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Case Report

Sources, Sites and Components of Greenhouse Gases (GHGs) from Animal Agriculture in West Papua Province, Indonesia

Deny A. Iyai[1, *], Yubelince Y. Runtuboi[2]

[1]Departmentof Animal Production, Faculty of Animal Sciences, the State University of Papua, Jl. Gunung Salju, Amban. Manokwari, Papua Barat

[2]Department of Forest Conservancy, Faculty of Forestry, Papua University, Jl. Gunung Salju, Amban. Manokwari, Papua Barat

Email address:

da.iyai@yahoo.com (D. A. Iyai)
[*]Corresponding author

Abstract: Environmental status of an area needs to be recognized with both locally and globally measureable indicators. Papua Barat has played important roles as carbon sink of the world with its forest cover. However, recently many areas are being converted for several functions. Agricultural function is a leading sector for the environmental degradation with emissions uncounted produced. Data collected from nine regencies compiled by West Papua province environmental department were accounted for. Quantifications were made to compute average emission resulted from large livestock, small livestock and poultry-manure production. Manure and slurry were the main sources of GHGs emissions, i.e. CO_2, CH_4 and N_2O. The highest contribution was produced by poultry followed by large livestock and small livestock ($p<0.01$). In terms of poultry, broiler was the highest ($p<0.05$) compared to village chicken, egg poultry and duck. The three highest producing emissions are Manokwari, Kota Sorong and Sorong.

Keywords: Manure, Greenhouse Gases, Methane, West Papua

1. Introduction

In the late two decades, greenhouse gases have been reported and questioned worldwide increasing the heat resulted in ozone depletion. Many factors had been identified causing this environmental phenomenon. Man-made products in such fields like agricultural field [3], fabrication and cars, are computed contributing on accumulated greenhouse gases (GHGs) in the ozone layer. These effects, such as acid rain and shifted local climate, are in turn resulted and experienced nowadays by many countries.

In country such us Indonesia, tropical rain forest is reduced significantly for various functions. Many forests cut and land converted to various functions such as infrastructure, buildings and agriculture productions. Although there has

been shifted, by the low and regulation of department of Forestry, Republic of Indonesia), in forest production and management, damaged forests in many hectares have been occurred. Tropical forest owned by Indonesia mentioned as one of the world green belt left beside Brazil with its Amazon and Zaire, Africa. The latter has been increased in use in West Papua. Oil palm plantation and land for other agricultural production, such as housed and un-housed raising livestock, have been demanded [2]. This may give positive impact on losing carbon sink and carbon sequestration in the nature. Land use conversion in West Papua has drastically changed for some agricultural functions, such as paddy field and palm plantation. Due to this, emissions resulted towards CH_4 and

N_2O-N are exist [7]. In Papua particularly due to abundant land, livestock and poultry are established to increase net income of farmers. Positive effects of increasing animal population are meat adequate need for animal protein, income generation, social-cultural function and negative effects contributed are greenhouse gases depleted in the ozone (O_3).

Emissions are classified into so-called environmental impact categories (EIC), such as global warming, acidification, ozone depletion, and eutrhophication [11]. Global warming has potential effect globally compared to other EICs.Hence, local environmental impacts are risk for local population. The gases produced as global warming are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) [3] and [14]. Population of livestock and other animal agricultures is calculated as a main source contributing to increasing number of greenhouse gases in the ozone [7]. GHGs emissions are globally and locally chemical components that change local and global environmental circumstances.

Many countries therefore seek means for reducing GHGs so that global and particularly local causes can be minimalized. However, knowing potential and real GHGs production resulted from animal agricultural in West Papua becomes the priority. This is therefore environmental province board had made a report reporting all development (planning) activities of this province so that thiscan be a direction for making regulations. This article was aimed for seeking the sources and production of greenhouse gases resulted and contributed to ozone depletion.

