Major Emitting Sources from the Livestock Sector: Trends in India and Mitigation Opportunities

Submitted to: National Livestock Conference, 28th Annual Convention, ISAPM-2021, UTKARSHA

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March 2022

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Abstract

The Agriculture, Forestry and Other Land use (AFOLU) sector comprises of greenhouse gas (GHG) emissions from agriculture practices, livestock, and changes in forest and land use. GHG emissions from livestock sub-sector includes emissions due to enteric fermentation in herbivores and manure management practices. Between 2012 and 2019, GHG emissions from livestock sub-sector grew at a CAGR of 0.05 per cent. Projections indicate that livestock emissions will be approximately 223.27 million tonnes[1] CO_2e by 2030. Various factors such as flock size, weight of animal, diet, manure management practices and topography influence GHG emissions from the sub-sector. This paper studies the emission trends and projections up to 2030 in the livestock sub-sector as well as suggests the best practices which can support mitigation of GHG emissions from the livestock sub-sector.

Keywords

GHG emissions, climate change, enteric fermentation, manure management, methane emissions

Introduction

Agriculture, Forestry and Other Land use (AFOLU) sector comprises of greenhouse gas (GHG) emissions from agriculture practices, livestock, and changes in forest and land use. In 2015, AFOLU contributed around 10.22 per cent in total economy-wide emissions (GHG Platform India, 2019).

The livestock sub-sector emits GHG emissions due to two key reasons: 1) enteric fermentation process in herbivore animals, and 2) animal manure management practices.

The GHG Platform India analyses show that in 2015 at the national level, the total livestock emissions contributed to around 9.6 per cent of total economy-wide emissions and 63 per cent to gross emissions of AFOLU sector (i.e. sinks not included). This is close to India's Third Biennial Update Report (BUR) analyses (for 2016), wherein livestock contributed 9.87 per cent and 61.28 per cent to economy-wide and gross AFOLU sector emissions respectively (MOEFCC, 2021). In terms of total methane emissions of India, livestock emissions contributed more than 50 per cent; this is followed by total waste sector emissions and emissions from rice cultivation (GHG Platform India, 2019).

Livestock emissions between 2003 and 2019 grew at a CAGR of 0.19 per cent, whereas between 2012 and 2019, the CAGR was 0.05 per cent. The business-as-usual (BAU) projections for 2030 (using CAGR b/w 2003 and 2019) suggest that livestock emissions would be approximately 227.57 million tonnes CO_2e; however, it could be around 223.37 million tonnesCO_2e if the CAGR between 2012 to 2019 is used (as shown in Figure 1).[2]

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[1] $MtCO_2$ e = million tonnes of Carbon dioxide equivalent

[2] Estimated using IPCC methodology following the Common Reporting Framework as also followed by GHGPI Phase III andNATCOM.20th Livestock Census data has been used.

