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REVIEW OF THE METHOD FOR CACULATION GREENHOUSE GAS (GHG) EMISSIONS FROM LIVESTCK SECTOR

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ABSTRACT
Anthropogenic greenhouse gas (GHG) has driven large increases in the atmospheric concentration of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) resulted to climate change. Agriculture sector was considered as the largest contributor to global anthropogenic CH_4 and N_2O. GHG emissions from livestock sector in Indonesia were calculated using 2006 GL Tier 1 and Tier 2 method. This study was conducted to review GHG emissions from livestock sector, the source of GHG emissions coming from livestock sector, GHG emissions calculation from IPCC guideline, and the assessment of GHG emissions from livestock sector in order to give suggestion related to GHG emission calculation and to present the trends in emission intensity from livestock sector in perspective of the Paris Agreement. In the future, this will help to improve the methodology of calculating GHG emissions from livestock sector.

KEYWORDS: Greenhouse Gas (GHG), Livestock Sector, Review

1. INTRODUCTION
Global warming has become a major environmental problem. Since the pre-industrial era, anthropogenic greenhouse gas (GHG) has driven large increases in the atmospheric concentration of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (IPCC, 2014) result to global warming. The average temperature of the earth's surface has risen by 0.6 degrees Celsius since late 1800s (FAO, 2006). In 1970, global GHG emissions were counted for 27 Gt CO_2-eq while in 2010, the GHG emissions increased up to 49 Gt CO_2-eq. CO_2 was counted for 37.24 Gt, while CH_4 was 7.84 Gt CO2-eq, N_2O was 3.038 Gt CO_2-eq, and F-gases was 0.98 Gt CO_2-eq (IPCC, 2014).
The agricultural sector is the largest contributor to global anthropogenic non-CO_2 GHGs, accounting for 24% of emissions in 2010 (U.S. EPA, 2017). Annual total non-CO_2 GHG emissions from agriculture in 2010 are estimated to be 5.2-5.8 $GtCO_2$eq/ year (IPCC, 2014) and comprised about 10-12% of global anthropogenic emissions.
Driven by this condition, in 1997, the 3rd Conference of Parties (COP3) to the Climate Convention was held in Kyoto, known as Kyoto Protocol, where industrialized nations committed to reducing their overall greenhouse gas emissions by at least five per cent below 1990 levels in the commitment period 2008 to 2012 (UNFCCC, 1998). As a Non-Annex I, Indonesia and South Korea strongly support in preventing the anthropogenic gas to endanger the earth. Indonesia reported their GHG emissions and projected emissions in through Indonesia First National Communication in 1999 and Indonesia Second National Communication in 2010. In 2015, Paris Agreement was reached to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below two degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius (UNFCCC, 2016). The Paris Agreement entered into effect on 4 November 2016 with ratification of the European Union.
This study was conducted to review GHG emissions from livestock sector, the source of GHG emissions coming from livestock sector, GHG emissions calculation from IPCC guideline and product based-environmental assessment of GHG emissions from livestock sector in the perspective of the Paris Agreement. In the future, this will help to improve the methodology of calculating GHG emissions from livestock sector.

2. METHANE AND NITROUS OXIDE PRODUCTION

2.1. Methane

CH_4 is one of the three main greenhouse gases with global warming potential (GWP) is 25-fold than of CO_2 in 100 year basis (IPCC, 2014). CH_4 production arises from microbial fermentation of hydrolyzed carbohydrates, and is considered an energy loss for the host (Alemu et al., 2011). CH_4 is generated by a process called methanogenesis. Methanogens, a group of obligate anaerobic archaebacterial are responsible for this process (Maier et al., 2009), and are chemoautotrophs (Atlas, 1995). The methane formers are pH sensitive, with optimum pH ranged from 6.8 to 7.4, strict anaerobis, and functions best at 95°F (Monteny et al., 2001). Some methanogens generate methane during autotrophic metabolism (Atlas, 1995).

$$4H_2 + CO_2 \longrightarrow CH_4 + 2H_2O \qquad \text{(1) (Maier et al., 2009)}$$

