Estimation of Greenhouse Gas Emission from the Livestock Sector of Bangladesh

Sayka Jahan[1], Dr. Abul Kalam Azad[2]

[1]Environmental Science and Technology Department, Jessore University of Science and Technology, Bangladesh

[2]Environmental Science Department, Khulna University, Bangladesh

Abstract: ***Livestock's are a significant contributor to global greenhouse (CH_4, N_2O) gas emissions. Greenhouse gas (GHG) emissions from the livestock sector are confined to enteric fermentation and manure management. The present study focused on estimation of GHGs emission from livestock sector by using country specific emission factors for individual livestock population and annual head of different livestock population. From the emission estimation it has been found that, in the year 2008-09 the estimated GHG emission is 601.25 Gg CH_4 and 17.97 Gg N_2O, in 2005-06 the emission was 578.96 Gg CH_4 and 16.99 Gg N_2O whereas in 1996 it was 521.62 Gg CH_4 and 14.69 Gg N_2O. From the emission trend it is found that, GHGs emission from livestock sector is in increasing trend in which methane emission is the dominant one, while nitrous oxide is negligible. Enteric fermentation is the major source (about 80%) of methane emission whereas manure management contributes other 20%. Again pasture range and paddock (grazing) is the main source of nitrous oxide emission which accounts for about 74% of the total nitrous oxide emission. Ruminants, especially bovines are the largest source (91%) of methane emission. The estimate also highlights methane emissions from dairy and non-dairy bovines and vulnerability of climate changes, which are useful in formulating mitigation strategies.***

Keywords: Greenhouse gas, Anaerobic Lagoon, Methane, Animal Waste Management System

1. Introduction

The agricultural sector emits large quantities of greenhouse gases (GHGs) which is responsible for global warming. Agriculture's global share of anthropogenic emissions has been estimated to be about fifty percent of methane, seventy percent of nitrous oxide, and twenty percent of Carbon dioxide (Cole *et al*., 1996). Contributions across countries vary with large differences existing between developing and developed countries. Agriculturally based emissions in developing countries largely arise from livestock rearing, manure management, deforestation and land degradation. Increased livestock production in developing countries results in additional income and employment. But intensified production in particular also produces problems: emissions are a source of environmental pollution. Ruminants such as cattle, sheep, goats and camels produce enormous amounts of methane gas as a by-product of digestion. Livestock production also results in greater accumulation of carbon dioxide and nitrogen oxide. Recent estimates have shown that livestock are consequently among the leading causes of the greenhouse effect world-wide. (***C***. de Haan, *et.al.2001*)

But emissions in developed countries are largely caused by fossil fuel based emissions through energy use; reductions in soil carbon through intensive tillage; nitrous oxide emissions through fertilizer applications, livestock feeding, residue management, and tillage (Watson *et al.*, 2008); methane emissions from livestock raising and rice production (Hayhoe, K.A.S.,1997).

Bangladesh which is a agriculture based country rear huge amount of Livestock's, is a significant contributor to global methane (CH_4) emissions. Although methane emissions from livestock systems are the largest global source of methane, representing 20 to 25% of all sources of methane gas emissions in the 1990 inventory (Environment Protection Agency, 1994), nitrous oxide and carbon dioxide are also produced by livestock systems. Sources of greenhouse gas from livestock systems include (i) methane from the digestive tract of cattle and livestock effluent management; (ii) nitrous oxide from agricultural soils, including nitrogen excreted in livestock faeces and urine, and nitrogen fertilizer application; and (iii) carbon dioxide from the combustion of fuels used in farm vehicles, tractors and pumps, and from fuel used to generate electricity consumed by the system (IPCC, 1997).

The main aim of this study is to estimate the emission of Green House Gases from the livestock sector of Bangladesh along with its trends of emission. At present days green house gases are very important study because of global warming problem. Bangladesh might be affected with this problem very soon. As a large amount of methane and other green house gases are emitted from our livestock sector, so the estimation of the emission of these gases is very important.

2. Materials and Methods

The study area had been selected according to the research objectives which are essential aspects for the study. The study area is selected for estimating the amount of different GHGs (CH_4, N_2O, and CO_2) emission from Livestock Sector in Bangladesh. Bangladesh is a South- Asian developing country; located Bangladesh stretches latitudinal between $20^0 34'$ N and $26^0 33'$ N, and longitudinally between $88^0 01'$ E and $92^0 41'$ E. This emission of GHGs is calculated according to the methodology of "2006 IPCC Guidelines: Methodology for Greenhouse Gas Emission from Agriculture Sector" (IPCC, 2006). The first method called as Tier 1, is used in this study and it is the simplest method and gives a rough estimation. According to IPCC guidelines (2006), the general methods for emission estimation from different source are given below.

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2.1 Methane emission from domestic livestock

The domestic livestock produce methane from two ways, one is enteric fermentation and another one is manure management.

2.2 Methane emission from enteric fermentation

Emission from enteric fermentation is calculated by the following equation (1).

