Estimation of Greenhouse Gas (GHG) Emission from Livestock Sector by Using ALU Tool: West Java Case Study

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Abstract. Livestock sector contributes to the increase of global warming through gas released from enteric fermentation and manure management. National estimation still uses a manual calculation. The aim of this study was to estimate the contribution of greenhouse gas (GHG) emission from livestock sector by using ALU tool version 6.0.1, in West Java Province in year 2016 as the case study. The emission were calculated by using Tier-1 and Tier-2 methodologies. Data used were livestock population and emission factors (EF) of CH4 and N2O of any livestock. The results showed that emission from enteric fermentation was 94.754 Gg CH4/year or 2,368.850 Gg CO2e/year with the highest emission from sheep (50.194 Gg CH4/year or 1,254.850 Gg CO2e/year). While emission of CH4 from manure was 6,767 Gg CH4/year or 169,175 Gg CO2e/year with the highest emission from dairy cattle (2,870 Gg CH4/year or 71,750 Gg CO2e/year) and direct N2O emission from manure was 0.366 Gg N2O/year or 109.138 Gg CO2e/year with the highest emission from sheep (0.189 Gg N2O/year or 56.212 Gg CO2e/year). As a conclusion, total emission from the livestock sector in West Java Province was 2,647.163 Gg CO2e/year with the largest emission was from enteric fermentation (2,368.850 Gg CO2e/year). This study suggests that ALU tool is applicable to estimate GHG emission for Livestock in Indonesia with limited data available.

Keywords: greenhouse gas emission, livestock, west java province, ALU tools

1. Introduction
Global warming is a process of increasing the average temperature of the atmosphere, sea and land of the earth that can threaten biodiversity and ecosystems, food security, health and economic growth. Global warming is caused by the effects of greenhouse gases (GHG), namely the occurrence of an increase in the accumulation of greenhouse gases, including carbon dioxide (CO2) and several other types of gases such as methane. This increase in temperature is caused by industrial activities, combustion of petroleum fuels and also the agricultural sector, which includes livestock, especially...
ruminants. Greenhouse gas emission from the livestock sector are CH₄ gas emission derived from enteric fermented ruminants and N₂O gas sourced from manure management.

Methane (CH₄) is one of greenhouse gasses (GHG) produced from anthropogenic activities, including from livestock activity. Other GHG are dinitro-oxide (N₂O), carbon dioxide (CO₂) and chlorofluorocarbon (CFC) [1]. Among other gasses, CH₄ is the second to CO₂ in term of its contribution to climate change [2]. In 2012, the total GHG emission from Indonesia becomes 1,453,957 Gg CO₂-e/year or increased by 45% from the GHG emission in 2000. Agricultural sector contributes for only 7.8%, after contribution of energy (34.9%) for national GHG. Contribution of GHG from livestock to agriculture sector is accounted for about 27,465 Gg CO₂-e/year or 24.4%, including CH₄, CO₂ and N₂O from enteric fermentation and manure management by Ministry of Environment. Among the livestock, ruminant contributes for about 94% and non ruminant contributes for about 6% of CH₄ emitted to the atmosphere.

Estimation of greenhouse gas emission can be conducted through 3 methods of Tier-1, Tier-2, and Tier-3. Nationally, calculations were carried out in Indonesia using the Tier-2 method while the calculation was conducted manually. Therefore, in this study, emission calculation was carried out using the ALU Tools software which the program was designed to calculate greenhouse gas emission based on the 2006 IPCC.

2. Methodology
This study used a literature study of method to obtain secondary data on livestock population in West Java Province then the data was tabulated using ALU Software to calculate GHG emission from the livestock sector. The data used were livestock population and emission factor (EF) of CH₄ and N₂O of any livestock.

In this method the data needed was the livestock population in one year in one province and emission factor (EF) of any GHG. In the IPCC [3] emission factor values for CH₄ and N₂O gas were determined from any livestock.

Greenhouse gas emission from livestock were calculated using the ALU Tool. In this method, two data were needed, namely livestock population data were collected from Directorate General of Livestock and Animal Health [4] and EF value of CH₄ and N₂O gas which refers to the IPCC[3] of any livestock.