The CH_4 generation consists of three steps. First is hydrolysis by cellulolytic and other hydrolytic bacteria, converting complex polymer (cellulose, other polysaccharides, proteins) into monomers, such as sugars and amino acids (Madigan et al., 2003). The second step is fermentation. During this step, the monomers are converted into H_2 + CO_2 and acetate as primary fermentation product, and propionate, butyrate, succinate^{2-}, and alcohols as secondary fermentation product by fermentative bacteria. Propionate, butyrate, succinate^{2-}, and alcohols are converted to substrates for methanogenesis and acetogenesis by H_2-producing fatty-acid oxidizing bacteria (synthrophs) (Madigan et al., 2003). Third step is methanogenesis. Acetate$^-$ and H_2 + CO_2 from primary fermentation can be directly converted to methane by methanogens, although H_2 + CO_2 can also be consumed by homoacetogens, converting H_2 + CO_2 to methane during acetogenesis. However, in rumen fermentation, acetate is not converted to CH_4 because the retention tie is too short for development of acetotrophic methanogens, which is typically grow slowly (Madigan et al., 2003). Methanogens that utilize CO_2 or H_2 are therefore autothropic. However, methanogens can also produce methane during heterotrophic growth on a limited number of other C_1 and C_2 substrates including acetate, methanol, and formate (Maier et al., 2009). The reduction of CO_2 is generally H_2 dependent, but formate, carbon monoxide, and even certain organic compounds such as alcohols can supply the electrons for CO_2 reduction (Madigan et al., 2003). Energy for microbial growth on organic matter in anaerobic environments is derived from substrate oxidation, involving electron transfer to acceptors other than oxygen (O_2) which is derived from substrate. The primary substrate for ruminal methanogenesis are hydrogen (H_2) and carbon dioxide (CO_2). Most of the H_2 produced during fermentation of hydrolyzed dietary carbohydrates, much of which is generated during the conversion of hexose to acetate or butyrate via pyruvate, ends up in CH_4.
A group of bacteria called the methanotrophs have developed the ability to utilize methane as a source of carbon and energy. The methanotrophs are chemoheterotrophic and obligately aerobic (Maier et al., 2009). Methanotrophs are a subset of a physiological group of bacteria known as methylotrops, aerobic bacteria that utilize one-carbon compounds more reduced than formic acid as source of carbon and energy and assimilate formaldehyde as a major source of cellular carbon (Hanson and Hanson, 1996). In the biodegradation pathway, the enzyme is methane monooxygenase (Maier et al., 2009).

2.2 Nitrous Oxide

N_2O contributed to 5% of enhanced greenhouse effect. Agriculture and associated sectors were responsible for 70% of the anthropogenic emissions of N_2O (Bhatia et. al., 2004). N_2O is produced during nitrification-denitrification of nitrogen contained in livestock waste (Monteny et. al., 2001).

2.2.1 Nitrification

Nitrification is the conversion of ammonium (NH_4^+) to NO_3^- by microbial action (Bitton, 2011). This is a two-step chemolithotrophic process whereby NH_4^+ is first oxidized to nitrite (NO_2^-), carried out by the ammonia-oxidizing bacteria (AOB), which is then oxidized to nitrate (NO_3^-), carried out by nitrate-oxidizing bacteria (NOB) (Willey et al., 2009 *cit.* Bitton, 2011).

$$NH_3 + 1.5O_2 \xrightarrow[\text{oxidoreductase}]{\text{Hydroxylamine}} NO_2^- + H^+ + H_2O \qquad \text{(2) (Ward, 2002)}$$

Nitrification occurs in the environment at a wide range of pH values (Bitton, 2011). *Nitrosomonas* has optimal pH between 7.0 to 8.0 and the optimum pH for *Nitrobacter* is approximately 7.5 to 8.0 (US.EPA, 2002). In environment with pH less than 6.0, nitrification rates are slowed, and below pH 4.5, nitrification seems to be inhibited (Maier et al., 2009). The growth rate of nitrifiers is affected by temperatature in the range of 8 to 30°C with optimum temperature to be in range of 25 to 30°C (Bitton, 2011).

2.2.2 Denitrification

Denitrification is the the microbial reduction to NO_3^- through various gases inorganic forms, to N_2. Two most important mechanisms of the nitrate reduction are assimilatory and dissimilatory nitrate reduction.
Assimilatory nitrate reduction. In this process, NO_3^- is taken up and converted to NO_2^- and then to NH_4^+. NO_3^- reduction is driven by wide range of assimilatory nitrate reductase, the activity of which is not affected by oxygen (Bitton, 2011).

