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Research article

Estimation of methane emission from beef cattle of Bangladesh

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A B S T R A C T

Agricultural sector emits large quantities of greenhouse gas, which is responsible for global warming. Some of the major greenhouse gases are methane, carbon dioxide, nitrous oxide etc. In our study, we have estimated the methane emission from beef cattle in Bangladesh. We followed the intergovernmental panel of climate change (IPCC) guidelines throughout our whole study. We used Tier 1 and Tier 2 methods for the calculation of methane emissions from beef cattle in Bangladesh. In the tier 1 method, we calculated the methane emission by using the emission factor provided by IPCC 2006 and 2019. According to IPCC 2019, we also calculated the methane emission using the tier 2 method which is based on dry matter intake. Finally, we have compared our calculated value. After calculation, in 2018, 2019, 2020 and 2021 total emission of methane from beef cattle based on Tier-1 (IPCC-2006) is 9990.00Gg, 10777.75Gg, 9996.75Gg and 10111.50Gg, respectively. Again based on IPCC-2019 emissions of methane are 17020.00Gg, 17169.50Gg, 17031.50Gg and 17227.00Gg, respectively. Using Tier 2 method (IPCC-2019) methane emissions from beef cattle in 2018, 2019, 2020 and 2021 are 16087.60Gg, 16228.91Gg, 16098.47Gg and 16283.26Gg, respectively.

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1. INTRODUCTION

The emission of greenhouse gases (GHGs) is a global concern because of their huge climate change impacts. Among the greenhouse gases, CO_2, CH_4 and N_2O are the major greenhouse gas, where methane is 20% more potent than CO_2.Global CH_4emission was about 570 million tons ofCO_2e, where enteric fermentation of ruminant and their manure management share 31% and 6%, respectively (Das et al., 2020). It is important to accurately determine emissions from ruminants that meet the standardized international guideline for national greenhouse gas inventories (Hoque et al., 2017). The agricultural sector is the major contributor to the emission of greenhouse gas. About 39% of total emission comes from the agricultural subsector activity. Among these31% comes from the enteric fermentation of ruminants. Beef is a ruminant and herbivore animal as enteric fermentation takes places in their digestive system. Methane is produced as a byproduct of enteric fermentation. A total (2-12%) of gross energy is lost during methane production (Das et al., 2020). The number of beef cattle is increasing day by day. In 2016 number of beef cattle was 14.55×10^6and2021 the number of beef cattle was 14.98×10^6 (Das et al., 2020). So accordingly methane production is also increasing. Landfills, oil, natural gas systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment and certain industrial processes all are sources of methane emission. In this study, it was estimated the calculation of total methane emission from beef cattle in Bangladesh perspective. The objectives of this study are to estimate methane emission from beef cattle in Bangladesh and to compare the CH4 emission between T1 and T2 model of IPCC 2006 and 2019.

2. MATERIALS AND METHODS

Based on IPCC there are three methods to estimate methane emission from beef cattle. These are tier1, tier 2 and tier 3. Here it will describe all three methods and will show the calculation of methane estimation based on tier 1 and tier 2.

Tier-1 Method

Most simplified method. Mainly in this report, we used the tier 1 method to calculate the methane emission from beef cattle. For each category, there is IPCC provided emission factors. Then every category was multiplied by the respective emission factor and 25 and divided by 10^6 (Eggelosten et al., 2006).

Total emission for enteric fermentation $= \sum T\{EF(E,T).N(T)\} \times \frac{25}{10^6}$ Gg/year CO_2e

Total emission for manure management= $\sum T\{EF(M,T).N(T)\} \times \frac{25}{10^6}$ Gg/yearCO_2e

Here,

EF=Emission factor
N=Number of cattle
T=Category (beef/others) (Eggelosten et al., 2006).

For the Indian subcontinent, IPCC-2006 and IPCC-2019 provided emission factors for different cattle categories.

Table 1. Emission factor provided by IPCC-2006(Eggelosten et al., 2006).

Category (Beef and Dairy)	Emission factor(kg/cattle/year)
Beef cattle	27
Dairy cattle	58

Based on IPCC-2019, there is an updated form of tier-1 method which is called as tier-1a methods. In case of T-1a system, beef and other cattle are again subdivided into high and low productivity. IPCC-2019 provided an emission factor for each subcategory (Eggelosten et al., 2019).

Table 2. Emission factor provided by IPCC-2019 (Eggelosten et al., 2019).

Category (Beef and Dairy)	Emission factor (kg/cattle/year)
Beef	46
Beef cattle (High productive)	41
Beef cattle (Low productive)	47
Dairy	73
Dairy cattle (High productive)	70
Dairy cattle (Low Productive)	74

Tier-2 Method

The final calculation of thetier-2 system is the same as thetier-1 system. But in case of thetier-2 system, we need to calculate a specific emission factor for each category of cattle while in tier-1 and tier-1a systems emission factor is provided by IPCC. There are three steps of the tier-2 method (Eggelosten et al., 2019).

Steps 1

Livestock population (The animal population data and related activity data) should be obtained.