2. Materials and Methods

Data samples were taken from annual reports of environmental status year 2009 compiled by environmental board. Data compiled were resulted from regencies of West Papua province, i.e. FakFak, Kaimana, Kota Sorong, Manokwari, Sorong, Sorong Selatan, Raja Ampat, Teluk Bintuni and Teluk Wondama. Databases derived from animal agricultural population in the West Papua province, i.e. livestock (cattle) as large animal agriculture, small livestock, i.e. goat and pigs, and poultry, i.e. village chicken, egg chicken, broiler chicken and duck. We also assumed that manure is the source of green house gases and contributed to global warming potential (GWP).Cattle produce 5 kg of feces day^{-1} of manure (+slurry), goat and pigs produce 4.5 kg manure day^{-1}and poultry produce 3 kg of manure day^{-1}. In 10 kg of manure, there is 0.5 kg of methane (CH_4). Therefore, we converted CH_4into CO_2 by dividing Constanta of 21 with manure production resulted from every animal agriculture. N_2O was calculated using 1×CO_2 production with 310 of N_2O, i.e.N_2O= 1×CO_2production×310 N_2O.

Environmental board of West Papua in collaboration with regencies had gathered records of animal agriculture population. In every 10 kg of manure, it was calculated to yield 0.5 kg of methane (CH_4). Global warming potential is composed by chemical components of CO_2, CH_4, and N_2O. GWP is expressed in kg CO_2 equivalent. Different CO_2 equivalent used for the main green house gases were for 1CO_2,

21CH_4 and 310N_2O (Assuming a 100 years time horizon). One kg of CH_4 has the same effect on global warming as 21 kg of CO_2. Emission of GHGs was calculated using equation as follows; Emissionof GHGs=$\sum_i Ai \times EFi$, where Emissions of GHGs are in terms of CO_2, CH_4 and N_2O. Ai is sum of product (yield) and Efi is factor or Constanta of product.

An analysis of one-way Anova [13] was used. Classification was based on the three characteristics consisted of big animal agriculture, small animal agriculture, i.e. goat and pigs, and poultry. Mathematical formula is $Yij = \mu + \alpha i + \varepsilon ij$, where Yij is variable responses consisted ofanimal population, manure production, CH_4 production, CO_2 production and N_2O production. The μ is overall mean, αi is effect of animal agriculture, i.e. livestock, small livestock and poultry and εij is errors with normal distribution, N (0, I). We also analyzed contribution of various poultry contribution, i.e. village chicken, egg chicken, meat chicken and duck as effect. We assessed differences among individual types of animals by pairwise comparison with the post hoc test of Duncen. Levene's test (α=0.05) was used to test for homogeneity of variance. Due to normality distribution test of data, such as animal population, manure production and methane production, log linear (ln) was employed. Qualitative and quantitative data were entered in Excel database, 2003. Analysis of data using SPPS version 18.0.was used.

3. Results and Discussions

3.1. Sources of Green House Gases

Gases resulted from manure or by-product of animal agriculture are methane (CH_4), carbon dioxide (CO_2), Nitrogen (N_2), hydrogen (H_2), carbon monoxide (CO), oxygen (O_2) and hydrogen sulfide (H_2S). Percentages in gas-bio are subsequently 54-70%, 27-45%, 3-5%,1-0%, 0.1%, 0.1% and in small percentages [16].