Emission (Gg) = LP*EF CH_4 Kg*Gg. 10^{-6} Kg^{-1}……………… (1) (IPCC, 1996)

Where,

LP: Livestock Population (head per year)

EF: Emission Factor (Kg CH_4 per head per year)

Since Bangladesh does not have any country specific data on methane emission from livestock enteric fermentation, we have used the Indian coefficients in estimating methane emission. Indian coefficients were obtained from Dr. A. P. Mitra of National Physical Laboratory. It is expected that the use of Indian coefficient will not result in major deviation from the actual emission as cattle rearing and production systems in the two countries are some extent similar. This is to be noted here that the emission factors for sheep and goats are directly taken from IPCC default values (IPCC, 1996). The default methane emission values from manure management of each livestock type, as presented in the GHG Emission Inventory Workbook (ICF Inc., 1995), are used for the estimation.

2.3 Methane emission from manure management

Methane emission from manure management is calculated by the following equation (2).

Emission (Gg) = LP*EF CH_4 Kg*Gg. 10^{-6} Kg^{-1}… (2) (IPCC, 1996)

Where,

LP: Livestock Population (head per year)

EF: Emission Factor (Kg CH_4 per head per year)

2.4 Estimating N_2O emissions from animal waste management systems

The most important parameters for estimation of nitrous oxide are derivation of nitrogen excretion that is generally expressed as kg N/animal/yr. In the absence of any reliable data from the Indian subcontinent, the default values are the most appropriate and useful though there are uncertainties in the values listed in relevant tables of IPCC. According to the guidelines, cattle (dairy and non-dairy), pigs and poultry only account for the nitrous oxide emissions and other animals like sheep, goat, camels, which do not account for manure management under wet system, are eliminated from the category of animals producing N_2O from AWMS.

Step 1: Population data same as used for estimation of methane from enteric fermentation and manure management.

Step 2: Nitrogen excretion – Values provided by IPCC are used for estimating nitrogen excretion/ animal. Dairy cattle – 60, Non-dairy cattle – 40, pigs – 16 and poultry – 60 kg/animal/yr.

Step 3: Nitrogen excretion from AWMS systems is derived as percentage of N_2 excretion from total N_2 excretion from animals according to IPCC guidelines.

Step 4: N_2O emission per animal is determined by multiplying the nitrogen excretion (N_2-AWMS) using emission factors (EF3) according to IPCC guidelines. IPCC default emission factor for Asia is N_2O – N/kg nitrogen excreted; Anaerobic lagoons and liquid systems = 0.001; others systems = 0.005.

Step 5: Total emission is determined by multiplying the number of animals in each category with the emission factor. Emissions from all categories are aggregated and total emission expressed as Gg nitrous oxide/yr.

Equation 2.1

$Nex_{(AWMS)} = \sum_{(T)}[N_{(T)} \times Nex_{(T)} \times AWMS_{(T)}]$…………………(3.1) (IPCC, 1996)

Where:

Nex (AWMS) = N excretion per Animal Waste Management System (Kg/yr).

$N_{(T)}$ = number of animals of type T in the country;

$Nex_{(T)}$ = N excretion of animals of type T in the country (kg N/animal /yr

$AWMS_{(T)}$ = fraction of $Nex_{(T)}$ that is managed in one of the different distinguished animal waste management systems for animals of type T in the country.

T = type of animal category.

2.5. Nitrogen excretion per AWMS

Calculation of Nitrogen Excretion per Animal Waste Management System (AWMS):

1) Enter the Number of Animals, N, in a country in column A.
2) Enter the Nitrogen Excretion, Nex, for each animal type in column B.
3) Enter the Fraction of Manure Nitrogen per AWMS in column C.
4) Multiply columns A, B, and C, and enter the results into column D.
5) Sum the values in column D and enter the total in the bottom of the column to obtain the Nitrogen Excretion for each AWMS, Nex (AWMS), in kilograms per year.

Equation 2.2

$N_2O_{(AWMS)} = \sum [Nex_{(AWMS)} \times EF_{3\,(AWMS)}]$………………….(3.2) (IPCC, 1996)

Where:

$N_2O_{(AWMS)}$ =N_2O emissions from all Animal Waste Management Systems in the country (kg N/yr);

$Nex_{(AWMS)}$ = See Equation 3.1, above;

$EF_{3\,(AWMS)}$ =N_2O emission factor for an AWMS (kg N_2O-N/kg of Nex in AWMS);

3. Result and Discussion

3.1The trends of livestock population in Bangladesh

The increasing trend of livestock population from 1983-84 to 2008-09 is shown in the Figure 1.1.

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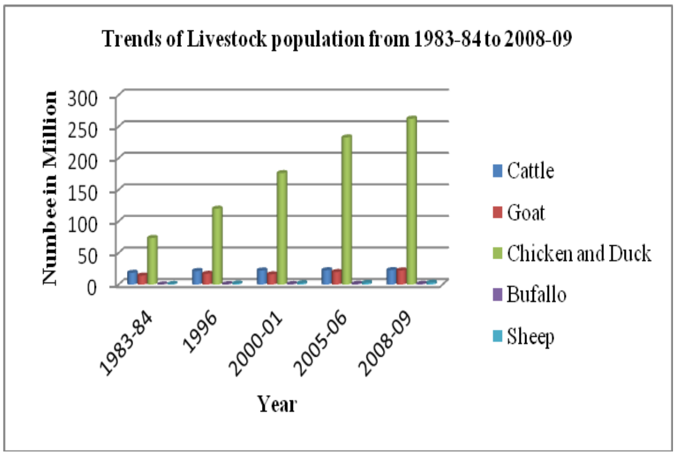

Figure 1.1: Increasing trend of livestock population from 1983-84 to 2008-09.