Dissimilatory nitrate reduction (denitrification).

$$NO_3 \longrightarrow NO_2 \longrightarrow NO \longrightarrow N_2O \longrightarrow N_2 \quad (3)$$ (Bitton, 2011)

Denitrification involves four steps. The first step is reduction of NO_3^- to NO_2^- by enzyme nitrate reductase which is inhibited by oxygen. The second is conversion of NO_2^- to NO by nitrite reductase. Synthesis of nitric reductase is inhibited by oxygen and induced by nitrate. The third is the conversion of NO to N_2O by nitric oxide reductase, and the last step is conversion of N_2O to N_2 gas by nitrous oxide reductase. The activity of the nitrous oxide reductase enzyme is inhibited by low pH and is even more sensitive to oxygen than the other three enzymes in the denitrification pathway (Maier et al., 2009). The microorganisms involved in denitrification are heterotrophic or autotrophic microorganisms that can switch to anaerobic growth when NO_3^- is used as the electron acceptor (Bitton, 2011). In the absence of oxygen and available organic matter, autotrophic ammonia oxidizers can carry out denitrification by using NH_4 as the electron donor and NO_2 as the electron acceptor (Bitton, 2011).
In wastewater treatment, denitrification is most effective at pH between 7.0 and 8.5 and the optimum is 7.0 (Christensen and Harremoes 1977; Metcald and Eddy Inc 1991 *cit*. Bitton, 2011). Alkalinity and pH increase following denitrification (Bitton, 2011). Denitrification may occur at 35 to 50°C, and also occurs at low temperatures around 5 to 10°C but at a slower rate (Bitton, 2011). Further, some of the gaseous intermediates are formed during denitrification, for example, N_2O. Under condition of high oxygen (in a relative sense, given microaerophilic niche) and low pH, N_2O is the final product of denitrification with the amount of dissolved oxygen equilibrium with water at 20°C and 1 atm pressure is 9.3 mg/l. Nitrous oxide reductase is inhibited by dissolved oxygen concentration of less than 0.2 mg/l (Maier et al., 2009).

2.2.3 Simultaneous Nitrification and Denitrification

Under certain conditions, simultaneous nitrification and denitrification may occur. Simultaneous nitrification and denitrification (SND) implies that nitrification and denitrification occur concurrently in the same reaction vessel identical overall operation (Munch et al. 1996). SND is most likely performed by conventional aerobic, autotrophic nitrifying microorganisms and anoxic, heterotrophic denitrifying microorganisms under low oxygen conditions (Beck, 2007).
In simultaneous biological nutrient removal (SBNR) where simultaneous nitrification and denitrification occur at the same time, three principal mechanisms may be responsible for SBNR. First is bioreactor microenvironment, anoxic or anaerobic zones may develop within the bioreactor as a result of the mixing pattern caused by the oxygen transfer device. Second is floc microenvironment, anoxic or anaerobic zones may develop inside the activated-sludge flocs. And third is novel microorganisms, recent advances in microbiology have revealed the existence of microorganisms using previously unrecognized biochemical pathways that could account for nutrient removal in aerated bioreactors (Daigger and Littleton, 2000). Two theories exist in the terms of novel microorganisms being responsible in SND. The first is that the organisms responsible for denitrification within the anoxic zone are able to continue to reduce nitrogen after oxygen levels increase for an undetermined amount of time. The second is that microorganisms responsible for denitrification have a greater physiological variety than originally thought. Some of these denitrifying microorganisms could be autotrophic, which reduce their rbCOD requirements (Sager, 2016).
The oxygen concentration affects the nitrification as well as the denitrification rate. This means that at low to moderate oxygen concentration, both process can run simultaneous with reduced speed (Henza et al., 1994). The favorable DO region for simultaneous nitrogen removal is from 0 to 1 ppm (Henza et al., 1994) while Won et al (2015) observed average DO concentration for SND to occur was between 0.5 and 1 mg/L. Floc structure and size has impact on the rate of the processes, as it influence the effect of diffusion limitation. This means that high turbulence will decrease simultaneous denitrification (due to small flocs or smaller zones without oxygen) and increase nitrification, also due to smaller flocs and less diffusion limitation (Henza et al., 1994).

