher wheat yield increases of upto 18% and higher rice yield increases of upto 20%. However, these do not necessarily mean a better bottom line for farmers since higher productivity is also accompanied by higher initial costs of moving towards multiple aeration ecosystems for rice cultivation along with greater recurring expenditures of cultivation.[8] This is illustrated by the fact that the net margins of most agricultural commodities have been declining, particularly in the recent past[9]. Further, a recent survey conducted by researchers of Punjabi University, Patiala and Dashmesh Khalsa College, Zirakpur, found that 85.9% of all sampled farmers and 80.07% of all sampled agricultural labourers were indebted in Punjab, a state which is a cradle of the green revolution in India and where farmers were for a long time considered among the most prosperous in India. In addition, the same study reported that in Punjab, the average debt per indebted farming household was Rs. 5.52 lakh, while the average debt per indebted agricultural labourer was Rs. 0.68 lakhs. The report also pointed out that the level of debt per operated acre in Punjab was Rs. 0.71 lakh[10]. This shows that even in a state like Punjab, farm incomes have been stagnating if not actually falling, which means that farmers have little or no capacity to make the switch needed to reduce emissions from rice cultivation autonomously.

And that is what appears to be the primary barrier in switching over from continuous flooded rice ecosystems towards multiple aeration rice ecosystems. Additionally, as in the case of the livestock sector, the farm sector in India is highly diverse and unorganized with millions of small farmers that are economically vulnerable and cannot make the initial investments to facilitate such a switch as has already been pointed out. Further, there are also barriers with respect to lack of knowledge among the farmers on the processes that they would need to modify during their activity cycles for growing rice. However, some of these barriers could be overcome if farmers could be compensated for avoiding emissions from rice cultivation, so that there is an upfront incentive for them to do so.

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[8] Mahesh K. Gathala, Virender Kumara, P.C. Sharma, Yashpal S. Saharawat, H.S. Jat, Mainpal Singh, Amit Kumar, M.L. Jat, E. Humphreys, D.K. Sharma, Sheetal Sharma, and J.K. Ladha, "Optimizing intensive cereal-based cropping systems addressing current and future drivers of agricultural change in the northwestern Indo-Gangetic Plains of India", published in Agriculture, Ecosystems and Environment 177 (2013) 85– 97, ELSEVIER
[9] Ashok Gulati and Prerna Terway "From Plate to Plough: Why Bumper Harvests Spell Doom" published in the Indian Express, June 19, 2017
[10] Singh Gian et. al. (2017), "Indebtedness Among Farmers and Agricultural Laborers in Rural Punjab" published in Economic and Political Weekly, Volume LII No 6, February 11, 2017

Conclusions

There are significant reductions of emissions that can be realized within the AFOLU sector that would also have associated environmental and economic co-benefits. In order to do so, however, there is a need for an outreach to the farmers and pastoralists of India that are economically and socially vulnerable and require upfront technical as well as financial support, to be able to take advantage of the environmental and economic co-benefits of taking up livestock rearing and rice cultivation that would be less emission intensive than it is at present.