3.2 Total Emission of Green House Gases from Livestock Sector

In Bangladesh domestic animals such as cattle, buffalo, sheep, goat and poultry accounts for the emission of CH_4, N_20 as a byproduct of enteric fermentation, manure management, anaerobic lagoon and other liquid system. In enteric fermentation methane emission results from normal digestive processes occurs in animal whereas manure management produces methane during the anaerobic decomposition of manure.

Methane emission from enteric fermentation

In Bangladesh total CH_4 emission from enteric fermentation has been calculated 407.15 Gg in 1983-84, in 1996 it was 434.98 Gg and in 2008-09 it was 502.10 Gg. The trend of CH_4 emission from enteric fermentation is gradually increasing which has been shown in the Figure 1.2

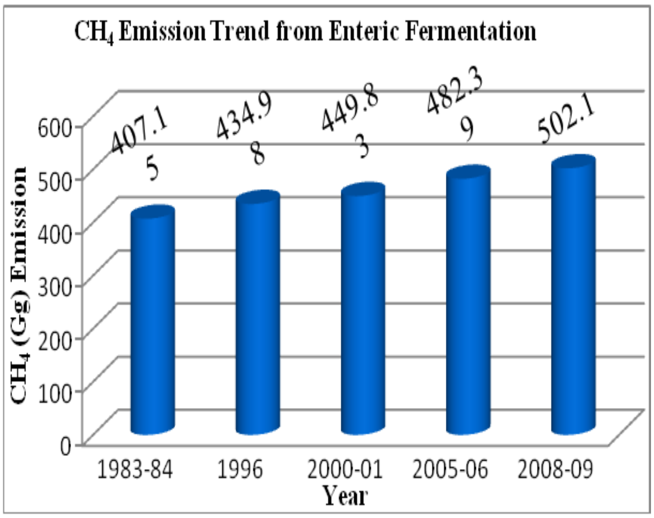

Figure 1.2: Increasing trend of CH_4 emission from 1983-84 to 2008-09.

In Bangladesh only four types of livestock is responsible for the emission of CH_4 by the enteric fermentation. The major contribution of this emission occurs from cattle which are about 322.5 Gg in 1983-84 and in 2008-09 it is about 344.5 Gg. The trend of CH_4 emission from the year 1983-84 to 2008-09 from cattle is given in Figure 1.3.

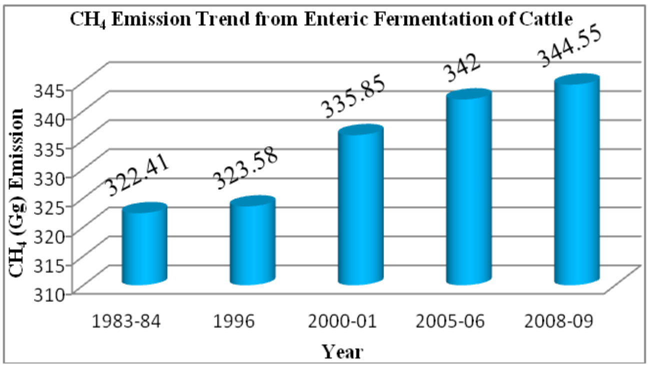

Figure 1.3: CH_4 emission trend from enteric fermentation of cattle (1983-84 to 2008-09)

The second major contribution of CH_4 emission occurs from enteric fermentation of goat which is about 71 Gg in 1983-84, in 1996 it is 85.60 Gg and in 2008-09 it is 112 Gg. The increasing trend of CH_4 emission from the year 1983-84 to 2008-09 from goat is shown in Figure 1.4.

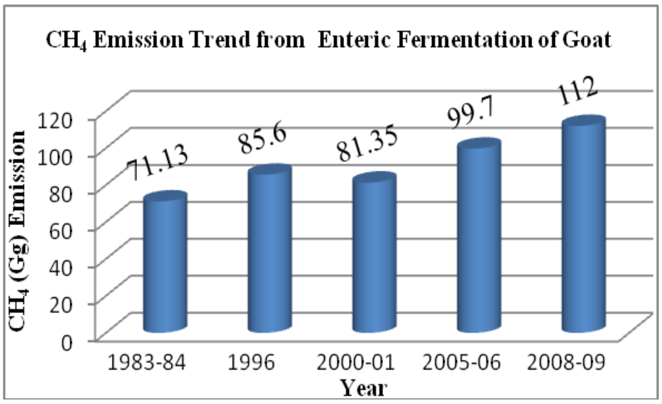

Figure 1.4: CH_4 emission trend from Goat (1983-84 to 2008-09)

From the Figure 1.4, it has been shown that the amount of CH_4 emission from goat is increasing from year to year except in 2000-01; it was probably the catastrophic flood in 1998. Thus greenhouse gas emission from enteric fermentation is very significant because of its large amount. Four types of livestock such as cattle, goat, sheep and buffalo is responsible for the CH_4 emission from enteric fermentation. Poultry is not considered for CH_4 emission from enteric fermentation.