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3 GREENHOUSE GAS EMISSIONS SOURCE FROM LIVESTOCK

3.1 Enteric Fermentation

Enteric fermentation, primary from ruminant, and manure management, are sources of CH_4 emissions from livestock. The contribution of GHG emission from enteric fermentation and manure management is almost in the ratio of 9:1 (Bhatia et. al., 2004). CH_4 from ruminant is mainly produced in the rumen, about 87 to 90% and in the large intestine about 13 to 10% (Broucek, 2014). In the rumen, the average gas composition being about 65% CO_2 and 35% CH_4 and these gases leave the ruminant during eructation (bleaching) (Madigan et al., 2003). Cattle produce about 7 and 9 times as much CH_4 as sheep and goats, respectively (Broucek, 2014). There are several factors affecting the CH_4 produced in rumen. These include dietary factors such as type of carbohydrate in the diet, level of feed intake, level of production (e.g. annual milk production in dairy), digesta passage rate, presence of ionophores, degree of and genetic factors such as efficiency of feed conversion (Nkrumah et al., 2006). Significant quantities of CH_4 enteric fermentation, particularly with high-protein diets, can also arise from microbial fermentation of amino acids with ammonia, volatile fatty acids (VFA), CO_2, and CH_4 as the-end products (Mills et al., 2001).

3.2 Manure Management

CH_4 from manure management is emitted from several manure management systems, such as manure deposited in animal houses and collection yard, manure storage and treatment, and manure spreading (Sommer et al., 2009). Animal wastewater has much higher concentrations of carbon, nitrogen, and phosphorus when compared to municipal wastewater (Won et al., 2015). Manure from livestock consists of a proportion of organic volatile solids which are fats, carbohydrates, proteins and other nutrients that act as source of food and energy for the growth and reproduction of anaerobic bacteria (Monteny et al., 2001). The acid formers group of bacteria break down the volatile solid in manures to a series of fatty acids in the acid forming stage and in the next stage highly specialized methane formers convert the acids to methane gas and carbon dioxide (Monteny et al., 2001). These conditions often occur when large numbers of animals are managed in a confined area (for example, dairy farms, beef feedlots, and swine, and poultry farms) where manure is stored in large piles or disposed of in lagoons. In the industrial model of livestock production under which a large number of animals are housed in confinement, the feces and animal wastes are stored in massive lagoons that create a suitable anaerobic pool for CH_4 production (Bhatia et al., 2004). The main factors affecting CH_4 emission from livestock manure are the amount of manure that is produced and the portion of the manure that decomposes anaerobically. The CH_4 production is represented as methane conversion factor (MCF) in which the actual methane production is expressed as the ratio between the actual and the ultimate methane production, the later occurs with very long storage time (Prusty et al., 2014). CH_4 emissions from manure management is also affected by the temperature of manure of slurry. Sommer et al (2007) implied that CH_4 production is low at temperature below 15°C and increase exponentially as temperature rises above 15°C while Massé et al (2008) indicated higher CH_4 emissions from slurry at 20°C compared to slurry at 10°C.

The management and fate of the animal manure determines the emission of N_2O from animal production system. Most of the N_2O originates from microbiological transformation of nitrogen in the animal excrements urine and dung during storage and management and following application or deposition to land (Granli and Bøckman, 1994). The majority of nitrogen in manure is in ammonia (NH_3) form. N_2O can be formed chemically in reactions involving NO_2 (which is first produced biologically) under acidic conditions. This process is also called 'chemodenitrification', and some studies have shown this to be a predominant source of N_2O under specific conditions (Venterea and Rolston 2002). Because of this multitude of sources and environmental controls, which are only partly manageable, N_2O emissions from animal production systems have a highly stochastic nature. Biochemical oxygen demand (BOD) and nitrogen concentration affect N_2O generation. Pereira et.al (2012) observed a significant increase in the NH_3, CO_2, and CH_4 production from dairy cattle excreta with a change in storage temperature from 5 to 35°C.

Biological treatment for manure varies from the presence of oxygen (aerobic), the absence of oxygen (anaerobic), and the presence of chemically available oxygen only (anoxic) (Agnew et al., 2010). Aerobic process for animal wastewater treatment has been mainly used to achieve nitrification and denitrification, despite the need for combined C, N, and P biological removal processes for the wastewater (Ra et al., 1999). In aerobic manure treatment, the aim is nitrogen removal by nitrification and denitrification that could be obtained with alternating (in space or in time) anoxic and aerobic phase or with low levels of aeration (Beline and Martinez, 2002). This process results in N_2 emissions and N_2O formation under unfavorable conditions (Loyon et al., 2007).