Actually several leading experts and authors of emission sources had written. [14] listed all components of methane sources and classifying to be natural sources and anthropogenic sources. The main sources of green house gases were originated of animal agriculture production is our concern. By-product sources of animal agriculture are manure including slurry [9]. Feces of large livestock, small livestock and poultry consist of manure and slurry. Uncounted GHGs potential can indeed be resulted from microbial digestion, i.e. methane (CH_4). Methane (CH_4) is much produced from microbial metabolic processes. Gases released from animal agriculture produced much more useless energy. No human-made technologies are available to collect combustion gases. [7] reported several potential sources of CH_4, i.e. ruminant animals, animal wastes, rice paddies, and biomass burning and N_2O, i.e. mineral fertilizer, animal wastes, N-fixation, biomass burning, soils after burning and forest conversion. Many literatures use 23×$CO_2$for CH_4 and 296 ×CO_2 for N_2O.While N2O-N can be sourced from mineral fertilizer, animal wastes, N-fixation, biomass burning, soils after burning and forest conversion which contributed around 4.2 Tg yr^{-1}.
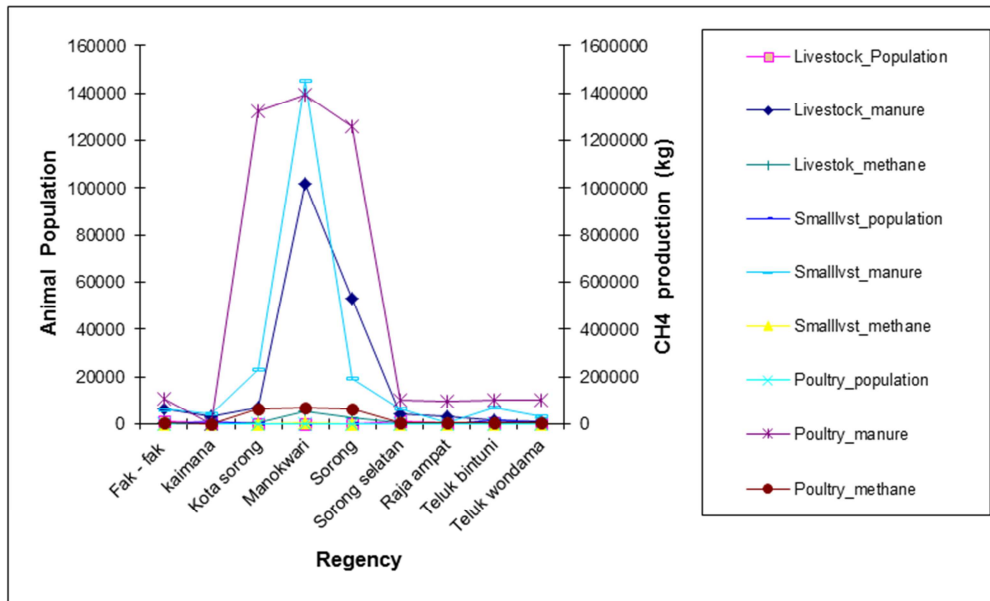
Figure 1. Number of animal population, manure production and methane production.

3.2. Potential Sites Producing GHGs

The three higher regencies-sources of animal agriculture population in West Papua were evidently produced by Manokwari followed subsequently by kota Sorong and Sorong (Figure 1.). However, if we add Sorong and kota Sorong, they become the main sources of methane, carbon dioxide and nitrate oxide in West Papua. They are the first three agricultural development in West Papua. The rest are the new regencies established under special autonomy regulation since year 2001. However, some of them are the so called new agricultural development potential in West Papua. Number of land available for agricultural land is161.272 ha, consist of 11.975 ha of paddy field, 120.086 ha dry land and29.211 ha farm land [2].

Effects of methane on human were not stated clearly. Esthetical was the reason of people perception obtained during observation. It is lack of information with related to emissions emitted and effect on human life in West Papua. Odor was the output of livestock and poultry keeping in West Papua. However, perception of local community is unrecorded. So, what we suggested is that perception, values, attitude of farmers' neighbor or local community should be documented. Therefore, standard in determining environmental quality specific of this province is not made yet. Direction is still using Indonesian national standard (SNI). So far, no certain and strategic livestock and poultry areas are determined. There are several environmental analysis used in agricultural production, i.e. ecological footprint analysis/ecological footprints accounts (EFA) (Redefining Progress) and life cycle assessment (LCA) [11]. Further study is needed to draw strategic plans, constraints, how to tackle that constraints and so forth.

Table 1. Sources of greenhouse gases (GHGs) from livestock, Small livestock and poultry.

| Cummulative | Animal Agriculture | | | | | | Total (n=27) | | Sig. |
| | Large Livestock (n=9) | | Small livestock (n=9) | | Poultry (n=9) | | | | |
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Animal population	4016.78a	6931.54	5293.33a	10247.84	166245.44b	207213.58	58518.52	138869.10	0.000
Manure (kg)	20083.89a	34657.70	23820a	46115.29	498736.33b	621640.73	180880.07	415197.95	0.001
CH_4 (kg)	1004.19a	1732.88	1191a	2305.76	498736b	621640.73	166977.17	419589.09	0.000
CO_2 (kg)	47.82	82.52	56.71	109.79	1187.46	1480.09	430.67	988.56	0.001
N_2O (kg)	14823.82	25580.68	17581.43	34037.48	368114.91	458830.06	133506.72	306455.63	0.001

Superscript with different notation shown significant at $p<0.01$.