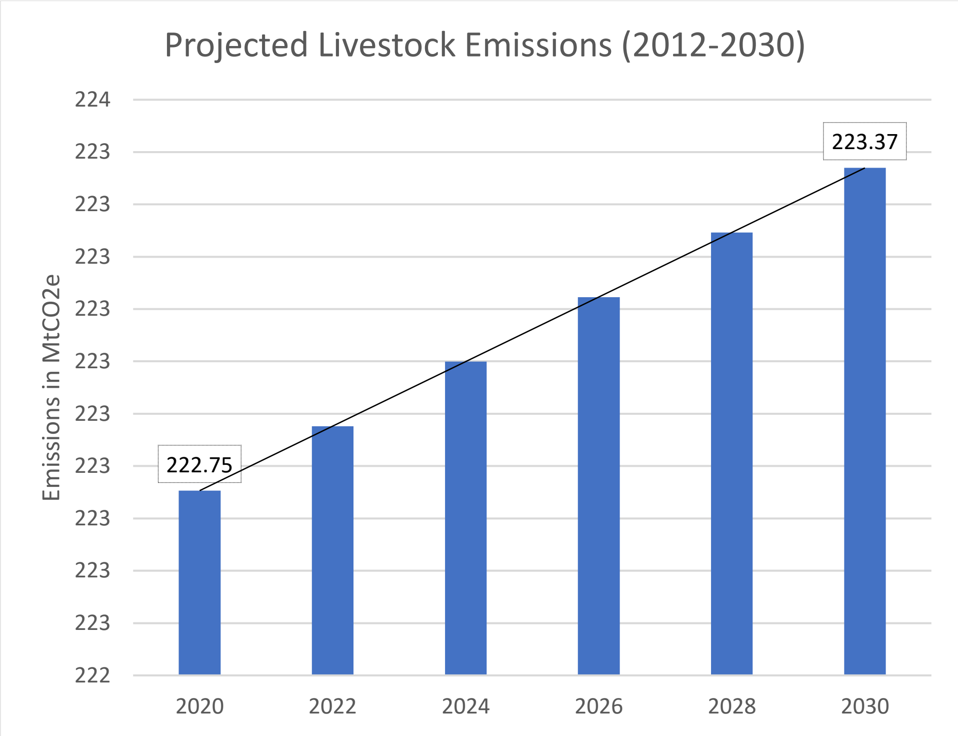

Figure 1: India's livestock emission projections (BAU) till 2030

In the case of enteric fermentation, the number of animals is the key determinant of emissions i.e. bigger the flock size higher will be the emissions. Diet impacting aspects like, the average body weight of the animals, gross energy intake and topographical differences are the other factors that play a role in methane emissions. It may be noted that in 2019, almost 88 per cent of emissions from the livestock sub-sector are due to bovines. Out of this 88 per cent emissions from bovines, on an average 40 per cent emissions are due to indigenous cattle, 42 per cent due to buffaloes and the remaining 18 per cent due to crossbred cattle.

Whereas, for manure management emissions, the key factors determining emissions are the type of decomposition conditions – aerobic or anaerobic, besides the flock size. Methane emissions from manure management tend to be smaller than the methane emissions from enteric fermentation. Manure management emissions grew at a CAGR of 0.13 per cent between 2012 and 2019 with 20.75 million tonnes CO_2e and 20.94 million tonnesCO_2e respectively. Further, nitrous oxide emissions from manure management vary significantly between the types of management systems used.

During the COP26 (Glasgow, 2021), the Hon'ble Prime Minister of India, committed that India will reach net zero by 2070. Assuming this goal is for GHG net-zero (and not just for CO_2 net zero), it is imperative that the highest contributor of methane i.e. the livestock sub-sector is managed with climate-conscious precepts. It may also be noted that the global warming potential[3] of methane is 21 times higher than that of CO_2 (Intergovernmental Panel on Climate Change, 2007) (MoEFCC, 2012). Therefore, we must look at climate-smart livestock practices, like, better feed additives, promoting a balanced mix of indigenous and crossbred cattle, etc.

[3] Global Warming Potential (GWP) values for Methane (CH4) in the AR6 Report of IPCC differs from the AR4 report but so far India has been using AR4 GWP values to compute the necessary calculations for its national communications (NATCOM & BURs) to the UNFCCC

The paper will bring forth this discussion in detail and dwell on the aforementioned issues and their plausible solutions.

AFOLU

The trend analysis (2005 to 2019) of gross GHG emissions from the major categories of AFOLU sector are depicted in the figure 2. It may be noted that this analysis only accounts for emissions and not sinks.

