

HYPOTHESIS TESTING ON ENVIRONMENTAL KUZNETS CURVE OF AGRICULTURAL SECTOR IN JAVA ISLAND: PANEL DATA ANALYSIS

Pengujian Hipotesis Kurva Lingkungan Kuznets (Environmental Kuznets Curve) Sektor Pertanian di Pulau Jawa : Analisis Data Panel

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ABSTRACT

One obstacle in the improvement of community welfare in the agricultural sector, especially in Java, is the environmental externality which constantly exists in every economic activity. The objective of this research was to estimate greenhouse gas emission coming from agricultural sector in Java and identify whether farmers in Java had allocated environmental conservation costs as the impact of greenhouse gas emission from agricultural activities in Java. The inventory method of greenhouse gas emission from agricultural sector is based on inventory guidelines published by IPCC (Intergovernmental Panel on Climate Change) in 2006. As for the analysis to determine the relationship between greenhouse gas emission and GRDP of agricultural subsector per agricultural labor, The Environmental Kuznets Curve (EKC) was employed, alongside greenhouse gas emission indicators representing environmental degradation and GRDP of agricultural subsector per agricultural worker representing of per capita income of agricultural. Overall, greenhouse gas emissions, both CH₄ methane emissions and carbon dioxide emission (CO₂) - produced from rice cultivation, fertilizer application, livestock enteric fermentation and poultry manure - are gradually increasing. And the relationship between greenhouse gas emission and GRDP per worker has inverted-U shape; and it is in line with EKC hypothesis. Thereby, the role of the entire community elements and government support in implementing mitigation technology and agricultural adaptation is needed to cope with impacts of greenhouse gas emission, such as climate change.

Keywords: *Agricultural Sector, EKC (Environmental Kuznets Curve), GHG Emission (Greenhouse Gas)*

INTISARI

Salah satu kendala dalam peningkatan kesejahteraan masyarakat di sektor pertanian, khususnya di Jawa, adalah eksternalitas lingkungan yang selalu ada dalam setiap aktivitas ekonomi. Tujuan dari penelitian ini adalah untuk memperkirakan emisi gas rumah kaca yang berasal dari sektor pertanian di Jawa dan mengidentifikasi apakah petani di Jawa telah mengalokasikan biaya

konservasi lingkungan sebagai dampak emisi gas rumah kaca dari kegiatan pertanian di Jawa. Metode inventarisasi emisi gas rumah kaca dari sektor pertanian didasarkan pada pedoman inventarisasi yang diterbitkan oleh IPCC (Intergovernmental Panel on Climate Change) pada tahun 2006. Sedangkan untuk analisis untuk mengetahui hubungan antara emisi gas rumah kaca dan PDRB sektor pertanian per tenaga kerja pertanian, menggunakan Environmental Kuznets Curve (EKC) di samping itu digunakan indikator emisi gas rumah kaca yang mewakili degradasi lingkungan dan PDRB subsektor pertanian per pekerja pertanian yang merupakan pendekatan pendapatan per kapita pertanian. Secara keseluruhan, emisi gas rumah kaca, baik emisi metana CH_4 dan emisi karbon dioksida (CO_2) yang dihasilkan dari budidaya padi, aplikasi pupuk, fermentasi enterik ternak dan pupuk unggas meningkat secara bertahap. Hubungan antara emisi gas rumah kaca dan PDRB sektor pertanian per tenaga kerja pertanian seperti U-terbalik, sehingga sejalan dengan hipotesis EKC. Dengan demikian, peran seluruh elemen masyarakat dan dukungan pemerintah dalam menerapkan teknologi mitigasi dan adaptasi pertanian diperlukan untuk mengatasi dampak emisi gas rumah kaca, seperti perubahan iklim.

Kata Kunci: *Emisi GRK (Gas Rumah Kaca), EKC (Environmental Kuznets Curve), Sektor Pertanian*

INTRODUCTION

Agriculture in Java remains as the dominant sector, viewed from its contributions to total GDP and the employment in this sector. If we view the agricultural sector's GDP contribution in Indonesia, the agricultural sector contributes to Rp.441.601.433,4 (Billion) or equal to 36.50% out of total GDP of Indonesian agriculture sector.

One of the obstacles in the improvement of community welfare in the agricultural sector, especially in Java, is the environmental externality which constantly exists in every economic activity, and it should be addressed in the economic development by means of improving the agricultural development performance. In reality, the environmental externalities in the agricultural sector are rarely considered, particularly in Indonesia. As proposed by Irham, (2002), the costs of

environmental damage resulted from the production process of goods and services have never been considered. As a result, the price used in the market is way too low in comparison with the applied price – as the price does not include 'environmental costs'.

As a key sector in the fulfillment of food needs, emissions generated from the agricultural sector are expected to continue to keep rising until 2030, alongside increasing food demand. In order to handle this Indonesian Government has committed to reduce GHG emission by 26% by 2020. (Ariani et.al., 2016).