The stages in completing the GHG inventory are the first step has to install the ALU Software on the next computer to access the ALU Tool, the second was bellow steps of:
1. Create an inventory database, username, country/region, and year of livestock data
2. Enter activity data in Module I for primary activity data (Livestock Population).
3. Enter activity data in Module I for secondary/supporting activity data. Determine the emission change factor/stock in Module II according to the source category.
4. Estimate emission and changes in stock C (with uncertainty values) in Module III.
5. Quality assurance and complete quality control (QA/QC).
6. Data on changes in emission (also for export to Excel files)
7. Results and mitigation analysis.

Livestock Population Data in West Java Province in 2016
Population data needed in calculating GHG emission using ALU Tool was the population of each type of livestock in a year. The data used must be official data issued by a government agency. Therefore population data was used from the Directorate General of Livestock and Animal Health in 2017 (Table 1).
Table 1. Population of livestock in West Java 2016

| Livestock category | Population (heads) 2016 |
|--------------------|-------------------------|
| Beef cattle        | 413,372                 |
| Dairy cows         | 119,595                 |
| Buffalo            | 102,571                 |
| Goats              | 1,237,990               |
| Sheep              | 10,038,828              |
| Market swine       | 7,055                   |
| Horses             | 13,597                  |
| Poultry            |                         |
|                   | - Local chicken         | 25,842,311             |
|                   | - Layer chicken         | 15,143,460             |
|                   | - Broiler chicken       | 649,829,868            |
|                   | - Duck                  | 9,282,534              |

Source: [4]

CH₄ and N₂O Gas Emission Factor (EF) for Enteric and Manure Management

In calculating GHG emissions using the ALU Tool, the amount of EF for any livestock was determined by IPCC. For the Indonesian region, the default factor (EF) was used for the Asian region. The EF value for CH₄ gas from enteric was presented in Table 2, while the EF value of CH₄ gas was collected from livestock manure based on environmental temperature (Table 3). Whereas the EF value for N₂O gas from livestock manure was based on the manure management system (Table 4).

Table 2. Enteric CH₄ emission factor

| Livestock category | Emission factor (kg CH₄/head/year) |
|--------------------|-------------------------------------|
| Buffalo            | 55                                  |
| Dairy cows         | 68                                  |
| Goats              | 5                                   |
| Horses             | 18                                  |
| Market swine       | 1                                   |
| Non-dairy cattle   | 47                                  |
| Sheep              | 5                                   |

Source: [3]

Table 3. Manure CH₄ emission factor based on mean annual temperature

| Livestock category     | Mean annual temperature (°C) | Emission factor (kg CH₄/head/year) |
|------------------------|------------------------------|-------------------------------------|
| Buffalo                | ≥ 28 (Warm)                  | 2                                   |
| Dairy cows             | 24 (Temperate)               | 24                                  |
| Goats                  | ≥ 28 (Warm)                  | 0.22                                |
| Horses                 | ≥ 28 (Warm)                  | 2.19                                |
| Market swine           | ≥ 28 (Warm)                  | 7                                   |
| Non-dairy cattle       | ≥ 28 (Warm)                  | 1                                   |
| Poultry                | ≥ 28 (Warm)                  | 0.02                                |
| Sheep                  | ≥ 28 (Warm)                  | 0.2                                 |

Source: [3]


### Table 4. Direct N₂O emission factor for manure system

| Livestock category | Manure management system | Emission factor (kg N₂O-N/kg N) |
|--------------------|--------------------------|---------------------------------|
| Buffalo            | Solid storage            | 0.005                           |
| Dairy cows         | Solid storage            | 0.005                           |
| Goats              | Pit storage below animal confinement | 0.002                          |
| Horses             | Solid storage            | 0.005                           |
| Market swine       | Liquid/Slurry- without natural crust cover | 0                             |
| Non-dairy cattle   | Solid storage            | 0.005                           |
| Poultry            | Poultry manure with litter | 0.001                          |
| Sheep              | Pit storage below animal confinement | 0.002                          |

Source: [3]

### 3. Result and Discussion

The value of GHG emission was generated by the livestock sector in West Java Province in 2016 based on calculation using ALU Tools with the 2006 IPCC (Intergovernmental Panel on Climate Change) standard (Table 5).