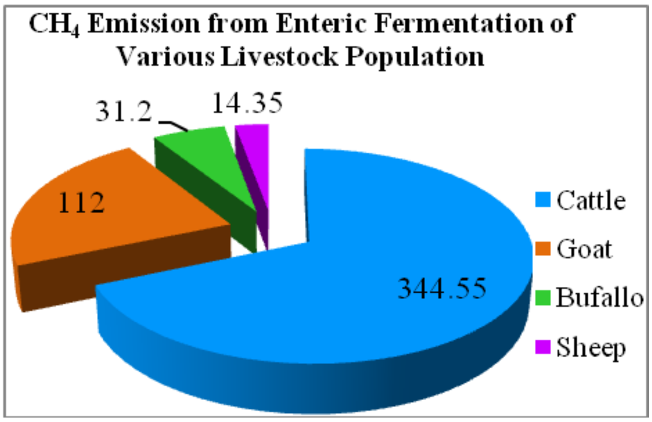

Figure 1.5: CH_4 emission (Gg) from enteric fermentation in 2008-2009

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Again if we use direct emission factor given by IPCC Guideline, then the greenhouse gases that emitted from the livestock sector of our country become much greater than that the study value by using the value of Dr. A. P. Mitra. According to Dr. A.P. Mitra's emission factors in 2008-09 the emission of CH_4 from enteric fermentation is 502.1 Gg where as by using the value of IPCC, CH_4 emission from enteric fermentation is 1018.11 Gg. The comparison between these two results is shown in Figure 1.6.

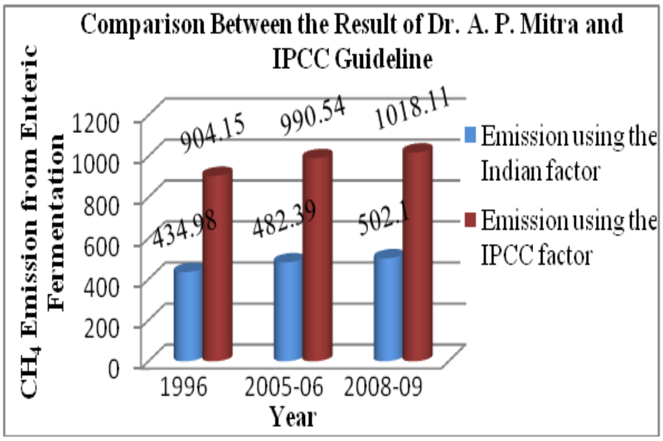

Figure 1.6: CH_4 emission from enteric fermentation by using the emission factor of IPCC and Dr. A. P. Mitra

The other emission factor given by Dr. A.P. Mitra are not significantly differ from IPCC, hence the result does not vary.

Methane emission from manure management

Total CH_4 emission from manure management has been calculated 80.7 Gg in the year 1983-83, in 1996 it was 86.64 Gg and in 2008-09 it was 99.15 Gg. The trend of CH_4 emission from manure management is gradually increasing which has been shown in the Figure 1.7.

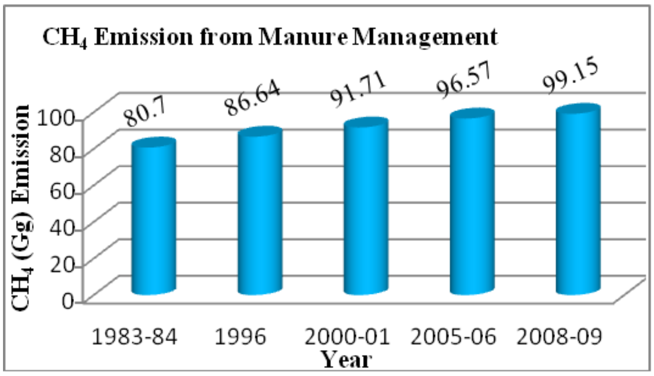

Figure 1.7: Increasing trend of CH_4 emission from manure management from 1983-84 to 2008-09.

CH_4 emission from dairy cattle is much greater than non-dairy cattle. The reason behind these is the emission factor. Emission of CH_4 from dairy cattle is 54.81 Gg in 1983-84 and from non-dairy cattle it is 21.06 Gg, in 1996 CH_4 emission from dairy cattle is 55.01 Gg and from non-dairy it is 21.14 Gg and in 2008-09 emission from dairy cattle is 58.57 Gg and from non-dairy it is 22.51 Gg. The emission comparison between dairy and non-dairy cattle is shown in the Figure 1.8.

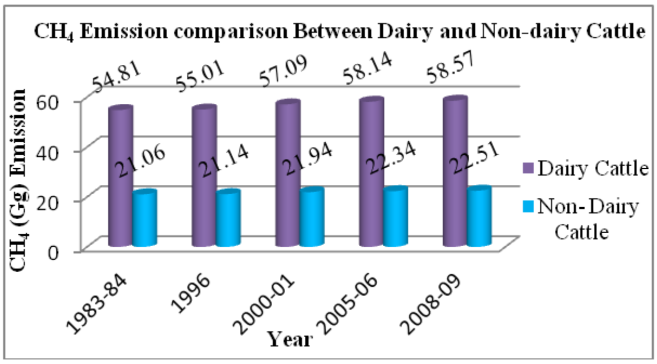

Figure 1.8: Comparison of CH_4 emission between dairy and non-dairy cattle from manure management from 1983-84 to 2008-09.