Anaerobic digestion on farm allows the production of renewable energy from biogas, recoverable locally into heat and/or electricity (Loyon, 2007). Anaerobic treatment can remove organic pollutants effectively, cut down the

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organic load for post-treatment, and produce biogas (Deng et al., 2007). Manure used for anaerobic digestion becomes a compound called digestate rich in nutrients, which makes it a potential substitute to chemical fertilizers in agriculture (Tambone et al., 2015).
An anoxic condition is defined as the absence of oxygen and the presence of nitrate as the electron acceptor (Bitton, 2011). In activated-sludge, anoxic zones can occur within flocs, depending on the oxygen concentration in the tank (Bitton, 2011). The anoxic zones occur at a point where the dissolved oxygen concentration is the lowest. Anoxic zones disappear when the oxygen concentration exceeds 4mg/L (Li and Bishop, 2004).

4 GREENHOUSE GAS EMISSIONS CALCULATION METHOD

The Intergovernmental Panel on Climate Change (IPCC) provides guidelines to estimates livestock emissions on a regional level. There are two editions of the guidelines, Revised 1996 IPCC guidelines (1996 GL) and 2006 IPCC guidelines (2006 GL). The 2006 GL are an evolutionary development with respect to the 1996 GL, the GPG 2000, and the GPG-LULUCF 2003 (Tubiello et al., 2015). The 2006 GL approach ensures continuity and enables experiences with the existing guidelines, new scientific information, and the result of the UNFCCC review process to be incorporated (Tubiello et al., 2015).
The guidelines also prescribes three level of detail (tiers) that may be used depending on the available data (IPCC, 2006). Tier 1 is the basic method using default emission factor (EF), and should be feasible for all countries whereas Tier 2 uses country-specific EFs and other parameters, and Tier 3 uses detailed emission models, measurements, and plant-specific data.

4.1 Revised 1996 IPCC Guideline

4.1.1 Tier 1 method

The average annual population of livestock is required for each of the livestock categories. A representative average of the population is needed. However, in the case of poultry and swine, the number of animals produced each year exceeds the annual average population because the animals live for the less than 12 months. In the case of dairy cattle, data on average milk production of dairy cattle is also required. The livestock populations must be described in the terms of warm, temperate, or cool climates for purpose of estimating emissions from livestock manure (IPCC, 1996).
Default emissions factors for enteric fermentation and manure management have been drawn from previous studies, and are organized by region for ease of use. Enteric fermentation emissions factor vary for developed and developing country, except for cattle. A range emission factor for cattle is shown due to typical regional conditions. The emissions factors vary by over a factor of four per head basis. An uncertainty of about ± 20 per cent exists due to variations in animal management and feeding (IPCC, 1996).
Methane Conversion Factor (MCF) for manure management emission factor values 1 to 2 per cent range. The higher value is appropriate for manure managed in warm climates, while the lower value is appropriate for manure managed in cooler and dryer climates. A middle value is assigned to temperate conditions. The uncertainty in the emissions factor remains substantial. The manure from cattle, buffalo, and swine is managed in a variety of ways, including both dry and liquid systems, so, the variations in manure management practices among regions and countries must be considered to develop emissions factors for these animals (IPCC, 1996).
The potential sources of N_2O emissions related to animal production are animals themselves, animal wastes during storage and treatment, dung and urine deposited by free-range grazing animals. Emissions from manure applied to agricultural soils from stables and from grazing animals are considered to be emissions from agricultural soils (IPCC, 1996). Default values are provided to estimate N_2O emissions.