Based on the calculation results, it could be seen that the total CH₄ emission from the rumen fermentation process in West Java Province was 94,754 (Gg CH₄/year) or equivalent to 2368.850 (Gg CO₂-e/year) with the highest emission come from sheep which equals to 50,194 (Gg CH₄/year) and equivalent to 1,254,850 (Gg CO₂-e/year). This is very relevant to the condition in the field where most of the population in West Java consisted of sheep. The sheep population is higher (10,038.828 heads, 84.27%) compared to other ruminants. This higher population resulted in sheep the highest contributing to emission from rumen digestion compared to other types of livestock.

### Table 5. Estimation of enteric CH₄ emission from livestock in West Java 2016 calculated by using ALU Tool Program

| Livestock category | CH₄ emission (Gg CH₄/year) | CH₄ emission (Gg CO₂-e/year) | Uncertainty (%) |
|--------------------|---------------------------|-----------------------------|-----------------|
| Non-dairy cattle   | 24.348                    | 608.700                     | 0.000           |
| Dairy cattle       | 8.132                     | 203.300                     | 40.000          |
| Buffalo            | 5.641                     | 141.025                     | 40.000          |
| Sheep              | 50.194                    | 1254.850                    | 40.000          |
| Goats              | 6.190                     | 154.750                     | 40.000          |
| Horses             | 0.245                     | 6.125                       | 40.000          |
| Market swine       | 0.004                     | 0.100                       | 40.000          |
| **Total**          | **94.754**                | **2368.850**                | **34.290**      |

The high and low value of emission produced by livestock is most likely influenced by forage feed eaten. This is in line with that reported by [5] stated that one of the CH₄ emission from manure management was influenced by the type of feed given. Generally livestock manure that consumes fibrous feed will produce higher CH₄ compared to manure that consumes feed from seeds. [6] stated that high nutritional types of feed such as feed concentrates tend to produce low amounts of methane while forage feed contributes to higher greenhouse gas emission, especially forage which is high in crude fiber.
Data on emission from livestock manure in Table 6 shows that the highest emission are produced by dairy cows which are equal to 2.870 (Gg CH\textsubscript{4}/year) which is equivalent to 71.750 (Gg CO\textsubscript{2}-e/year). This is caused by the maintenance system of dairy cows in West Java Province generally anchored and the management of the manure is still very simple, farmers usually only pile or drain dairy cow dung even though some also use it as fertilizer. However, due to the high production of dairy cow dung, farmers generally only accumulate the manure to become fertilizer.

**Table 6. Estimation of manure CH\textsubscript{4} emission from livestock in West Java 2016 calculated by using ALU Tool Program**

| Livestock category | CH\textsubscript{4} emission (Gg CH\textsubscript{4}/year) | CH\textsubscript{4} emission (Gg CO\textsubscript{2}-e/year) | Uncertainty (%) |
|--------------------|----------------------------------------------------------|----------------------------------------------------------|-----------------|
| Beef cattle        | 0.856                                                    | 21.400                                                   | 5.947           |
| Dairy cattle       | 2.870                                                    | 71.750                                                   | 30.000          |
| Buffalo            | 0.205                                                    | 5.125                                                    | 30.000          |
| Sheep              | 2.008                                                    | 50.200                                                   | 30.000          |
| Goats              | 0.272                                                    | 6.800                                                    | 30.000          |
| Horses             | 0.030                                                    | 0.750                                                    | 30.000          |
| Market swine       | 0.030                                                    | 0.750                                                    | 30.000          |
| Poultry            | 0.496                                                    | 12.400                                                   | 30.000          |
| **Total**          | **6.767**                                                | **169.175**                                              |                 |