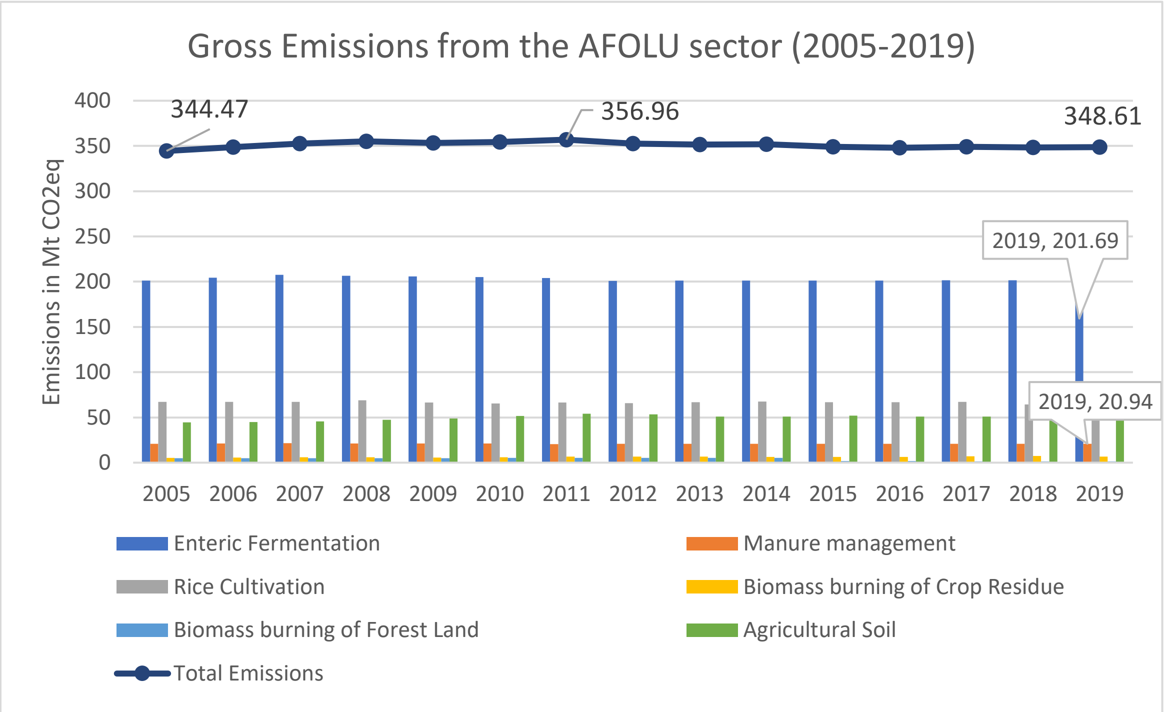

Figure 2: India's gross emissions from the AFOLU sector (2005-2019)

As can be seen, from figure 2, within the AFOLU sector, emissions from the livestock sub-sector contribute the maximum quantity of GHGs. The contribution of this sub-sector was 222.63 million tonnes of CO_2 equivalent in 2019. The other emitting sub-sector viz. rice cultivation, agricultural soil and others contributed around 36 per cent of the emissions to the gross emissions of AFOLU sector i.e. around 126 million tonnes of CO_2 equivalent in 2019.

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 to GHG emissions, accounting for around 90 per cent of the emissions from this sub-sector. In 2019, for instance, of the total GHG emissions of 222.63 million tonnes CO_2 equivalent from livestock, 201.69 million tonnes of CO2 equivalent were emitted due to enteric fermentation. Figure 3 shows the trends of emissions from the livestock sector from 2003 to 2019.

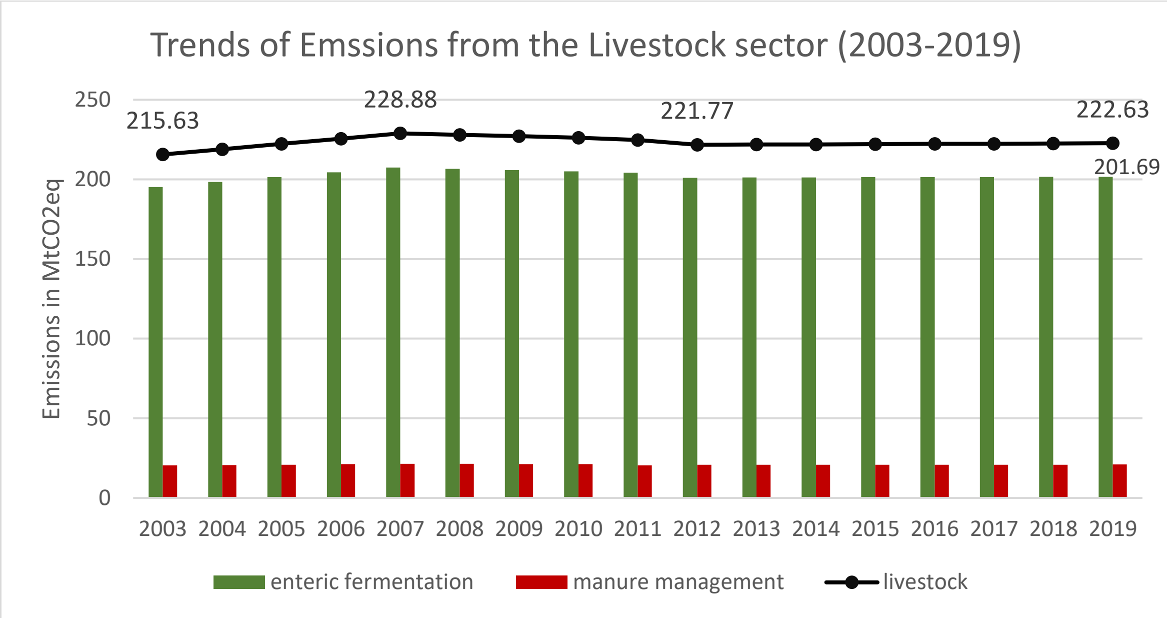

Figure 3: Emission Trends from the Livestock sector (India, 2003-2019)