Dasgupta et.al. (2002) proposes the hypothesis used in this EKC: at the early stage of the industrialization process, pollution grows real swiftly because the main priority is to increase output, and the community tends to be more interested in getting jobs and having higher income,

rather than getting good environmental quality. According to Everett et al. (2010) the reversed-U curve illustrates the degree of environmental degradation will go together with increasing per capita national income. De Brunye, et al., (1998) believes that EKC does not happen in the long run. It is, therefore, the U-Shape will only happen at the early stage of the relationship between environmental damage level and per-capita income. In the condition above, a certain level of income will have a new turning point. Dinda (2004) and Song, et.al. (2008) develop EKC relationship in the form of cubic polynomials, where such model can be used to examine several relationship forms between environmental indicators and economic growth.

Environmental degradation becomes a hotly debated issue between economic experts and environmental experts. Lau et al. (2014) empirically tested the hypothesis of the Kuznets Environment Curve in Malaysia by looking at the relationship between Foreign Direct Investment and free trade system with CO² emissions, viewed for its short and long term. Farhani et al., (2014) carried out a research to examine the hypothesis of Kuznets environmental curve in Middle East and North Africa countries using panel data from 1990-2010. The results demonstrate that the EKC model obtains inverted-U between environmental degradation and income per capita. Azam and Khan (2016)

undertook a research to estimate the Kuznets Environment Curve hypothesis for 4 countries. The use of OLS in this research is capable of proving the EKC hypotheses in countries with low income and rather low income. Wang et.al., (2016) performed a research to investigate impacts of economic growth and urbanization on level of sulfur dioxide in the air of China. The research results suggest the evidence of inverted-U relationship between economic growth and sulfur dioxide emissions. However, the relationship between urbanization and sulfur dioxide emission does not show relationship similar to inverted-U.

Apergis and Ozturk (2015) tested the hypothesis (Environmental Kuznets Curve) in 14 countries in Asia in 1990-2011. The results of the analysis show that per capita income has a significant and positive influence on CO₂ emissions in 14 Asian countries studied, as well as population density also have an effect on emissions increase. In addition, the average economic growth in 14 countries in Asia is still in the early stages so that the increase in income per capita still has an impact on the increase of environmental pollution.

The objective of this research is to estimate greenhouse gas emissions coming from the agricultural sector in Java, in order to identify whether farmers in Java have allocated environmental conservation costs as impacts of greenhouse gas emission from agricultural activities in Java.

METHODS

The selection of research site was conducted purposively, taking location-specific condition into consideration. The reason for selecting Java for this research was based on the roles of agricultural sector, employment rate and its contribution to the national GDP. The provinces in Java have large percentage.

The data was collected by documentation: the data used was recorded from the data sources or existing documents from 2001-2015 in five province of Java Island. The documents were people's notes or works on events in the past. The data employed in this research were those resulted from recordings in government agencies, such as East Java Provincial Government, Central Java Provincial Government, Yogyakarta Provincial Government, West Java Provincial Government and Banten Provincial Government; Central Statistics Agencies of East Java Province, Central Java Province, Yogyakarta Province, West Java Province, and Banten Province. In addition, other supporting data were also obtained from other institutions.

The Measurement of Greenhouse Gas Emission (GRK) from Agricultural Sector in Java

The inventory method of greenhouse gas emissions from the agricultural sector is based on the inventory guidelines published by IPCC (Intergovernmental

Panel on Climate Change) in 2006. The measurement methods are as follows:

a. Agriculture (Food Crops, Horticultures, and Plantations)

Emissions from agricultural sector especially food crops, horticultures and plantations can be approximated from CH₄ emission from rice paddy cultivation and carbon dioxide resulted from urea fertilizers application. CH₄ emissions are calculated by multiplying the daily emission factor by the length of rice cultivation and harvest area using the following equation (IPPC, 2006):

$$E_{CH_4} = LT \times HT \times EF_{\text{flooded land}} \times 10^{-3}$$

Where:

E CH₄ = CH₄ emission of rice paddy (ton/year)

RPA = Rice paddy planting area

HT = In average total day, planting rice paddy within a year (rice paddy harvest index in average is 220)

EF_{field} = Emission factor of rice paddy CH₄ (1.3 kg CH₄/ha/day) CO₂ Emission of urea fertilizer can be calculated using equation below (IPPC, 2006):

$$CO_2 \text{ Emission} = (M_{\text{Urea}} \times EF_{\text{Urea}})$$

Where:

CO₂-Emission = annual CO₂ emission from Urea application (ton/year)

M_{Urea} = total urea fertilizer being applied (ton/year)

EF_{Urea} = emission factor, CO₂ ton per urea application.

