Greenhouse Gas Emission (GHG) from ruminant on 2016 at Central Sulawesi Province

F F Munier, Wardi and M Takdir
Assessment Institute for Agriculture Technology of Central Sulawesi
Jl. Poros –Kulawi Km 23 Sigi Districts, Palu, Sulawesi Tengah

E-mail : wardiok1@gmail.com

Abstract. Ruminant is the one of sectors livestock that contribute to increase global warming originates manure and animal eructation. Ruminant sector accounted for carbon dioxide (CO\textsubscript{2}), methane (CH\textsubscript{4}), nitrous oxide (N\textsubscript{2}O), and ammonia that caused the acid rain. The objective of this research was to determine the contribution of livestock sector for greenhouse gas emission (GHG) on 2016 at Central Sulawesi. The research was used ALU Tool software to calculate the emission of GHG. Data source were from livestock population and emission factors (EF) of CH\textsubscript{4} and N\textsubscript{2}O of any livestocks. The results showed that Central Sulawesi Province contribute to 574.020 (Gg CO\textsubscript{2}e) emission a year from ruminant. Big Rumintant or Beef cattle is the main contributor on GHG emission in form of enteric fermentation CH\textsubscript{4} 453.550 (Gg CO\textsubscript{2}e), as much as 76.42%. Small rumintant is the production of N\textsubscript{2}O from goats as much as 106.021 (Gg CO\textsubscript{2}e) or equivalent to 17.12 %.

1. Introduction
Indonesia First Biennial Update Report (1st BUR) [1] reported that total Greenhouse Gas (GHG) emissions from all sectors increased by around 3.6% per year. Agricultural contribution is only 7.8% of total GHG emissions and the increase of 1.3% per year for livestock sector. While the contribution of agricultural sector is quite small, the government program for self-sufficiency of food including livestock products will encourage an increase of agricultural area and livestock population [1]. Vlaming [2] in Widiawati [3] CH4 gas has a greater effect than CO2 gas on global warming, because the power to capture CH4 gas heat is 25 × CO2. Widiawati (2013) states that nationally, the contribution of GHG from the livestock sector is still relatively low at <1.5% of the total national GHG. The livestock sector contributes methane (CH4), carbon dioxide (CO2), nitrous oxide (N2O) and ammonia which can cause acid rain due to human intervention.

Ruminant is the one of sector that contributes to increase global warming originates manure and animal eructation. Livestock sector contributes carbon dioxide (CO\textsubscript{2}), methane (CH\textsubscript{4}), nitrous oxide (N\textsubscript{2}O), and ammonia which cause acid rain due to human intervention. Greenhouse gas emissions from livestock sector are calculated from methane emissions (CH\textsubscript{4}) originates enteric cattle fermentation and nitrous oxide (N\textsubscript{2}O) produced from manure management [1]. The population and composition of livestock Central Sulawesi Province produced of different value on GHG emissions based on type of livestock. The calculation using ALU Tool Software with the IPCC standard was done to determine the contribution of GHG emissions based on type of livestock [1].
ALU Tool is a method for calculating GHG emissions based on livestock population and several other factors which can be used by many countries. Data of livestock population per year at one province and the value of emission factor (FE) from each type of GHG were necessary in this method. The FE values for each GHG (CH$_4$ and N$_2$O) based on type of livestock have been established in IPCC guidebook. The objective of this study is to show an overview the contribution of GHG emissions from livestock sector at Central Sulawesi Province estimated using by ALU Tool.

2. Research Methods

The GHG emissions from livestock were calculated using ALU Tool Software [4]. Two kinds of data were required consisted of livestock population and FE value of CH$_4$ and N$_2$O based on type of livestock. Calculation of each type of livestock have to be done because they emit the different types and values of GHGs. The first step was installing the ALU Software Application for completing the GHG inventory. Then, access the ALU Tool and following the steps were:

1. Created an inventory database, username, country / region, and year of the data
2. Input the livestock population in Module I as a primary activity data.
3. Input activity data in Module I for secondary/supporting activity data. Determine the factor of emission/stock change in Module II according to the source category.
4. Estimated the emissions and the changes of stock C (with uncertainty values) in Module III.
5. Completed the quality assurance and quality control (QA/QC).
6. Result the data of emission changes and C (also for export to Excel files).
7. Analyze and result the mitigation.