Further, the relative share of emissions from bovines, both dairy and non-dairy animals, to the overall emissions emanating from the livestock sub-sector is around 88 per cent of all emissions as shown in Figure 4.[4]

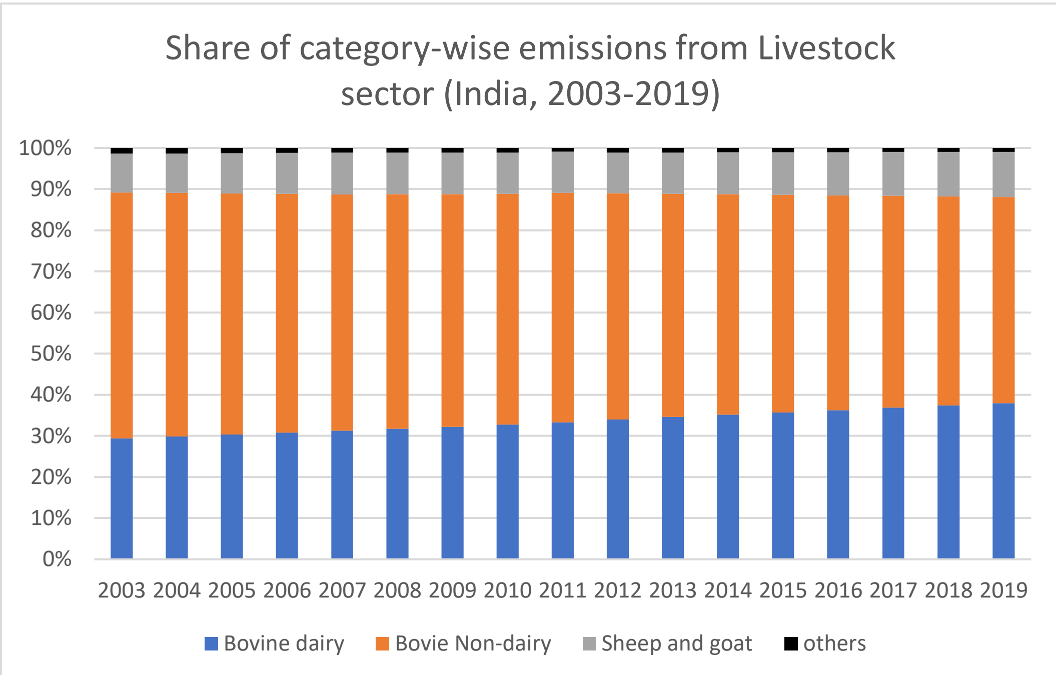

Figure 4: The percentage share of category-wise emissions from the livestock sub-sector (India, 2003-2019)

Spatially, the top 10 contributors among states to emissions from the livestock sector accounted for 74 per cent of India's livestock emissions, as is shown in Figure 5. Amongst the states, Uttar Pradesh accounts for the highest livestock emissions i.e. 36.71 million tonnes of CO_2 equivalent, followed by Rajasthan (21.35 million tonnes of CO_2 equivalent) and Madhya Pradesh (19.85

[4] The total number of indigenous cattle and buffaloes have significantly decreased between census 2007 and 2019.

million tonnes of CO_2 equivalent.)