Table 1 shows us that all data, animal population in every of the 9 regencies were differ significantly ($p<0.01$). This of course resulted in the number of manure produced, methane, carbon dioxide and nitrous oxide production. From quantified and computed data (as shown in Table 1), high increasing number of methane production was yielded by poultry (498736.33±621640.73, $p<0.01$) and subsequently followed by small livestock, i.e. pigs+goats which produced 1191±2305.76 kg of methane emissions and large livestock, i.e. bali cattle which produced 1004.19±1732.88 kg. In line with this, carbon dioxide produced was higher therefore in poultry (1187.46±1480.09 kg, $p<0.01$) and followed by small livestock and livestock. Total average CH_4, CO_2 and N_2O produced was 166977.17±49589.09, 430.67±988.56, and 133506.72±306455.63, respectively.

Despite growing livestock populations, global methane

emissions from livestock remain static. One of the reasons for this is that monogastric production is growing faster pace than ruminant production. About 80% of the total growth of the livestock sector is attributed to pigs and poultry which emit comparatively small amount of methane. Any reduction in methane production, however, is likely to result increased emission of other gases, notably carbon-dioxide and nitrous oxide, as fossil fuels and fertilizer will be required in the intensification process.

These various database obtained from regencies determine precise number of population of animal agricultures kept by farmers. Providing a valid database in terms of housed and un-housed livestock, small livestock and poultry will easily determine further computation. Housed and un-housed animal will determine in term of manure and slurry management whether applied by farmers in their farm land, used as biogas and/or useless. Production of manure *per se* of animal in terms of physiological age also differs. Starter (day old chicken, DOC/day old duck, DOD), grower and adult poultry and/or livestock vary. [4] and [14] stated that contribution of ruminant on GHGs emission 84 Tg y^{-1}. This should be divided to obtain valid quantification of GHGs beside taking into account several circumstances mentioned above.

So far it is known in Indonesia that only cattle and poultry manure have been applied as bio fertilizer and biogas. Manure resulted from pigs and goat is sometime avoided by farmers. Only in some regions of Indonesia, such as in Medan and East Nusa Tenggara, manure from pigs are collected and used as biogas. Cattle and dairy cattle (cow) produce 28 kg of manure day^{-1}, buffalo produce 35 kg of manure, goat produce 1.13 kg and pig produce 3.41 kg (= ±4.5 kg) day^{-1}, village chicken/race produce 0.18 kg of manure day^{-1}, duck produce 0.34 kg of manure day^{-1} and man produce 0.15 kg of manure

day^{-1}. Some agricultural animals are bred in outside Papua Barat, such as several Bali cattle breed, Etawa goat (recently introduced in Papua), meat poultry, egg poultry and duck. No breeding centers are available in Papua.

In terms of feeding, livestock feedssuch as concentrates and other commercial feed and ingredients are grown, processed and produced outside Papua. These activities need manufacturing involvements in processing such animal basic needs. This manufacturing needs energy, which is fossil fuel. Therefore this fossil fuel energy is released as residues of produced feeds. During transporting feeds and animal agriculture in Papua, ship and plane are used. Energy consumption in terms of producing one unit (kg) of products should be calculated precisely. We therefore need to establish system analysis to limit our study based on the objective of research. Forages for livestock particularly cattle and goat are abundant. Forages in terms of grasses and legume with its technologies for reducing methane component are priority for further research in West Papua