Steps 2

The emission factors for each category of livestock are estimated based on the gross energy intake and methane conversion factor for the category. The gross energy intake data should be obtained using the following approach. The following sub-steps need to be completed to calculate the emission factor under the tier 2 method (Eggelosten et al., 2006).
Mainly we have performed the calculation of methane emission based on dry matter intake.

So, Emission factor (EF) = DMI× $(\frac{MY}{1000})$.365

Here,
EF = Emission factor, $kgCH_4\ head^{-1}\ yr^{-1}$
DMI = kg DMI per day
MY = Methane yield, $kgCH_4\ kgDMI^{-1}$

Than,

DMI=$BW^{0.75}\times$ $(0.0582.\mathrm{NE_{mf}} - 0.00266.\mathrm{NE_{mf}}2 - 0.0869/0.239\ .\mathrm{NE_{mf})}$

Here,
DMI= Dry matter intake

NE_{mf}=Estimated dietary net energy concentration of the feed or diet
BW=Body weight.

Table 3. Examples ofNE_{mf}content of typical diets fed to cattle for estimation of dry matter intake (Eggelosten et al., 2019).

Diet type	NE_{mf} (MJ (kg dry matter)$^{-1}$)
High grain diet > 90%	7.5 - 8.5
High quality forage (e.g., vegetative legumes and grasses).	6.5 - 7.5
Moderate quality forage (e.g., mid-season legume and grasses).	5.5 - 6.5
Low quality forage (e.g., straws and mature grasses).	3.5 - 5.5

Development of methane yield (MY)

The extent to which feed energy is converted to CH_4 depends on several interacting feed and animal factors and that rate of conversion is embodied in the methane conversion factor (Y_m), defined as the percentage of gross energy intake converted to methane. If we calculate based on 'dry matter intake' another parameter 'Methane Yield (MY)' comes. IPCC provided both Y_m and MY for specific cattle categories (Eggelosten et al., 2019).

Step-3

To estimate total emissions, the selected emission factors are multiplied by the associated animal population and summed. As described above under tier-1, the emissions estimates should be reported in gigagrams (Gg) (Eggelosten et al., 2019).

Tier-3 method

Increased accuracy and identification of causes of variation in emissions are at the heart of inventory purposes. Improvements in country methodology, whether as components of current tier 1 or 2 or if additional refinements are implemented with tier 3, are encouraged.

Japanese T-3 method

Y= -17.766 + (42.793 × DMI) - (0.849×DMI)
MEF= (Y/22.4) × 0.016 × 365

Here,

Y = Daily enteric methane emission per head of cattle (GigagramCH_4/year)
MEF=Methane emission factor (kg CH_4/head/year) (Eggelosten et al., 2019).

Emission of methane based on tier-1 system

Three steps for completing our calculation of the tier-1 system:

Step-1: Categorization and estimation of cattle population. Categories and their population are shown in Table 5. Here, both data are collected according to Das et al. (2020) and we use the AGR (Annual Growth rate) to calculate the population in 2020 and 2021.Here, the AGR is 0.27 for dairy, 0.61 for beef, 0.48 for total (Das et al., 2020).

Table 4. Methane conversion factor (Y_m) and methane yield (MY) provided by IPCC (Eggelosten et al., 2019).

Description	Feed quality digestibility (DE %) and neutral detergent fibre (NDF, % DMI).	MY (g CH_4 kgDMI$^{-1)}$	Ym[3]
> 75 % forage	DE ≤ 62	23.3	7
Rations of >75% high quality forage and/or mixed rations, forage of between 15 and 75% the total ration mixed with grain, and/or silage.	DE 62–71	21	6.3
Feedlot (all other grains, 0- 15% forage).	DE ≥ 72	13.6	4
Feedlot (steam-flaked corn, ionophore supplement in 0-10% forage).	DE > 75	10	3

Table 5. The livestock population of Bangladesh ($\times 10^6$ Heads)(Das et al., 2020) (DLS)

Year	Total cattle	Beef cattle	Dairy cattle
2017	24.10	14.68	9.34
2018	24.16	14.80	9.36
2019	24.31	14.93	9.38
2020	24.21	14.81	9.40
2021	24.40	14.98	9.42

Step-2: Emission factor collection from IPCC guidelines. There is a huge change in emission factors between 2006 and 2019. Here, we will show our calculation by considering both emission factors provided by IPCC in 2006 and 2019. IPCC-2019 provides emission factors for both average categories and subcategories. In our calculation, we will calculate considering the average emission factor. Then we will compare our calculation obtained from considering both emission factors.

Step-3: Estimation of total methane emission by multiplying cattle population with emission factors.

Emission of methane based on tier-2 system (2019)

Step-1 (Methane yield development)

Here methane yield is provided by IPCC-2019 for different cattle categories and subcategories. Bangladesh perspective, methane yield showed in Table 4.

Step-2 (Emission factor development)

For the development of the emission factor, we need a DMI value. Again to estimate DMI value we need the data of body weight followed by the estimated dietary net energy concentration of the feed or diet (NE_{mf}). The NE_{mf} value is given in table 3.