From manure management emission of CH_4 from other livestock like buffalo, goat, sheep and poultry is insignificant in comparison to the cattle population. CH_4 emission from the manure management of other livestock is shown in the Figure 1.9.

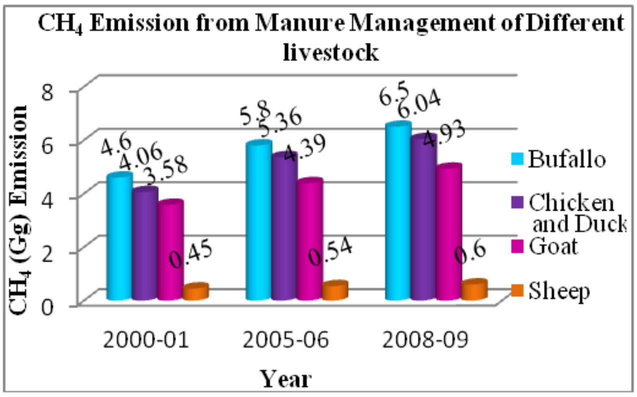

Figure 1.9: CH_4 emission from manure management of different livestock population

Estimated methane emission from different livestock population

CH_4 emission from enteric fermentation and manure management of different livestock is increasing over the years. In 1983-84 total CH_4 is 482.75 Gg, in 1996 it is 521.62 Gg, in 2000-01 it is 541.54 Gg and in 2008-09 it is 601.25 Gg. The increasing trend of CH_4 emission from different livestock is shown in Figure 1.10.

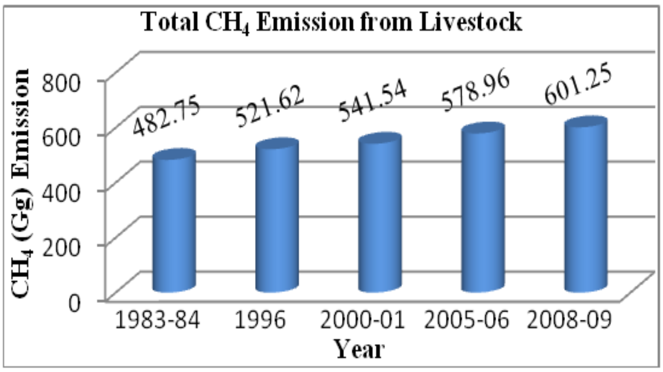

Figure 1.10: Total emission of CH_4 from livestock (1983-84 to 2008-09).

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N_2O emission from anaerobic lagoon/liquid system and any other system

N_20 emission from livestock population occurs mainly from anaerobic lagoon, liquid system, daily spread, Pasture range and paddock (grazing) and other system. This emission from livestock population is very insignificant. Among all the livestock, cattle both dairy and non-dairy contribute significant amount of N_2O in comparison with others. The emission of N_2O that occurs from both dairy and non-dairy cattle over the year 1983-84 to 2008-09 is shown in Figure 1.11.

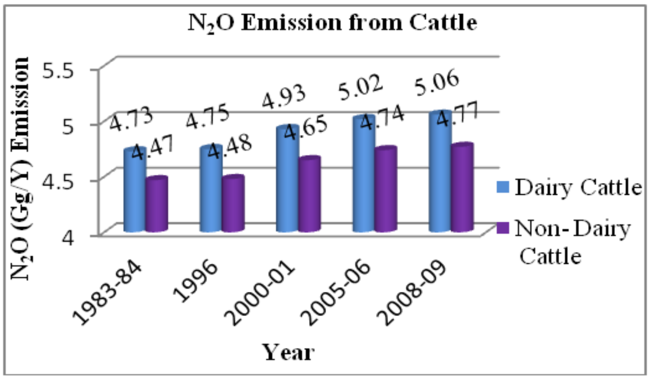

Figure 1.11: N_2O emission from cattle from 1983-84 to 2008-09

In case of dairy cattle, Pasture range and paddock (grazing) and used fuel contribute larger amount of N_2O in comparison with the anaerobic lagoon and liquid system. For dairy cattle N_2O from various systems is shown in the Figures 1.12 and 1.13.

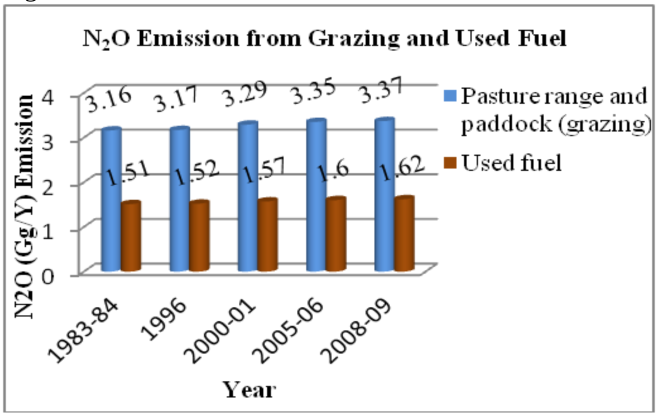

Figure 1.12. Emission of N_2O from Grazing system and used fuel of dairy cattle (1983-84 to 2008-09).