3.3. Poultry Population, Manure and Methan Production

Data recomputed from 9 regencies (Figure 2.) resulted that Manokwari, kota Sorong and Sorong regencies were the three higher population of meat poultry kept by poultry farmers in West Papua.Number of meat poultry actually changeable every season and in line this the poultry population kept per farmer.Manure of poultry is not mostly utilizable. Only in small number of farmers, manure is applied as bio fertilizer.Meat poultry in Papua is demanded white meat for consumers compared to livestock and small livestock. Temporary growing population in West Papua has been stimulated real sector of agricultural field.
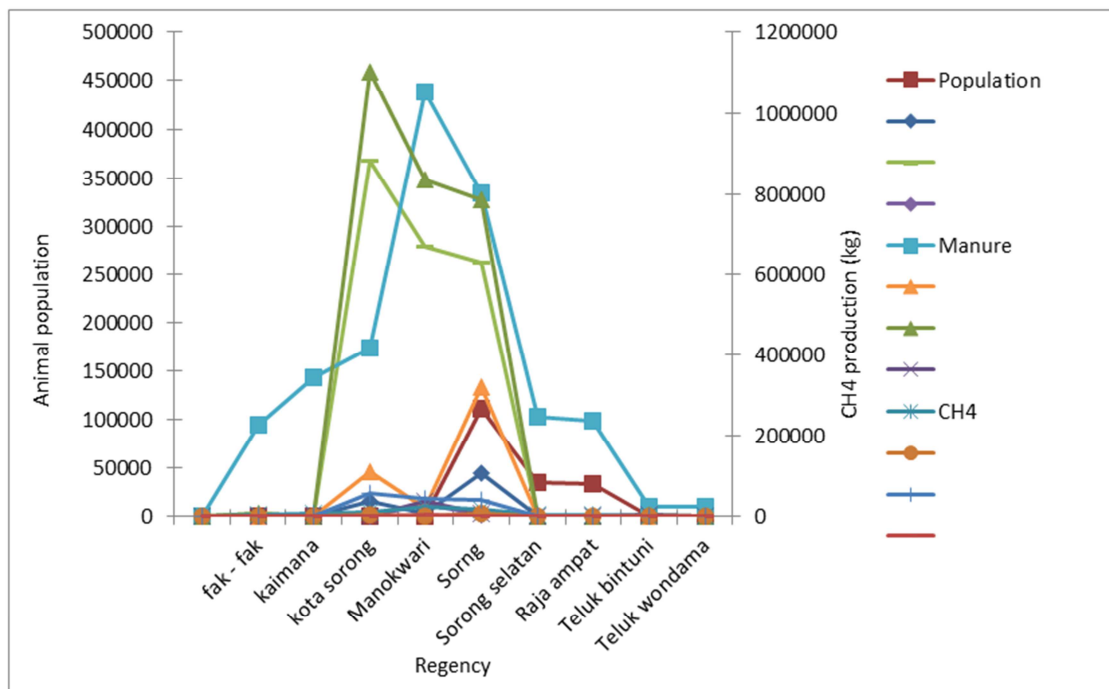

Figure 2. *Poultry population, manure and CH4 production resulted in West Papua.*

Not only gases of emission were emitted, but also were several chemical components leached to the groundwater, surface water and soil. Data on groundwater pollution, surface water and soil are not studied yet.

Table 2. Sources of green house gases (GHGs) from poultry.

Poultry	Types of Poultry								Total (n=36)		Sig.
	Village chicken (n=9)		Egg Poultry (n=9)		Meat poultry (n=9)		Duck (n=9)				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Animal population	51987.78a	47728.15	6973.67a	14954.41	101363.3b	153711.01	1799.55a	4084.04	40531.08	87388.35	0.047
Manure (kg)	155963.33a	143184.46	20921a	44863.22	304090b	461133.05	5398.67a	4084.04	121593.25	262165.08	0.047
CH_4 (kg)	7798.17a	7159.22	1046.05a	2243.16	15204.50b	23056.65	269.93a	612.61	6079.66	13.108.25	0.047
CO_2 (kg)	371.34a	340.34	49.81a	106.82b	724.02b	1097.93	12.85a	29.17	289.51	104.03	0.047
N_2O (kg)	115115.79a	105683.77	15441.69a	33113.32	224447.38b	340360.11	3984.73a	9043.24	89747.39	193502.79	0.047

n representing regencies. Superscript with different notation shown significant at 95% (p<0.05).

Table 2 depicts that the higher average poultry population existing in West Papua was meat poultry (101363.3±153722.01, p<0.05). The rest subsequently were vary followed by village chicken, egg chicken and duck (p<0.05). We cannot identify yet that means of poultry keeping kept by poultry farmers look like for instance battery cage (BC), deep litter (DL), deep litter with outdoor run (DLO) and aviary with outdoor run (AO). We cannot identify that how many farmers with BC, DL, DLO and AO. The number of farmers is sometimes fluctuative and numbers of poultry that are kept also vary. Village chickens raised by local farmers were lagging behind sharing poultry market in Papua Barat. Meat chicken is still demanded of consumers in Papua. [11] is stated that global warming potential (GWP) is higher for DLO compared to BC. Besides, for acidification potential is higher for DL compared to DL and intermediate for AO, due to higher ammonia emission from manure, present in the house, storage facility, or outdoor run. Eutrophication potential is highest for DLO and intermediate for DL and AO. This is due to the fact that DLO and DL had higher ammonia emission whereas systems with outdoor run had higher EP due to leaching from the manure in the outdoor run.