2.1 Livestock Population at Central Sulawesi Province on 2016

Calculating GHG emissions using ALU Tool required the population data of each type of livestock per year. It must be officially data issued by a government agency. Therefore, data used was from central Sulawesi statistical center on 2016. Population data based on type of livestock were presented in Table 1.

| Livestock Category | Population (Head) |
|--------------------|-------------------|
| Beef Cattle        | 320,537           |
| Dairy Cattle       | 10                |
| Buffalo            | 3,842             |
| Goat               | 6,735             |
| Sheep              | 6,735             |
| Horse              | 200,524           |

Source: Central Sulawesi statistical center [5]

2.2 Emission Factor (EF) For Enteric and Manure Management

Calculating GHG emissions using ALU Tool required default factor of FE for each type of livestock that had been determined by IPCC. The default factor of FE for regions of Indonesia was the values of Asia region. The FE values of CH$_4$ from enteric fermentation and livestock manure that were presented in Table 2. While, the FE values of N$_2$O from livestock manure and animal body weight that were presented in Table 3.
Table 2. Factor emissions (FE) of CH₄ from enteric fermentation and manure management

| Livestock Category | Digestion Process (kg/head/year) | Manure Management (kg/head/year) |
|--------------------|----------------------------------|----------------------------------|
| Beef Cattle        | 47                               | 1.00                             |
| Dairy Cattle       | 61                               | 31.00                            |
| Buffalo            | 55                               | 2.00                             |
| Goat               | 5                                | 0.22                             |
| Sheep              | 1                                | 0.2                              |

Source: IPCC [6]

Table 3. Factor Emissions (FE) Of N₂O from Livestock Manure and Animal Body Weight

| Livestock Category | Emission Factor of Kg N₂O/Head/day | Life of Day |
|--------------------|------------------------------------|-------------|
| Beef Cattle        | 0.34                               | 365         |
| Dairy Cattle       | 0.47                               | 365         |
| Sheep              | 1.17                               | 365         |
| Goat               | 1.37                               | 365         |
| Buffalo            | 0.32                               | 365         |

Source: IPCC [5]

3. Results and discussion

The value of GHG emissions which is generated by livestock sector in Central Sulawesi Province on 2018 using ALU Tools based on IPCC [5] standard is shown in table 4.

Table 4. Results of CH₄ Emissions from Enteric Fermentation

| Livestock Category | CH₄ Emission (Gg CH₄) | CH₄ Emission (Gg CO₂e) | Uncertainty (%) |
|--------------------|-----------------------|------------------------|-----------------|
| Beef Cattle        | 15.885                | 397.125                | 0               |
| Dairy Cattle       | 0.001                 | 0.025                  | 40              |
| Buffalo            | 0.211                 | 5.275                  | 40              |
| Goat               | 2.011                 | 50.275                 | 40              |
| Sheep              | 0.034                 | 0.85                   | 40              |
| Total              | 18.142                | 453.550                | 30              |

Source: Data Processed (2019)

Methane emission sourced enteric fermentation showed the highest number from beef cattle 15.885 CH4 which is equivalent to CH₄ emissions of 397,125 (Gg CO₂e). This is very relevant to conditions that Central Sulawesi region supports the development of beef cattle farming so that cattle is the highest population. The highest value of gas emissions produced is may influenced by forage as the main feed of cattle. Central Sulawesi Provinceregion is dominated by pasture area including legumes and many cattle maintained by grazing system. In addition, environmental factors also support the occurrence of potential emissions by ruminal fermentation of rice bran or others.
Table 5. Results of CH$_4$ emissions from manure

| Livestock Category | CH$_4$ Emission (Gg CH$_4$) | CH$_4$ Emission (Gg CO$_2$e) | Uncertainty (%) |
|--------------------|-----------------------------|-----------------------------|-----------------|
| Beef Cattle        | 0.569                       | 14.225                      | 5.628           |
| Dairy Cattle       | 0                           | 0                           | 30              |
| Buffalo            | 0.008                       | 0.2                         | 30              |
| Goat               | 0                           | 0                           | 0               |
| Sheep              | 0.001                       | 0.025                       | 30              |
| Total              | 0.574                       | 14.449                      | 22.5            |

