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RESEARCH ARTICLE

Livestock-related greenhouse gas emissions - a profile of Bengaluru urban district, India

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Abstract

The major greenhouse gases emitted from livestock are methane and nitrous oxide (direct and indirect). Livestock productions are responsible for greenhouse gas emissions in terms of enteric fermentation, biomass decomposition, manure storage and disposal, and use of fertilizers for fodder. With this context, the study attempts to estimate the methane emissions from livestock and the contribution of emissions from enteric fermentation to global greenhouse gas emissions in Bengaluru urban district using Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines - Agriculture, Forestry and Other Land-use sector by adopting Tier 1 approach. The methane emission from livestock (enteric fermentation) in terms of carbon dioxide equivalent for the year 1990-1991 was 36.125Gg CO_2eq while 2012-2013 was 9.850Gg CO_2eq. The direct and indirect nitrous oxide emissions from livestock (manure management) for the year 1990-1991 was 15.198Gg CO_2eq while 2012-2013 was 11.324Gg CO_2eq and in the year 1990-1991 was 93.250Gg CO_2eq while 2012-2013 was 68.975Gg CO_2eq. The study can be concluded that, the significant decrease in methane and nitrous oxide (direct and indirect) emissions from the livestock was observed over the years. This may be due to conversion of agriculture land to residential and commercial activities and on the other hand livestock population also decreased. The greenhouse gas emission by livestock needs to be quantified to define the magnitude of the impact of livestock on climate change.

Introduction

Livestock plays a key role in food production for the millennia. Livestock production contributes to climate change, when the green house gases like methane, nitrous oxide and carbon dioxide are produced and released into the atmosphere. The importance of livestock in providing human societies with food, income, employment, nutrients and risk insurance is widely recognized (Perry and Sones, 2007). Livestock are important to humankind since most of the world's vegetation biomass is rich in fibre; only herbivores i.e livestock can convert this high fibre vegetation into high-quality protein sources (meat and milk) for human consumption and this will need to be balanced against the related production of methane. At the same time there is a growing awareness within the research and policy groups that rapid growth in global production and consumption of livestock. Methane emissions from livestock makes up 18 per cent of total world greenhouse gas emissions and the net contribution of enteric fermentation to greenhouse gas is 5 per cent (IPCC, 2006). With this context, the study attempts to estimate the methane emissions from livestock and the contribution of emissions from enteric fermentation to global greenhouse gas emissions in Bengaluru urban district.

Study area and Methodology

Study Area: The present study was carried out in Bengaluru urban district; one of the fastest growing cites in India, with a population of 8.4 million (Census of India, 2011) indicating a development of 2196 sq.km area (DES, 2013); located 920m above mean sea level, and experiencing a salubrious climate throughout the year with an annual rainfall of about 850-950mm. Bengaluru is one of the fastest growing cities in India and is branded as 'Silicon Valley of India' for heralding and spearheading the growth of Information Technology (IT) based industries in the country. Bengaluru has become a cosmopolitan city attracting people and business alike, within and across nations (Sudhira et al., 2007). Bengaluru charm as a garden city may have diminished in the last two decades. Due to rapid urbanization, land utilization was totally changed from the past two decades and converted the non-agricultural lands, open lands and barren lands into settlements. The variability in annual rainfall leads to shortage of fodder which resulted in the decrease of livestock over the years.

Methodology: Greenhouse gas emissions by livestock are typically small, often negligible for most urban regions, so this category needs to be carefully considered. The key greenhouse gases of concern in livestock sector are methane and nitrous oxide (direct and indirect). The greenhouse gas emissions associated with livestock were determined using Tier 1 approach using Intergovernmental Panel on Climate Change (IPCC) guidelines - Agriculture, Forestry and Other Land-use sector (IPCC, 2006).