In database, several poultry data of regencies were not recorded. Therefore, the Bapedalda should organize gathering database.Field farming visits are needed to be explored to gain physical condition of livestockand poultry farming of every regency in terms of physiological age, feeding, farming systems.

3.4. Gases Emissions of Livestock and Wastes

Livestock are major sources of trace gases contributing to environmental at local to global scale, contributed about 80 Tg yr^{-1} [7]. Ammonium volatilization can lead to nitrogen deposition, harming the natural ecosystem. In ruminant based systems, enteric fermentation and emissions from manure represent the bulk of emissions, whereas manure management and feed production represent the bulk of emissions associated with monogastric. Monogastric is non-ruminant animal agricultures such as pig and poultry.

There are two main sources of livestock-related carbon dioxide emissions related to climate change. First, carbon dioxide emissions resulted from biomass burning, part of which can be attributed to land clearing and bush fires for pasture and enhancing pasture growth. Second, carbon dioxide is released in relation to livestock-related consumption of fossil fuel for heating, manufacturing of machinery, and production of feed [9].

Methane gas is 23 times more aggressive in causing global climate change than carbon dioxide. Methane is the by-product of animal production and manure management, rice cultivation [12] and [10], production and distribution of oil and gas (pipelines), coal mining, and landfills [7]. Every year, livestock and manure management are estimated to emit 80 terra grams of methane, representing 25% of man-made sources. Methane is produced as a by-product of the feed digestion of mainly ruminant and, on average, about 6% of the feed energy is lost in methane [1]. Methane emission is the direct result of the capacity of ruminants to digest large amounts of fibrous grasses and other feeds which cannot be used for human consumption. Pigs and poultry cannot digest these fibrous feed and therefore emissions from these animals are relatively low.

Twenty percent of methane emanating from animal production comes from manure stored under anaerobic conditions. High levels of methane emissions from manure management are usually associated with high levels of productivity and intensity, as well as from large production units.

Nitrous oxide is the most aggressive greenhouse gas produced by livestock (296 times CO_2). It is produced from animal manure. Every year livestock emit approximately 0.5 terra gram of nitrous oxide, representing 6% of man-made sources.

3.5. Reducing Greenhouse Emissions

We should inventory all emissions leaving the product system entering the surrounding environment, such as nitrous oxide (N_2O), methane (CH_4), ammonia (NH_3), carbon dioxide (CO_2), nitrate (NO_3), phosphate (P_2O_5) and pesticides leaching to the air, water or the soil. Emissions are classified into so-called environmental impact categories, such as global warming, acidification, ozone depletion, and eutrophication. Nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2) contribute to global warming potential (GWP). Eutrophication potential (EP) can be computed based on atrophying components, i.e. nitrate (NO_3^-), nitrogen oxide

(NO_x), ammonia (NH_3) and phosphate (PO_4^-).Eutrophication potential has a strong local impact, and, therefore, generally expressed in kg NO_3^- equivalent ha^{-1} farm area and per kg product. Different NO_3^- equivalent used are 1 for NO_3^-, 1.35 for NO_x, 3.64 for NH_3 and 10.54 for PO_4^-. Acidification potential (AP), as a local and global impact, generally is expressed in kg SO_2 equivalent ha^{-1} farm area and per kg product. Different SO_2 equivalents used are 1 for SO_2, 0.7 for NO_x, and 1.88 for NH_3.

Currently, the main policy constraint is the lack of appropriate incentives for the many existing technologies to reduce greenhouse emissions. The adoption of biogas technologies which convert methane from manure into energy is often hampered by the price of fossil fuels. In addition, there is still a lack of information on how to evaluate the benefits accruing from reducing the losses in the global common and on which mechanisms to use for distributing these benefits. Countries which have ratified Kyoto protocol have committed to reducing their greenhouse emissions, improving manure management seem to be the most cost-effective option, both in monogastric and ruminant based systems. Emissions from the various stages of manure management should be tackled animal house (periodicity of manure collection, building ventilation), storage (covering, temperature), processing (biogas production, and application/discharge (timing, mode of application).

4. Conclusions

Manokwari, kota Sorong and Sorong are the first three regencies contributed in GHGs. Poultry contributes in the highest GHGs emissions in West Papua followed by small-livestock and large livestock. Poultry production contributed GHGs emissions are meat poultry, village poultry, egg poultry and duck. It is suggested to identify other impact categories based on eutrophication potential, accidification potential resulted in West Papua.

Acknowledgement

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