Enteric Methane from Small Ruminants in Indonesia for Recent Years: Tier 2 Methods

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ABSTRACT
Indonesia, as an agricultural country, has a large amount of small ruminant population, which contributes a significant amount to national enteric CH_4 emission. This study aimed to calculate enteric CH_4 emission from small ruminants (sheep and goat) in Indonesia using Intergovernmental Panel on Climate Change (IPCC) Tier-2 method. Emission factors (EF) from the country-specific calculation in Indonesia was used in this study. The national population of sheep and goat based on production categories (weaning, yearling, and mature) were obtained from the Director-General of Livestock and Animal Health Services (DGLAH) of Indonesia. From 2016 to 2019, the enteric CH_4 emission from sheep and goat increases approximately 4.36% and 1.11%, respectively, due to the increase in the animal population. On contrary, from 2019 to 2020, the enteric CH_4 emission from sheep decreases 0.36%. An increase in the goat population from 2019 to 2020 leads to 3.43% increase in CH_4 emission. Sheep and goat that are at production levels (mature) produce 63.49% - 54.86% of the total enteric CH_4 emissions from small ruminants. Despite having a greater population, goats produce lower enteric CH_4 than sheep. These results are related to the lower EF value for goats due to the indigenous feed consumed by goats in Indonesia, that contains a lot of secondary metabolites compounds. Further research is needed on how to reduce enteric CH_4 emission from small ruminants in Indonesia.

Keywords: *Enteric CH_4, Goat, Tier-2, Sheep.*

1. INTRODUCTION

Gases that contribute to the greenhouse gasses (GHG) effect include: H_2O (65%), CO_2 (33%) and the rest are CH_4, N_2O and ozone [1]. The agricultural sector represented approximately 24% of the global total in 2010 [1], [2]. Ministry of Environment and Forestry of Indonesia [3] reported that the agricultural sector contributed 131,641.97 Gg CO_2e from total anthropogenic GHG emissions. As a part of the agricultural sector, livestock sub-sector contributes quite high GHG emissions. Livestock population growth leads to an increase in GHG emissions from the livestock sector. Generally, CH_4 emission from livestock are obtained from manure management and enteric fermentation. Nugrahaeningtyas *et al.* [4] reported that CH_4 from enteric fermentation was the main source of GHG emission from the livestock sector. In 2018, enteric CH_4 contributed 61.10% GHG of the national total in Indonesia from livestock [3].

Table 1. Sub-categories of sheep and goat in Indonesia based on production level [7]

Sub-categories	Composition in total population (%)	
	Sheep	Goat
Weaning	24.46	25.84
Yearling	26.69	26.26
Mature	48.85	47.90

Table 2. Population of sheep and goat since 2016 to 2020 [7]

Year	Population (heads)	
	Sheep	Goat
2016	15,717,000	17,862,000
2017	17,142,000	18,208,000
2018	17,611,000	18,306,000
2019	17,834,000	18,463,000
2020	17,769,000	19,096,000

The population of small ruminants in Indonesia always increases every year due to the stable market and its position as livestock savings. As ruminants, sheep and goats produce enteric CH_4 which is harmful to the environment. In 2018, sheep and goats were ranked 3rd and 4th and accounted for 7.29% and 5.66%, respectively, of the total CH_4 emissions from the livestock sector [3]. Enteric fermentation calculations from small ruminants are necessary to support the mitigation of GHG emissions. Widiawati and Tiesnamurti [5] and Krisnan and Ginting [6] have reported the calculation of enteric CH_4 emissions from sheep and goat using Tier 1 and Tier 2. Furthermore, it was demonstrated that Tier 2 was more accurate data due to it includes specific emission factor (EF) from each country. In recent years (2016-2020), there have been no studies reporting on enteric CH4 emissions produced by small ruminants in Indonesia by sub-categories animals. Therefore, the present study aims to calculate enteric CH_4 emission from small ruminants (sheep and goat) in Indonesia using IPCC Tier-2 method.

2. MATERIALS AND METHODS

2.1. Characterization of population and subcategories for small ruminants

The livestock that was included in the CH_4 emission intensity calculation were small ruminant commodities, such as sheep and goat. Data on the sheep and goat population was collected from the Director-General of Livestock and Animal Health Services [7]. Small ruminants categories based on production levels were also obtained from [7]. Data population of sheep and goat was from 2016-2020.

Data of sheep was categorized by three sub-categories, namely weaning (0 – 12 weeks), yearling (12 weeks to 1 year) and mature (more than 1 year). Whereas, data of goat was categorized by weaning (0 – 8 weeks), yearling (8 weeks to 9 months) and mature (more than 9 months). The sub-categories percentage of sheep and goat in Indonesia are presented in Table 1. The population of sheep and goat in each sub-category from 2016 to 2020 was obtained from the multiplication of the data of each year with the percentage of animal sub-categories and presented in Table 2.

2.2. Enteric CH_4 emission from small ruminants

The emissions from the small ruminants were calculated using Tier 2 methods by IPCC (2006) based on animal population or each sub-category and the emission factor (EF) specific for Indonesia, by the following equation:

$$\text{Enteric } CH_4 = EF_{(T)} \times (N_{(T)} / 10^6) \times 21/1000$$

Enteric CH_4 emission is the CH_4 emission emitted (Gg CO_2-e/year), $EF_{(T)}$ is the emission factor for each animal sub-categories. The country-specific EF for the enteric fermentation in Indonesia for sheep was available for weaning (1.30 kg CH_4/head/year), yearling (4.33 CH_4/head/year) and mature (5.25 CH_4/head/year) [5]. For goat, the EF is also available for weaning (2.29 kg CH_4/head/year), yearling (2.65 CH_4/head/year) and mature (3.27 CH_4/head/year) [6]. $N_{(T)}$ is the population of sheep or goat for each sub-categories T in Indonesia (head). T is sub category of sheep or goat in Indonesia. 21/1000 is the conversion factor from CH_4 to $CO_{2\text{-e}}$ [8], [9].