Equation 1: Methane emissions from Enteric Fermentation and Manure Management

$$CH_{4\ Enteric} = N_{(T)} \times EF_{(T)} \times 10^{-6} \qquad CH_{4\ Manure} = N_{(T)} \times EF_{(T)} \times 10^{-6}$$

Where:

$CH_{4Enteric}$ = CH_4 emissions from Enteric Fermentation ($GgCH_4yr^{-1}$)

$CH_{4Manure}$ = CH_4 emissions from Manure Management ($GgCH_4yr^{-1}$)

$N_{(T)}$ = Number of heads of livestock species

T = Species / category of livestock

$EF_{(T)}$ = Emission factor for Enteric Fermentation and Manure Management (kg $head^{-1}$ yr^{-1})

Equation 2: Direct and Indirect N_2O emissions from Manure Management

$$N_{MMS\_Avb} = NE_{MMS} \times (1\text{-}Frac_{LossMS} \times 10^{-2}) + N_{(T)} \times MS_{(T,S)} \times N_{beddingMS} \times 10^{-6}$$

Where:

N_{MMS_Avb} = Amount of managed manure nitrogen available ($GgNyr^{-1}$)

NE_{MMS} = Total nitrogen excretion for the Manure Management System (MMS) ($kgNyr^{-1}$)

$Frac_{LossMS}$ = Amount of managed manure nitrogen for livestock category T that is lost in the MMS (%)

$N_{(T)}$ = Number of heads of livestock species

$MS_{(T,S)}$ = Fraction of total annual nitrogen excretion managed in MMS for each livestock category (-)

$N_{beddingMS}$ = Amount of Nitrogen from bedding (kg N $livestock^{-1}$ yr^{-1})

Results and Discussion

Livestock are categorized by the presence of rumen, a special digestive organ having unique ability to digest fibrous and low grade roughages or plant material. Methane is one of the gasses emitted from livestock manure; it persists for long periods of time. It is the second most abundant greenhouse gas after carbon dioxide. Even though there is less methane emissions compared to carbon dioxide, its ability to warm the atmosphere is 25 times greater. Nitrous oxide is another by-product of animal agriculture, is about 298 times more potent in trapping heat of the atmosphere. Table 1 presents the livestock category and their total number in Bengaluru urban district.

Table 1:Livestock category and their numbers

Year / Livestock category	1990-1991	2000-2001	2010-2011	2011-2012	2012-2013
Dairy Cows	210000	63701	28954	25584	23615
Other Cattle	0	107292	98485	87348	85918
Buffalo	37100	27429	11254	5704	5010

Sheep	91600	124671	80106	55917	53315
Goats	46500	41292	41097	37903	36594
Rabbit	0	0	1276	531	508
Poultry	1604200	1430477	1453513	1416383	1418709
Dogs	72200	125262	124163	121137	12083
Pigs	4400	7202	4522	4495	4503
Other	1600	1790	1140	791	821

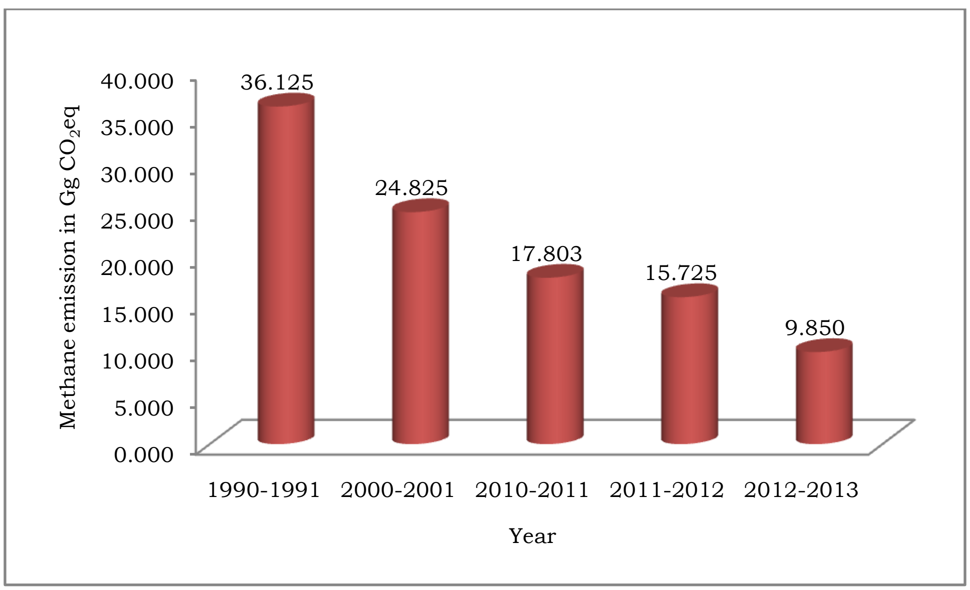
Source: Directorate of Economics and Statistics, Bengaluru