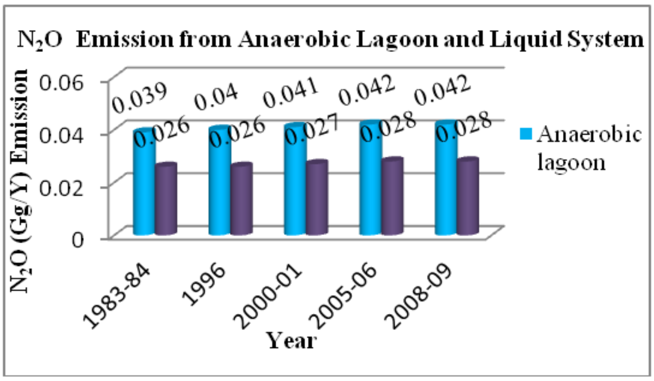

Figure 1.13: Emission of N_2O from Anaerobic lagoon and Liquid system of dairy cattle (1983-84 to 2008-09).

In case of non-dairy cattle Solid storage and drylot, Pasture range and paddock (grazing) and used fuel is responsible for N_2O emission. Among the system Pasture range and paddock (grazing) emits larger amount than other two systems, which is shown in the Figure 1.14.

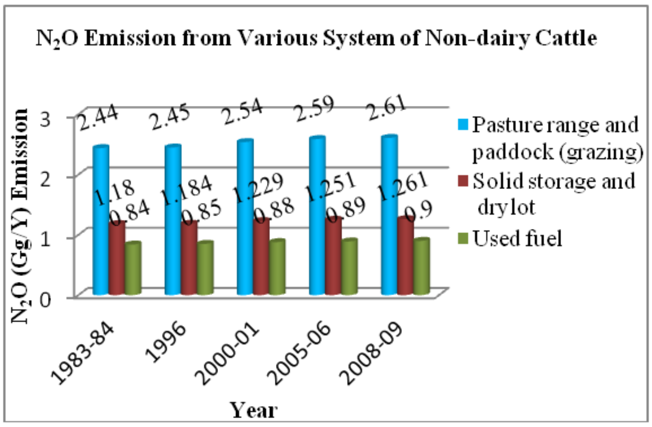

Figure 1.14: Emission of N_2O from various system of non-dairy cattle (1983-84 to 2008-09).

For buffalo there is no separate value for nitrogen production percentage. In this case value of non-dairy cattle is used for estimation of N_2O production. From buffalo N_2O produced from three ways, these are Solid storage and drylot, Pasture range and paddock (grazing) and used fuel. Emission from this system is shown in Figure 1.15.

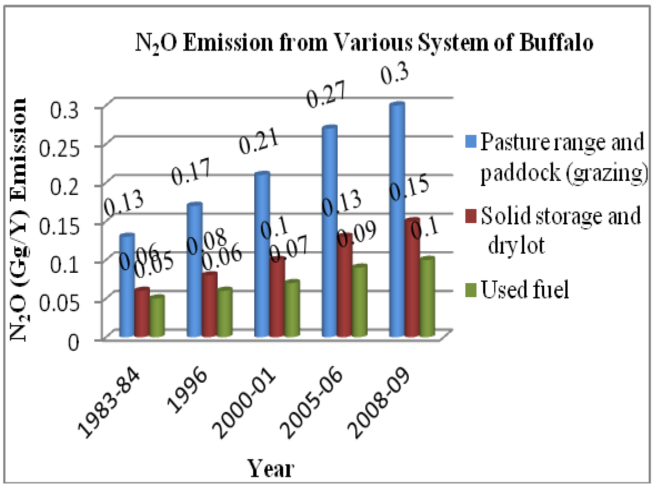

Figure 1.15: Emission of N_2O from various system of Buffalo (1983-84 to 2008-09).

N_2O from goat and sheep population occurs from Pasture range and paddock (grazing) and others system, in which Pasture range and paddock (grazing) system contributes the major part. The amount of N_2O that emits from goat and sheep is shown in Figure 1.16.

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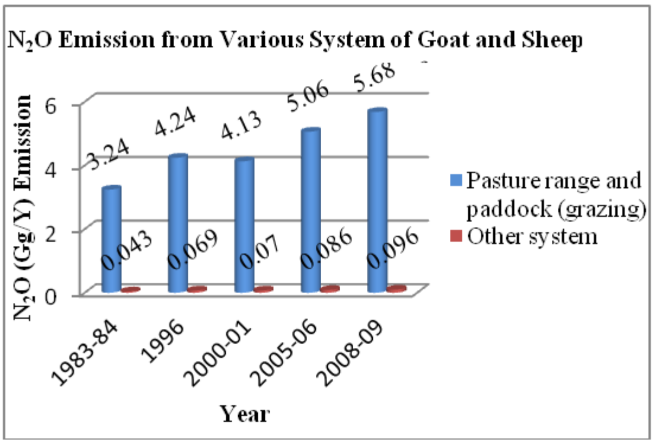

Figure 1.16: Emission of N_2O from various system of Goat and sheep (1983-84 to 2008-09).