Table 3. Population of sheep and goat based on sub-category since 2016 to 2020

Year	Population					
	Sheep			Goat		
	Weaning	Yearling	Mature	Weaning	Yearling	Mature
2016	3,844,378	4,194,867.	7,677,754	4,615,540	4,690,561	8,555,898
2017	4,192,933	4,575,199	8,373,867	4,704,947	4,781,420	8,721,632
2018	4,307,651	4,700,375	8,602,973	4,730,270	4,807,155	8,768,574
2019	4,362,196	4,759,894	8,711,909	4,770,839	4,848,383	8,843,777
2020	4,346,297	4,742,546	8,680,156	4,934,406	5,014,609	9,146,984

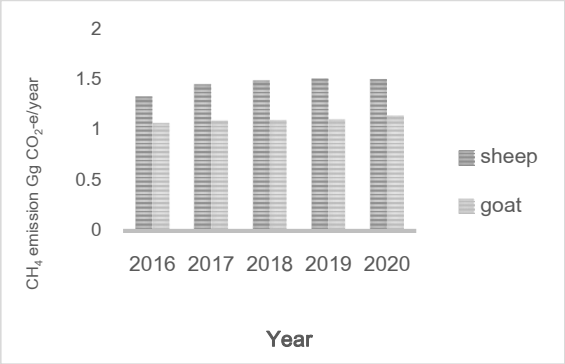

Figure 1. Year 2016 to 2020 total enteric CH_4 emission from sheep and goat in Indonesia

3. RESULTS AND DISCUSSION

In 2019, Indonesia has started to develop country-specific data for CH_4 emissions from enteric and manure from 2006 to 2014 [10]. In the present study, the data were collected from the Director-General of Livestock and Animal Health Services [7], because they demonstrated the actual situation and conditions of the small ruminants population in Indonesia. The population of sheep and goat in each sub-category since 2016 to 2020 is reported in Table 3. The results of enteric CH_4 emissions from small ruminants in total and each sub-category are presented in Figure 1 and Table 4.

Sheep is the major emitter of the enteric CH_4 emission from 2016 to 2020, accounting for 1.33 to 1.51 Gg CO_2e $year^{-1}$ (Fig. 1). This high contribution is attributed to the higher EF for enteric CH_4 in sheep compared with goat in yearling and mature sub-categories. Emission from yearling and mature sheep has shown greater values than goat. On contrary, for weaning sub-category, CH_4 emission of goat is higher than sheep. The cause of this situation is the higher country-specific EF for the weaning sub-category in goat than for the sheep. From 2016 to 2019, the enteric CH_4 emission from sheep and goat increases approximately 4.36% and 1.11%, respectively, due to the increase in the animal population. On contrary, from 2019 to 2020, the enteric CH_4 emission from sheep decreases 0.36%. The increase in goat population from 2019 to 2020 leads to 3.43% increase in CH_4 emission. Sheep and goat that are at production levels (mature) produce 63.49% - 54.86% of the total enteric CH_4 emissions from small ruminants. Data distribution for enteric CH_4 from 2016 to 2020 is almost identical to the distribution of the previous study in 2006 – 2014 [5]. In the previous study, mature sheep contributed 62.19% of total emissions.

Despite having a greater population, goats produce lower enteric CH_4 than sheep. These results are related to the lower EF value for goats due to the indigenous feed consumed by goats in Indonesia, that contains a lot of secondary metabolites compounds. This assumption is derived from the differences in the feeding behavioural, i.e. sheep are grazers and goats are browsers [11]. Tropical browse plants tend to contain high concentrations of secondary metabolites compounds [12]. Plant secondary metabolites has potential to be used as feed additives to reduce enteric CH_4 production due to anti-methanogenic activity [13], [14]. This is relevant to the Ministry of Environment and Forestry of Indonesia [3] recommendation which stated that the provision of feed additives is an effort to reduce GHG emission from the livestock sector.

Table 4. Estimation of enteric CH_4 emission from sheep and goat in Indonesia since 2016-2020 calculated using Tier-2 method

Livestock	Year	Enteric CH_4 emission (Gg CO_2-e/year)		
		Weaning	Yearling	Mature
Sheep	2016	0.105	0.381	0.846
	2017	0.115	0.416	0.923
	2018	0.118	0.427	0.948
	2019	0.119	0.433	0.960
	2020	0.119	0.431	0.957
Goat	2016	0.222	0.261	0.588
	2017	0.227	0.266	0.599
	2018	0.228	0.267	0.602
	2019	0.230	0.269	0.607
	2020	0.238	0.279	0.628

4. CONCLUSION

From 2016 to 2019, the enteric CH_4 emission from sheep increases approximately 4.36% per year. On contrary, from 2019 to 2020, the enteric CH_4 emission decreases 0.36%. For goat, from 2016 to 2020, the enteric CH_4 increases 1.69% per year. Sheep and goat that are at production levels (mature) produce 63.49% - 54.86% of the total enteric CH_4 emissions from small ruminants. More research is needed on how to reduce enteric CH_4 emissions from small ruminants in Indonesia.

AUTHORS' CONTRIBUTIONS

Teguh Wahyono designed the experiment, collected the data, and wrote the first draft of the manuscript. Dadang Priyoatmojo and Tri Handayani performed data analysis. Afi Candra Trinugraha checked data analysis and revised the manuscript. Widhi Kurniawan and Tekad Urip Sujarnoko supervised the experiment and revised the manuscript.

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