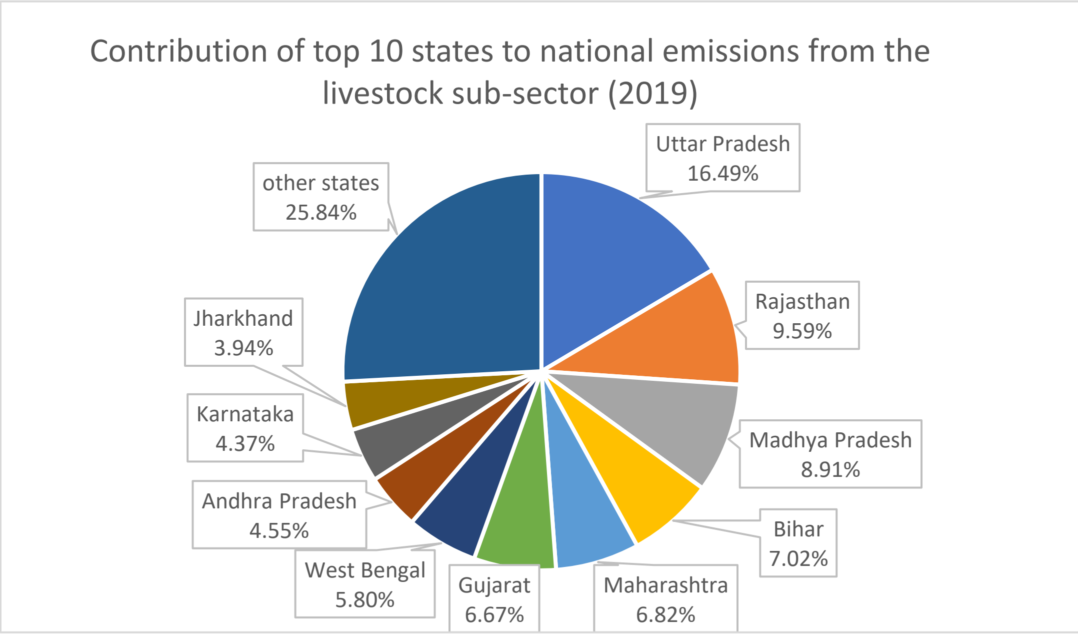

Figure 5: The percentage share of emissions from India's top 10 states in the Livestock sector (2019)

Given our findings, it is important to discuss the mitigation options for enteric fermentation and manure management. However, mitigation options in both these cases cannot be pursued from a pure emissions reduction perspective due to their importance as activities that form an important part of the rural economy and 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

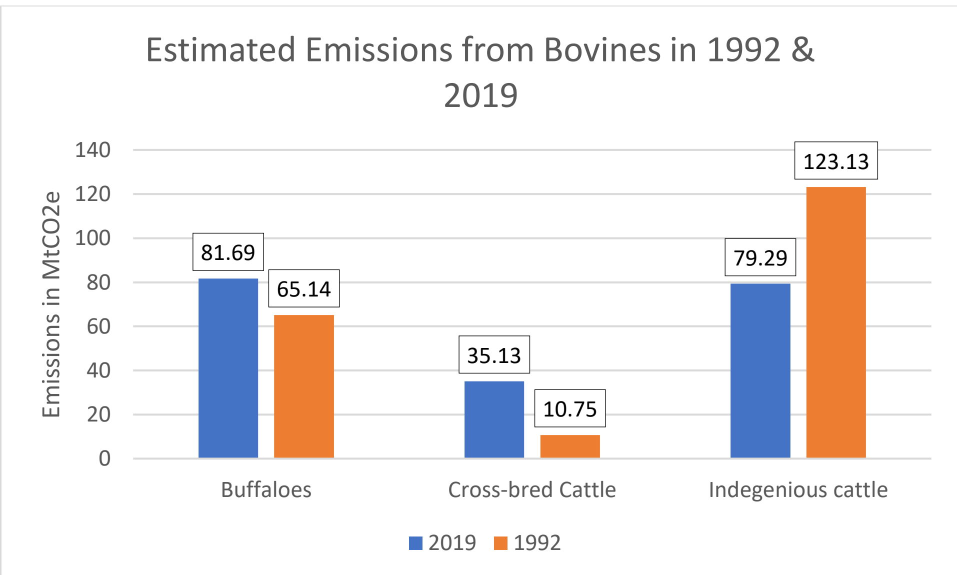

Figure 6: Emission estimation from the Bovines between the years 1992 and 2019

Figure 6 shows the emissions estimated from the bovines *viz* buffaloes, cross-bred cattle and the indigenous cattle. The emissions estimated between the years 1992 and 2019 showed that indigenous cattle and buffaloes were the main drivers of emissions from the livestock sub-sector.

Among the cattle population, the three categories are crossbred cattle, indigenous cattle and buffaloes. Between 2003 – 2019, the population of indigenous cattle has gone down by around 25 per cent, while the overall cattle population increased by 5 per cent. Of the three categories of cattle, the indigenous cattle population is around 40 per cent of the total cattle population. If the country's population of indigenous cattle for the year 2019 had remained the same as 2003 level, the total emissions from the enteric fermentation (of livestock sub-sector) would have been higher by 8.13 million tonnes of CO_2 equivalent or 10.25 per cent higher than the 2019's estimated value. Table 1 illustrates the trend in the population decrease of indigenous cattle. However, given ecological complexities and germplasm diversity in livestock, it would be difficult to deduce one variety over the other.