Probably poultry emits N_2O from various sources although the amount of which is very insignificant. N_2O that emits from anaerobic lagoon, liquid system, Pasture range and paddock (grazing), used fuel and other system is shown in Figure 1.17.

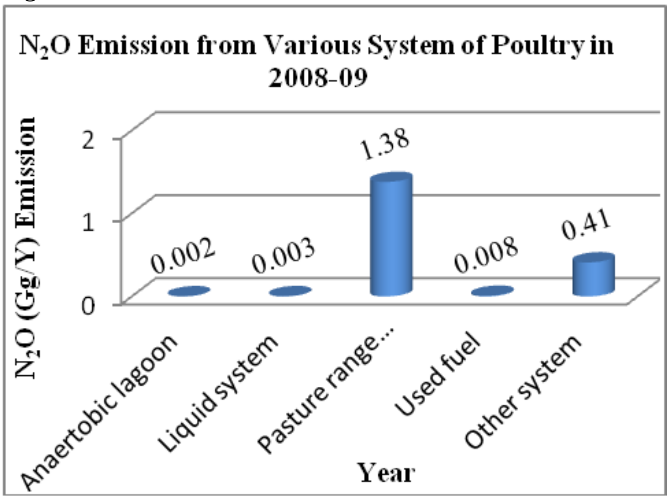

Figure 1.17: Emission of N_2O from various system of Poultry in 2008-09.

From the Figure 1.17 it is also seen that, Pasture range and paddock (grazing) contribute larger amount than other system.

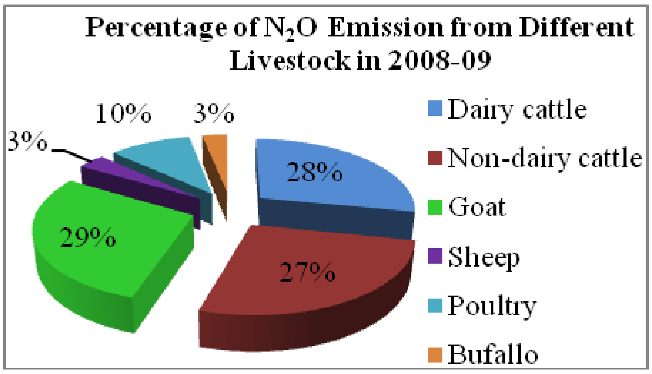

Figure 1.18: Percentage of N_2O from various Livestock in 2008-09

From the year 2008-09 it is found that, cattle both dairy and non-dairy contribute 55% of the total N_2O emission, goat contribute 29%, buffalo contribute 3%, poultry 10% and sheep Contribute 3% of the total N_2O emission. The percentage of contribution by different livestock is shown in the Figure 1.18.

The Trends of Green House Gas Emission

In Bangladesh there is no separate data for estimating green house gases from livestock sector. Again, probably there is no research available on estimating green house gases from this sector. But by using, data of Dr. A. P. Mitra of National Physical Laboratory, India and default values from IPCC guidelines, 2007, I have estimated the amount of green house gases that emits from the livestock sector of Bangladesh. From the estimation it is found that, all types of livestock available in Bangladesh is responsible for the emission of CH_4 and N_2O. It is found that, with the increase of livestock population the amount of CH_4 and N_2O emission is also increasing. The increasing trend of CH_4 and N_2O emission from livestock population over the year is shown in Figure 1.19 and 1.20.

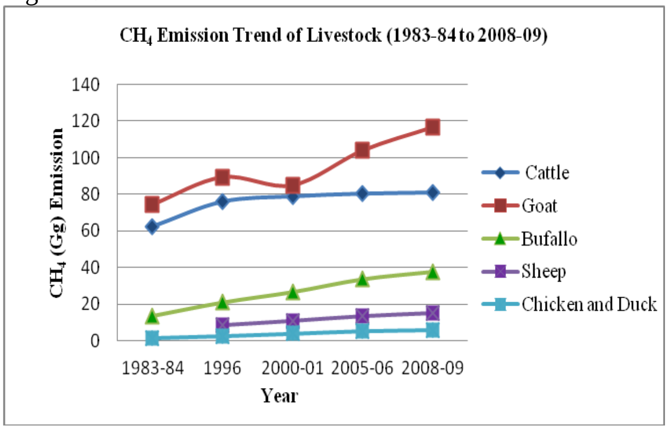

Figure 1.19: CH_4 emission trend of different livestock population.

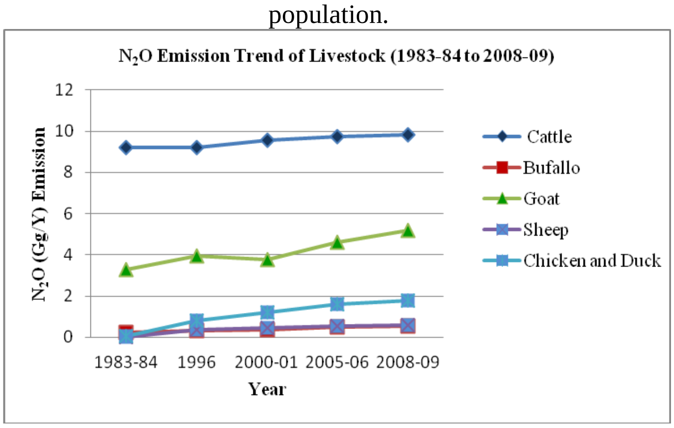

Figure 1.20: N_2O emission trend of different livestock population.