**Table 7. Estimation of direct N\textsubscript{2}O emission from manure system from livestock in West Java 2016 calculated by using ALU tool program**

| Livestock category | N\textsubscript{2}O emission (Gg N\textsubscript{2}O/year) | N\textsubscript{2}O emission (Gg CO\textsubscript{2}-e/year) | Uncertainty (%) |
|--------------------|-----------------------------------------------------------|-----------------------------------------------------------|-----------------|
| Beef cattle        | 0.052                                                     | 15.514                                                   | 36.585          |
| Dairy cattle       | 0.056                                                     | 16.813                                                   | 90.692          |
| Buffalo            | 0.018                                                     | 5.330                                                    | 90.139          |
| Sheep              | 0.189                                                     | 56.212                                                   | 95.000          |
| Goats              | 0.029                                                     | 8.697                                                    | 95.000          |
| Horses             | 0.001                                                     | 0.318                                                    | 95.000          |
| Market swine       | 0.000                                                     | 0.000                                                    | 0.000           |
| Poultry            | 0.021                                                     | 6.254                                                    | 95.000          |
| **Total**          | **0.366**                                                 | **109.138**                                              |                 |

The results obtained for the calculation of direct N\textsubscript{2}O emission from manure management were equal to 0.366 Gg N\textsubscript{2}O/year or equivalent to 109.138 Gg CO\textsubscript{2}-e/year with the largest contributor was from sheep which reached 0.189 Gg N\textsubscript{2}O/year or equivalent to 56.212 Gg CO\textsubscript{2}-e/year. Sheep produces feces that contain high N values. N\textsubscript{2}O is produced from microbial transformation in soil and manure. Therefore, the gas increased when the availability of nitrogen exceeds the needs of plants, especially in wet condition[3]. The higher population of sheep in the province of West Java with a system of raising the majority of sheep herded so that livestock manure reacted with the soil resulting in N\textsubscript{2}O emission. This majority rearing caused the emission of N\textsubscript{2}O gas produced by sheep was higher than other types of livestock.

The total greenhouse gas emission in West Java Province is presented in Table 8. Based on the Table 8, the total greenhouse gas emission in West Java Province in 2016 was dominated by CH\textsubscript{4} gas
from the discharge of enteric fermentation activities in ruminants. It was 2,365.850 (Gg CO$_2$-e/year) (89.49%) while manure management was only accounts for emission of 278.313 (Gg CO$_2$-e) (10.51%) which included 169.175 (Gg CO$_2$-e/year) CH$_4$ emission and 109.138 (Gg CO$_2$-e/year) N$_2$O emission. This condition was influenced by the high number of ruminants compared to the number of other livestock.

Table 8. Calculated CH$_4$ and N$_2$O emission from enteric and manure management in West Java, 2016

| Livestock category         | CH$_4$ emission (Gg CO$_2$-e/year) | N$_2$O emission (Gg CO$_2$-e/year) | Total (Gg CO$_2$-e/year) |
|----------------------------|------------------------------------|-----------------------------------|-------------------------|
| Enteric fermentation       | 2,368.850                          | NA                                | 2,368.850               |
| Manure management          | 169.175                            | 109.138                           | 278.313                 |
| **Total**                  | **2,538.025**                      | **109.138**                       | **2,647.163**           |

4. Conclusion

Total emission from the livestock sector in West Java Province was 2,647.163 Gg CO$_2$-e/year with the largest emission was from enteric fermentation (2,368.850 Gg CO$_2$-e/year). The ALU tool is an applicable to estimate GHG emission for Livestock in Indonesia using limited data available.

References

[1] P. J. Gerber, A. N. Hristov, B. Henderson, H. Makkar, J. Oh, and C. Lee. 2013. Technical options for the mitigation of direct methane and nitrous oxide emission from livestock: a review. Animal: an international journal of animal bioscience.

[2] K. R. Lassey. 2007. Livestock methane emission: From the individual grazing animal through national inventories to the global methane cycle. Agric For Meteorol [Internet]. Feb;142(2–4):120–32. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0168192306002978

[3] Intergovernmental Panel on Climate Change. 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme. Forestry [Internet]. 4:87. Available from: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

[4] DGLAH. 2017. Statistik Peternakan dan Kesehatan Hewan 2017/Livestock and Animal Health Statistics 2017. 234 p.

[5] C. H. Prayitno, R. Fitria, and M. Samsi. 2016. Suplementasi Heit-Chrose pada Pakan Sapi Perah Pre-Partum Ditinjau dari Profil Darah dan Recovery Bobot Tubuh Post-Partum. J Agripet. 14(2):89.

[6] A. Bamualim, Thalib, Y.N. Anggraei, and A. M. Marriyono. 2008. Teknologi Peternakan Sapi Potong. Wartazoa.