Table 1:Total Population of Indigenous cattle, Cross-bred cattle and Buffaloes

Year of Cattle census (Department of Animal Husbandry & Dairying, 2019)	Total Population of Indigenous cattle (in thousands)	Total Population of Cross-bred 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	166,014	33,086	105,342
2012	151,170	39,732	108,702
2019	141,763	51,410	109,852

As seen in Table 1, the population of indigenous cattle steadily dropped from 189,369 thousand heads to 141,763 thousand heads of cattle. In 2019, 44 million tonnes of CO2e were avoided due to the decline in the population of indigenous cattle with respect to 1992 levels. Thus, improving the productivity of cattle while at the same time reducing emission potential and keeping a check on headcount of each variety would be an important aspect of mitigation that would also have important environmental as well as socio-economic benefits (Department of Animal Husbandry & Dairying, 2019).

There are additional mitigation opportunities that are available in the Indian context, especially for dealing with enteric fermentation from cattle. Many studies across the globe illustrate various techniques and practices to reduce enteric fermentation. Potentially suitable strategies for the Indian context include:

1) Feed additives – various feed additives can reduce methane emissions in cattle
    a) Tannins – adding plants containing condensed tannins has been shown to effectively reduce enteric methane emissions in cattle between 13-16 per cent, the effect can vary based on plant species used and care must be taken to prevent a reduction in diet digestibility and therefore animal productivity. Tannins can also reduce excess loss of nitrogen through urine, which ultimately reduces nitrous oxide losses (Arango, et al., 2020), (Panchasara, Samrat, & Islam, 2021).
    b) Fats and oils – including fats and oils in diet can reduce enteric methane emissions and methane yields by up to 40% depending on the dosage. Just a 1per cent increase in oil intake can reduce 3.5per cent of methane production; however high concentration of free fat can have detrimental effect on the rumen microbial population (Arango, et al., 2020), (Panchasara, Samrat, & Islam, 2021), (Llonch, Haskell, Dewhurst, & Turner, 2017).
    c) Nitrate – feeding nitrate can lead to substantial reductions in methane emissions (5-30per cent) but care needs to be taken to prevent nitrate toxicity in the long run (Llonch, Haskell, Dewhurst, & Turner, 2017).
    d) Chemical inhibitors – can help improve energy efficiency in cattle and can potentially reduce GHG emissions by up to 91per cent (Arango et al., 2020)
    e) Ionophores – including ionophores in diet improves energy efficiency and lowers risk of rumen bloat while reducing GHG emissions between 5 to 30per cent (Llonch, Haskell, Dewhurst, & Turner, 2017).
2) Improved forage species - Plant breeding has long been used to improve the feeding value of forage crops, reduce the environmental footprint of cattle production and increase livestock productivity. The reduction in methane yield has been shown to be up to 30per cent in some studies (Arango, et al., 2020).
3) Improved pasture management – high quality pasture has been shown to lower methane emission yield by 12 to 51per cent as compared to traditional low quality grazing systems (Arango, et al., 2020).
4) Seaweed – feeding livestock many seaweeds – red, green or brown marine macroalgae – has been shown to reduce methane production by 40per cent to 98per cent when added to feed in various proportions varying from 1 to 5 per cent. Seaweed also has additional benefits such as improved fertility and reduced oxidative stress (Panchasara, Samrat, & Islam, 2021), (Vijn, et al., 2020).
5) Improved herd management – to reduce the number of unproductive cattle and to improve the health and lifespan of cattle, while ensuring higher offspring survival.
6) Smart livestock farming – helps in monitoring animal grazing in open pastures or location in big stables, detecting air quality and GHG emissions, monitoring offspring in animal farms to ensure their survival, growth and health (Arango, et al., 2020), (Panchasara, Samrat, & Islam, 2021).

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 per cent. This would amount to around 56.66 million tonnes of CO_2 equivalent not being released into the atmosphere, w.r.t. BAU 2030 emissions.

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.

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 (Sirohi, Michaelowa, & Sirohi, 2007).

Conclusions

There are multiple possibilities to reduce emissions that can be realized within the livestock sub-sector in the AFOLU sector with multiple 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 who are economically and socially vulnerable and require upfront technical as well as financial support, to be able to take advantage of the economic as well as environmental benefits of livestock rearing that would be less emission-intensive than it is at present.

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