Table 5 shows the highest number emissions of manure and urine produced is from beef cattle of 0.569 (Gg CH$_4$). It is equivalent to CH$_4$ Emission 14.225 (Gg CO$_2$e). Farmer managed livestock manure traditionally and disposed into the pasture area. This is as reported by Prayitno et al. [7] stated that one of the CH$_4$ emissions from manure management was influenced by the type of feed given. Generally livestock manure that consumes fibrous feed will produce higher CH$_4$ compared to livestock manure which consumes feed origin of grains. High-nutrient types of feed tend to produce low amounts of methane production such as concentrate feed while forage feed contributes to higher greenhouse gas emissions especially forage feed which is high in crude fiber [8].

Table 6. Direct N$_2$O Gas Emissions from Manure Systems

| Livestock Category | CH$_4$ Emission (Gg CH$_4$) | CH$_4$ Emission (Gg CO$_2$e) | Uncertainty (%) |
|--------------------|-----------------------------|-----------------------------|-----------------|
| Beef Cattle        | 0.035                       | 10.467                      | 34.734          |
| Dairy Cattle       | 0                           | 0.001                       | 90.692          |
| Buffalo            | 0.001                       | 0.2                         | 90.139          |
| Goat               | 0.32                        | 95.315                      | 95              |
| Sheep              | 0                           | 0.038                       | 95              |
| Total              | 0.356                       | 106.021                     | 79.479          |

Table 6 shows the highest number of N$_2$O emissions from manure produced is from goats of 0.32 (Gg N$_2$O). It is equivalent to CH$_4$ emissions of 95.315 (Gg CO$_2$e). Another factor is manure management that had not been managed properly. Generally, community of Central Sulawesi dispose the manure into open and spread in the yard. Besides that, there is no manure management into organic fertilizer and biogas environmentally friendly. The same as reported by Lintangrino et al. [9] that manure management with a dry lot system that is managed by being stacked to dry contributors to GHG. In addition there is also no management of manure into organic fertilizer and biogas that is environmentally friendly.

Table 7. Summary of Emissions from Livestock and Manure Management

| Emission of Category | CH$_4$ Emission (Gg CH$_4$) | CH$_4$ Emission (Gg CO$_2$e) | Total (Gg CO$_2$e) |
|----------------------|-----------------------------|-----------------------------|--------------------|
| Enteric Fermentation | 18.142                      | 453.550                     | 453.550            |
| Emission Gas CH4 Manure | 0.574                      | 14.449                      | 14.449             |
| N2O Manure Systems  | 0.356                       | 106.021                     | 106.021            |
| Total                | 19.072                      | 574.020                     | 574.020            |

Table 7 showed the largest contributed of CH$_4$ on total greenhouse gas emissions at Central Sulawesi Province on 2016 results which was from enteric fermentation of feed as much as 453.550 (Gg CO$_2$e). It was followed by N$_2$O produced from the processing of goat manure as much as 106,021 (Gg CO$_2$e).
CO2e). Those are influenced by several factors including the higher population of ruminants than other livestock. Another factor is the society culture at Central Sulawesi province that applied grazing system for their cattles at grazed fields, gardens or open spaces. It caused the faeces being wasted in open spaces and not managed properly. It contributed to N₂O sourced livestock manure immediately released into the air. This is consistent with the results of Samiaji [10] research that N₂O gas has an impact of 298 more absorbing heat per unit weight than carbon dioxide so that it becomes part of the contribution of GHG.

4. Conclusion
Central Sulawesi Province contributes to GHG emissions of 574.020 CO₂-e Gg / year from ruminant. Beef cattle was the main contributors to the highest of GHG emissions sourced 76.42% of enteric fermentation in the form of CH₄ 453.550 (Gg CO₂e) that followed by goats manure in the form of N₂O as much as 106.021 (Gg CO₂e) or equivalent to 17.12%.

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