Table 2:Emission factors for Enteric Fermentation

Livestock category	**Emission factor (kg head^{-1}yr^{-1})**
Dairy Cows	58
Other Cattle	27
Buffalo	55
Sheep	5
Goats	5
Rabbit	0.08
Poultry	27
Dogs	27
Pigs	27
Other	27

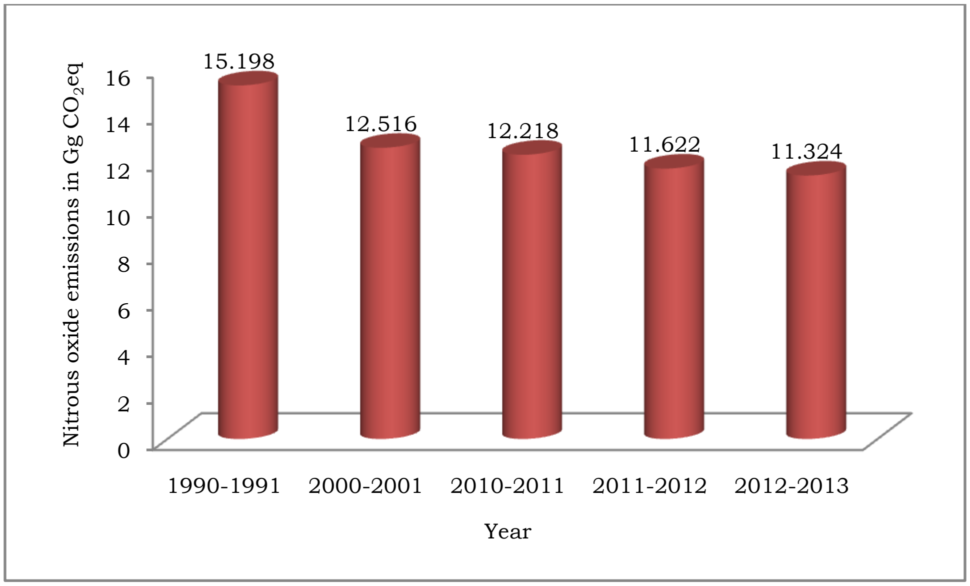
Source: IPCC, 2006

The methane emission from livestock (enteric fermentation) in terms of carbon dioxide equivalent for the year 1990-1991 was 36.125Gg CO_2eq while 2012-2013 was 9.850Gg CO_2eq (Graph 1). A tremendous decrease in the emission from enteric fermentation was observed over the years due to urbanization and infrastructure development in the periphery of Bengaluru urban district, scarcity of grazing places and reduction in fodder production. The enteric fermentation in livestock is highly useful for humankind because it converts coarse and fibrous plants into food for humankind.