4.1.2 Tier 2 method

To develop precise estimates of emissions, cattle should be divided into categories of relatively homogeneous groups. For each category, a representative animal is chosen and characterized for the purpose of estimating an emission factor. For each of the representative animal types defined, the required information are annual average population (number of head), average daily feed intake (mega joule per day and kg per day of dry matter), and methane conversion rate (percentage of feed energy converted to methane) (IPCC, 1996). There are some rules of thumb recommended for the methane conversion rates. A 6 per cent conversion rate (±0.5 per cent) is recommended for all cattle in develop countries except feedlot cattle consuming diets with a large quantity of grain, while several recommendations are made for different animal management situations in developing countries (IPCC, 1996). Country-specific exceptions to these general rules of thumb should be taken into consideration (IPCC, 1996). The emission factors for each category of cattle are estimated based on the feed intake and methane conversion rate for the category. Some information required to estimate feed energy intakes are maintenance, feeding, growth, lactation, draft power, and pregnancy. To estimate the emission factor for each cattle type, the feed intake is multiplied by the methane conversion rate (IPCC, 1996). For each of the representative animal types defined, the required information is annual average population (number of head) by climate region (cool, temperate, and warm), average daily volatile solids (VS) excretion (kg of dry matter per day, methane-producing potential (B_o) of the manure (cubic meters (m^3) of methane per kg of VS), and manure management system usage (percentage of manure managed with each management system). To calculate the emission factor for each animal type, a weighted average methane conversion factor (MCF) is calculated using the estimates of the manure managed by waste system within each climate region. The average is then multiplied by the VS excretion rate and the B_o for the animal type (IPCC, 1996).

4.2 2006 IPCC Guideline

4.2.1 Tier 1

When using Tier 1 method for estimating methane from manure management, methane emission factors by livestock category or subcategory are used. Default emissions factors by average annual temperature are presented for each of the recommended population subcategories. These emission factors represent the range in manure volatile solids content and in manure management practices used in each region, as well as the difference in emissions due to temperature. Emission factors for cattle, swine, and buffalo are listed by the annual average temperature for the climate zone where the livestock manure is managed. The default manure management emission factors for other animal species are separated for developed and developing countries, reflecting the general differences in feed intake and feed characteristic of the animals in the two regions. Except for poultry "layers (wet)", these emission factors reflect the fact that virtually, all the manure from these animals is managed in 'dry' manure management systems, including pastures and ranges, dry lots, and daily spreading on fields (IPCC, 2006).

The Tier 1 method for estimating direct N_2O emissions from manure management entails multiplying the total amount of N excretion (from all livestock species/ categories) in each type of manure management system by an emission factor for that type of manure management system. Emissions are then summed over all manure management systems. The Tier 1 method is applied using IPCC default N_2O emission factor, default nitrogen excretion data, and default manure management system data (IPCC, 2006). For calculating indirect N_2O emission, the Tier 1 calculation of N volatilization in forms of NH_3 and NO_x from manure management system is based on multiplication of the amount of nitrogen excreted (from all livestock categories) and managed in each manure management system by a fraction of volatilized nitrogen. The annual nitrogen excretion rates should be determined for each livestock category defined by the livestock population characterization. The default nitrogen excretion rates are presented in units of nitrogen excreted per 1000 kg of animal per day.

4.2.2 Tier 2 method

The enteric fermentation emissions factor for each category of livestock are estimated based on the gross energy intake and methane conversion factor (Y_m) for the category. The extent to which feed energy is converted to CH_4 depends on several interacting feed and animal factors (IPCC, 2006). Total emission is calculated by multiplying the selected emission factors by the associated animal population and summed.

The Tier 2 for methane emission from manure management is applicable when manure management is a key source or when the data used to develop the default values do not correspond well with the country's livestock and manure management conditions. Because cattle, buffalo, and swine characteristic and manure management systems can vary significantly by country. The Tier 2 method relies on two primary types of inputs, manure characteristic and manure management system characteristic. Manure characteristic includes the amount of volatile solids (VS) produced in the manure and the maximum amount of methane able to be produced from that manure (B_o). Manure management system characteristic includes the types of systems used to manage manure and a system-specific methane conversion factor (MCF) that reflects the portion of B_o. The methane emission factor from manure management is estimated by multiplying the average MCF by the VS excretion rate and the B_o for the livestock categories.

The Tier 2 method follow the same calculation as Tier 1 but would include the use of country-specific data for some or all of the variables for estimating the direct and indirect N_2O emissions from manure management. In the case of estimating indirect N_2O emissions, a Tier 2 method would require more detailed characterization of the flow of nitrogen throughout the animal housing and manure management systems used in the country (IPCC, 2006). The annual amount of N excreted by each livestock species/ category depends on the total annual N intake and total annual N retention of the animal.