4. Comparison with Other Study

Very limited data are available for comparing the estimated greenhouse gases (GHGs) emission from livestock sector in Bangladesh. Probably there is no separate work carried out for emission estimation of livestock in Bangladesh. It's mentionable that the present study has a sufficient resemblance with the National Greenhouse Gas Inventory, Bangladesh, 1990. National Greenhouse Gas Inventory of Agriculture Sector, Bangladesh represents some data on livestock which has been shown in Table 1.1

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Table 1.1: National Greenhouse Gas Inventory of Agriculture Sector in 1990.

Source	CO_2 Emission	CH_4	N_2O	CO_2 equivalent (excluding TBB)	% of total CO_2 equivalent
Agriculture	2,383.780	1366.460	.110	28729.760	61.05%
1.Enteric fermentation		518.690		10892.490	23.15%
2.Manure Management		73.070		1534.470	3.26%
3.Rice cultivation		770.00		16170.000	34.36%
4.Field burning of agriculture residue	2383.980	4.700	.110	132.800	.28%

Source: Ahmed and Rehman, 1998.

The Table 1.1 shows that, in 1990 CH_4 emission from enteric fermentation is 518.690 Gg and CH_4 emission from manure management is 73.070 Gg. The present study results have been compared with the above National Greenhouse Gas Inventory, Bangladesh, 1990 result in the Table 1.2. Study results compares here with above result with study in 1990-91 and 2008-09. Present study has not conducted the estimation of greenhouse gases from livestock sector in 1990-91 because of data unavailability.

Table 1.2: Comparison with present and 1990 result of National Greenhouse Gas Inventory, Bangladesh

Sources of GHGs emission	GHGs emission(Gg) from agriculture sector in 1990-91	GHGs emission(Gg) from Livestock sector in 2008-09
1.Enteric fermentation	518.690 as CH_4	502.1 as CH_4
2.Manure management	73.070 as CH_4	99.15 as CH_4
3. Anaerobic Lagoon /Liquid System or Others	0.110 as N_2O	17.97 as N_2O

Source: Estimated result, 2010

Bangladesh Department of Environment (DoE) estimated National Greenhouse Gas Inventory of Agriculture Sector in 1990, Bangladesh (Source: Ahmed and Rehman, 1998) that Bangladesh emits 591.760 Gg CH_4 from livestock sector both by enteric fermentation and manure management. But from the present study it is found that, in 2008-09 domestic livestock produce 601.25 Gg CH_4. The result shows that in 2008-09 emission of CH_4 is near to that of CH_4 emission in 1990. The reason behind this, Department of Environment in National Greenhouse Gas Inventory of Agriculture Sector, 1990 used the emission factor given by IPCC guideline. But present study used emission factor for enteric fermentation given by Dr. A. P. Mitra of National Physical Laboratory, India. The emission factor of Dr. A. P. Mitra varies from the emission factor given by IPCC. Because Dr. A. P. Mitra calculates emission factor based on the characteristics(body weight, food types of livestock, amount of milk given by dairy cattle, temperature, etc) of the sub-continent. In case of N_2O emission from livestock sector in Bangladesh, there is no data available for cross checking. But from present study it is found, amount of N_2O that is emitted from livestock population in 2008-09 is 17.97 Gg/Y.

5. Conclusion

In the present study number of livestock population, emission estimation of GHGs from the livestock sector and their trend over the years has been analyzed. From the study result it is found that, the livestock population is increasing over the years and comprises the CH_4 emission by enteric fermentation and manure management and N_2O from anaerobic lagoon, liquid system or any other system. The GHGs emission from livestock sector has been estimated for both 2008-09 and for past twenty five years to analyze the present emission and its trend from livestock sector in Bangladesh.

- In the year 2008-09 total GHGs emitted from livestock sector in Bangladesh are amounted 601.25 Gg CH_4 from both by enteric fermentation and manure management (in which 502.1 Gg from enteric fermentation and 99.15 Gg from manure management) and 17.958 Gg N_2O from various system of livestock sector.
- The major contribution of CH_4 emission occurs from cattle which are about 398.28 Gg in 1983-84 and 425.63 Gg in 2008-09. Again CH_4 emission from dairy cattle is much greater than non-dairy cattle. The second major contribution of CH_4 emission occurs from goat which is about 74.26 Gg in 1983-84 and 116.93 Gg in 2008-09. Buffalo, sheep and poultry emitted small amount of CH_4.
- Among the livestock population, cattle both dairy and non-dairy contribute significant amount of N_2O in comparison with others. The amount of N_2O that is emitted by cattle is 9.20 Gg in 1983-84 and in 2008-09 it is 9.83 Gg. From the year 2008-09 it is found that, cattle both dairy and non-dairy contribute 55% of the total N_2O emission, goat contribute 29%, buffalo contribute 3%, poultry 10% and sheep Contribute 3% of the total N_2O emission. Again among all the system Pasture range and paddock (grazing) system contribute about 74% of the total N_2O emission.

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