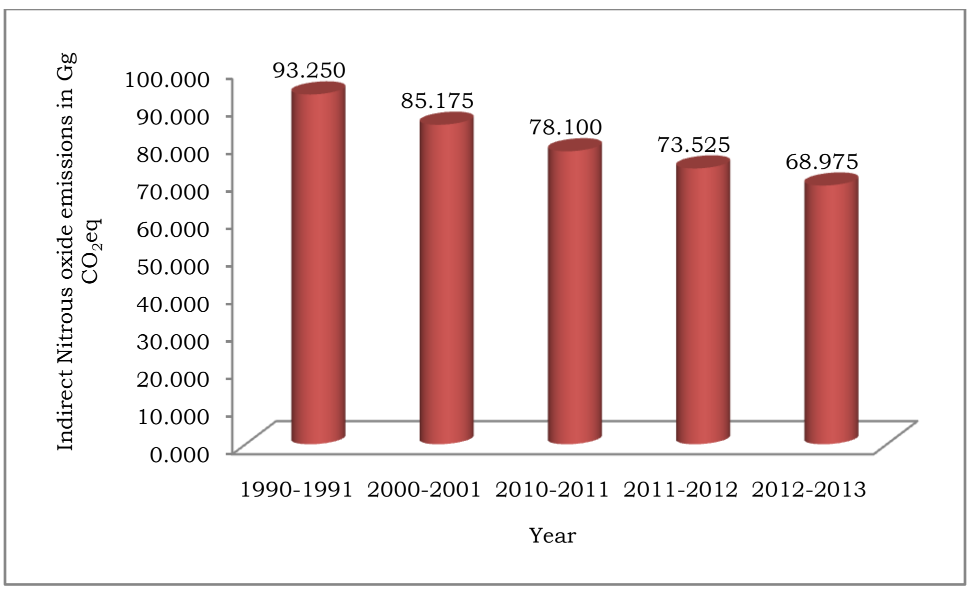


Graph 1:Methane emissions (Gg CO_2eq) from enteric fermentation

However, enteric fermentation in rumen also produces methane through bacterial breakdown of feeds called as methanogenesis. The animals release methane into atmosphere through exhaling or ruminating through mouth or nostrils. Methane production and release accounts for release of digestible energy to atmosphere and therefore inefficient utilization of feed energy. Global emission of methane from digestion process of livestock is about 80 Million tonnes per year and considered to be single largest source of anthropogenic methane emission (IPCC, 2006). Swamy and Bhattacharya (2006) revealed that, more than 90% of the total methane emission in India is from enteric fermentation is being contributed by the large livestock like cow and buffalo, and rest from small livestock. Similarly Chhabra et al., (2009) states that livestock such as dairy cows, buffalo, sheep, goats, rabbit, dogs, pigs and poultry contributes the major proportion of total livestock emission of methane and McMichael et al., (2007) revealed that methane emission from livestock provides enough scope of easy and practical management for reduction in methane emission.



Graph 2:Direct N_2O emissions (Gg CO_2eq) from manure management



Graph 3:Indirect N_2O emissions (Gg CO_2eq) from manure management

The direct and indirect nitrous oxide emissions from livestock (manure management) for the year 1990-1991 was 15.198Gg CO_2eq while 2012-2013 was 11.324Gg CO_2eq (Graph 2) and in the year 1990-1991 was 93.250Gg CO_2eq while 2012-2013 was 68.975Gg CO_2eq (Graph 3) respectively. The direct nitrous oxide emissions occur through combined nitrification and denitrification of nitrogen contained in the manure. The emission of nitrous oxide from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment. To reduce direct and indirect emissions manure management ensure that, manure is not left in the open environment for extended periods of time. Manure kept in open environment will tend to be warmer and will produce more methane. Solid manure management systems, where livestock and poultry are housed on dry bedded manure packs of grass or hay were found to have lower methane emissions when compared to liquid or slurry handling systems.

Conclusion

The study can be concluded that, although livestock are important in agriculture, food production and economic development, the emissions of methane and nitrous oxide to total greenhouse gas emissions is significant. The significant decrease in methane and nitrous oxide (direct and indirect) emissions from the livestock was observed over the years, this may be due to conversion of agriculture land to residential and commercial activities and on the other hand livestock population also decreased. The methane and nitrous oxide (direct and indirect) emissions from manure and enteric fermentation can be mitigate using anaerobic fermentation to produce biogas and inoculating genetically engineered rumen bacteria to reduce methane production by the livestock. The greenhouse gas emissions by livestock needs to be quantified to define the magnitude of the impact of livestock on climate change and to understand their contribution relative to other sources. This kind of information will enable effective mitigation strategies to be designed to reduce greenhouse gas emissions and improve sustainability of the livestock sector.

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