Now we need the body weight from the BLRI acquaintance-16. We found the cumulative live weight (Kg) of native beef cattle of BCB1 (261.3 Kg) or RCC (195.2 kg). So we made an average to calculate the DMI value. The average is 228.25kg at 24 months of age (Talukder, 2017; Das et al., 2020)

Step-3 (Total emission calculation)

Total emissions were calculated by multiplying the number of cattle by the emission factor.

3. RESULTS

For tier-1 Method:

In table 6 we have shown methane emission in gigagram per year based on the emission factor provided by IPCC-2006. In table 7 we have shown methane emission in gigagram per year based on the emission factor provided by IPCC-2019. In table 8, there is a comparison between emission gigagrams per year based on the emission factors provided by IPCC in 2006 and 2019.

Table 6. Methane emission (gigagram per year) based on the emission factor by IPCC-2006.

Years	Emission from beef cattle
2018	9990.00
2019	10077.75
2020	9996.75
2021	10111.50

Table 7. Methane emission in gigagram per year based on the emission factor provided by IPCC-2019.

Years	Emission from beef cattle
2018	17020.00
2019	17169.50
2020	17031.50
2021	17227.00

Table 8. Comparison between emissions (gigagram per Year) based on emission factors provided by IPCC in 2006 and 2019.

years	Emission from beef cattle based on IPCC 2006	Emission from beef cattle based on IPCC 2019
2018	9990.00	17020.00
2019	10077.75	17169.50
2020	9996.75	17031.50
2021	10111.50	17227.00

For tier-2 method

Our calculation of methane emissions based on the tier-2 system is shown in table 9 according to IPCC-2019. In table 10, there is a comparison between the calculation of methane emission using tier-1 and tier-2 systems.

Table 9. Methane emissions based on the tier-2 system.

Year	No of beef cattle (Das et al., 2020)	Emission from beef cattle (2019)
2018	14.80	16087.60
2019	14.93	16228.91
2020	14.81	16098.47
2021	14.98	16283.26

4. DISCUSSION

Tier-1 method

Here, based on IPCC-2006 in 2018, 2019, 2020 and 2021 total methane emissions from beef cattle are 9990.00, 10077.75, 9996.75 and 10111.50 gigagrams, respectively and based on the IPCC-2019 these are 17020.00, 17169.50, 17031.50 and 17227.00 gigagrams, respectively. So, we are seeing that for the difference of emission factor at IPCC-2006 and IPCC-2019 there are difference of around 7115.50 gigagrams emission of methane every year from beef cattle. Again according to Mahmud and Biswas (2022), the methane emission based on the tier 1 method (IPCC 2006) in dairy cattle is 539.58, 541.72 542.88 and 544.04 gigagrams in 2016, 2017, 2018 and 2019, respectively. According to IPCC 2019 the emission is 679.63, 681.82, 683.28 and 684.74 gigagrams in 2016, 2017, 2018 and 2019, respectively (Mahmud and Biswas, 2022).

Tier-2 method

Here, our calculated emission factor for beef cattle is 43.48 kg/cattle/year respectively which is slightly different from IPCC-2006 provided value. In 2018, 2019, 2020 and 2021 our calculated emissions of methane from beef cattle are 16087.60, 16228.91, 16098.47 and 16283.26 gigagrams of methane, respectively.
If we see our calculation of total emissions based on Tier-1 (IPCC-2006) and Tier-2 (DMI basis) in 2018, 2019, 2020 and 2021 total emissions of methane calculated using the Tier-1 method are 9990.00, 10077.75, 9996.75 and 10111.50 gigagrams of methane respectively and based on Tier-2 method total emissions 16087.60, 16228.91, 16098.47 and 16283.26 gigagrams of methane, respectively.

We can see a difference of around 6171.76 gigagrams of methane emission between the calculation using the Tier-1 and Tier-2 methods every year. Again according to Mahmud and Biswas (2022) the methane emission based on the tier 2 method (IPCC 2006) in dairy cattle is 544.63, 546.39, 547.56 and 548.73 gigagrams in 2016, 2017, 2018 and 2019, respectively (Mahmud and Biswas, 2022).

In Jahan and Azad (2013) a gradual increase of emission methane from 1983 to 2009 was shown. In our study, we can also see the gradual increase in the emission of methane from 2018 to 2021 by using every method of calculation.

5. CONCLUSION

As the beef cattle population is increasing day by day in Bangladesh, so methane production is also increasing. Following this, greenhouse effects are uprising. So the result of this situation is increasing global warming, air pollution resulting respiratory diseases and others. As it is high time to reduce methane emission from the animal. Collection of the expiratory gases of cattle and processing them into useful things can be the solution of this problem.

Table 10. Comparison of methane emission (Gigagram per year) between tier-1 system based on the IPCC-2006 and 2019 and tier-2 system based on the IPCC 2019 (Eggelosten et al., 2019).

Years	Emission from beef cattle Tier-1 system(2006)	Emission from beef cattle Tier-1 system (2019)	Emission from beef cattle Tier 2 system (2019)
2018	9990.00	17020.00	16087.60
2019	10077.75	17169.50	16228.91
2020	9996.75	17031.50	16098.47
2021	10111.50	17227.00	16283.26

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