5. PRODUCT BASED-ENVIRONMENTAL ASSESSMENT OF GHG EMISSIONS FROM LIVESTOCK SECTOR

Global consumption of livestock product is growing and demand for meat and milk is set to double (FAO, 2006). To keep below this tipping point, global GHG emissions need to be reduced by at least 50% and as much as 85% on year 2000 levels (IPCC, 2007). Meeting this target will require substantial emission cuts by all sectors of the economy and society, including food, especially agriculture sector because agriculture plays important role in global environment issues, and the livestock sector has come into focus because of its large interface with the environment (Gerber et al., 2013).

Carbon footprint (CF) is the sum of all GHGs, expressed as CO_2 equivalent (CO_2-eq). Carbon foot printing can be used on products packaging as a so-called carbon label to inform supply chain professionals about the relative impacts of different products and activity (Zervas and Tsiplakou, 2012).

Baek et al (2014) suggested a GHG emission quantification procedure for dairy cow systems based on a life cycle assessment (LCA) approach incorporating the IPCC's GHG emission calculation equations, and set up a relationship between the feed composition and corresponding GHG emissions. They developed a tool that allows the control of greenhouse gas (GHG) emissions from a dairy cow system by considering variables such as feed composition, growth phase, enteric fermentation, and manure management.

Emission intensity is the level of GHG emissions per unit of economic activity (Baumert et al., 2005). In the terms of livestock industry, the emission intensity is usually expressed by GHG emission per unit per animal product. Emission intensity estimates enable comparison of the emissions associated with a standard unit of output across sectors and regions (Henderson et al., 2011). The emissions from livestock supply chains come from three sources, according to the assessment developed by FAO, Global Livestock Environment Assessment Model (GLEAM). First is upstream, divided to feed production and non-feed production. Second is animal production unit, referring to livestock production. Last one is downstream, referring to post farm gate (Gerber et al., 2013). Emissions intensities vary among livestock, especially ruminant products. Different agro-ecological conditions, farming practices and supply chain management explain this heterogeneity, observed both within and across production system (Gerber et al., 2013) When the emissions are expressed on a per protein basis, beef is the commodity with the highest emission intensity followed by small ruminants (Gerber et al., 2013).

Several studies related to emission intensity have been conducted in several countries, varying from meat-producing commodity to milk-producing commodity. Ruminant meat intensities are larger than those of milk and monogastric meat within each world region, and there is also larger regional variability within each commodity. The emission intensity of ruminant meat in Argentina is more than an order of magnitude greater than in the Republic of Korea (Gerber et al., 2013). Emission intensities for beef are highest in South Asia, sub-Saharan Africa, Latin America and the Caribbean, and East and Southeast Asia (Gerber et al., 2013) Emission intensity of buffalo meat production is particularly high in East and Southeast Asia because productivity of the animals is low due to poor feed resources and low reproductive efficiency (Gerber et al., 2013).

Enteric fermentation by ruminants explains much of the variation in emission intensities between ruminant and monogastric meat (Henderson et al., 2011). The faster reproductive cycles and live weight rates of monogastric animals, particularly poultry, result in higher conversion efficiencies for monogastric production compared with ruminant meat production (Wirsenius, 2003). In ruminant production, there is strong relationship between productivity and emission intensity. Emission intensity decreases as yield increases up to relatively high level of productivity (Gerber et al., 2013).

6. CONCLUSION

This study was conducted to review GHG emissions from livestock sector, the source of GHG emissions coming from livestock sector, GHG emissions calculation from IPCC guideline and product based-environmental assessment of GHG emissions from livestock sector. In this review the benefit of product based-environmental assessment method was found in the comparison ways of GHG emissions per product unit which was actually consumed by capita. Parties using IPCC's guidelines such as 1996GL and 2006GL are able to show the total GHG emissions from their parties. However, this guidelines are not able to show the efficiency of production in livestock sector. The Paris Agreement apparently showed the emphasis of food security as an international concern in the preamble. Also article 2.1 mentioned that food production with manners of low greenhouse gas emissions was needed but it should not threaten food production. From a perspective on the Paris Agreement, GHG emissions per product would be better to show the efficiency of livestock sector in terms of food production per resource consumed directly, and food security and improvement of technologies for livestock sector indirectly in developing countries than current IPCC guidelines 1996GL and 2006GL.

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