Based on IPCC (Tier 1) for the urea emission factor is 0.20 or equivalent to C content of urea fertilizer based on atomic weight (20% of CO (NH₂)₂).

b. Livestock

Greenhouse gas emissions in livestock are calculated from methane emissions (CH₄) generated from livestock enteric fermentation and methane emissions from livestock manure management. The estimation of CH₄ emission level from livestock enteric fermentation uses the equation below (IPPC, 2006):

$$\text{Emissions} = \text{EF}_1 \times \text{NT} \times 10^{-3}$$

Where

Emissions = CH₄ Emission from enteric fermentation (ton/year)

EFT = CH₄ Emission factor from certain types of livestock (kg CH₄/animal/year)

NT = total certain types/categories of livestock slaughtered individually

Livestock manure does not only produce feces and urine, but also considerably high methane (CH₄). The livestock manure potential to emit methane may occur during storage and even processing. This methane production process can occur and will increase if the environment is in anaerobic condition. The methane emission is strongly affected by types of feed, the quality of poultry feed

and livestock manure management. In the present research, methane emissions from livestock management used the formula from IPPC (2006) below (IPPC, 2006):

$$\text{CH}_4 \text{ Manure} = \sum_T \frac{\text{EF}_T \times \text{NT}}{10^3}$$

Where:

CH_{4 manure} = CH₄ Emission from livestock manure management (ton/year)

EF_(T) = CH₄ Emission factor from certain types of livestock manure (kg CH₄/animal/year)

N_(T) = Total certain category of livestock being slaughtered (per animal)

T = Types or categories of livestock

The Analysis of Relationship between Environmental Degradation and Agricultural Sector GRDP per Worker

The relationship between environmental degradation and average income of agricultural workers is conducted to answer whether the actors in the agricultural sector in Java have allocated some of their income to improve the environment as an effort to manage their farming business. This analysis employs The Environmental Kuznets Curve (EKC) model with greenhouse gas emission indicators representing environmental degradation and average agricultural sector workers representing per capita income. As stated by Kuznets,

EKC shows that environmental degradation (greenhouse emissions) will increase in line with increasing per capita income, but if it has reached a certain point called turning-point, there will be decline in environmental degradation despite rising per capita income. Based on the above, the estimation that can be used to view the relationship between environmental degradation and per-capita income is: The Environmental Kuznets Curve (EKC) model with greenhouse gas emission indicators:

$$GHG = C + \beta_1 GRDP AL_{it} + \beta_2 GRDP AL_{it}^2 + \varepsilon$$

Description:

GHGt = Total Green House Gas Emissions (CO₂ and CH₄ converted to CO₂) from Agricultural Sector Activity (ton / year)

GRDP AL = Regional Domestic Income Bruto Per Agricultural Workers (rupiah)

C = Constant

E = Stochastic Disruption

B = Coefficient of independent variable

t = Year t

The research will be conducted using testing with three possible models in panel data analysis, namely OLS, fixed effect, and random effect to get description on the difference of these three results. Further

best model selection was done through Chow Test, Breusch-Pagan, and Hausman.

Chow Test

The testing mechanism using Chow Test is described as follows (Gujarati, 2006);

Hypothesis:

$H_0: \alpha_1 = \alpha_2 = \dots = \alpha_i$ (similar intercept, no significant effects from cross section unit)

$H_1: \alpha_i \neq 0; i = 1, 2, \dots, n$ (at least there is one different intercept, a significant effect is found in the cross section unit).

If $F_{count} > F_{(\alpha; [db]_1; [db]_2)}$ or Probability value $< \alpha$ then H_0 is rejected. That is, Fixed Effect Model is better than Common Effect Model.

Breusch-Pagan Test

The null hypothesis is rejected if LM statistic value is greater than the critical value of chi-square statistics. In such condition, Random Effect Model becomes a more appropriately-selected method than OLS (Common Effect Model). In contrast, the null hypothesis is accepted if the statistical LM value is smaller than the critical value of chi-square statistics. That is, panel data estimation using OLS (Common Effect Model) is more preferable than Random Effect Model.

Hausman Test

The testing mechanism takes after Wald's criteria using statistical values that will follow the chi-square distribution below (Gujarati, 2006):

Hypothesis:

H_0 : Correlation $(X_{it}, \varepsilon_{it}) = 0$ (cross sectional effect is not related to other independent variables, REM is better than FEM)

H_1 : Correlation $(X_{it}, \varepsilon_{it}) \neq 0$ (cross sectional effect is related to other independent variables, FEM is better than REM)

The decision over Hausman test is based on comparisons using the chi-square test. If the value of $\chi_{obs}^2 > \chi_{tab}^2$ or p-value is smaller than the significance level specified, H_0 is rejected. That is, Fixed Effect Model is better than Random Effect Model.

RESULTS AND DISCUSSION**The Measurement of Greenhouse Gas Emission (GRK) from Agricultural Sector in Java**

Global warming is the process of increasing the average temperature of the atmosphere, the ocean, and the Earth's land caused by increasing concentrations of greenhouse gases due to human activities (Suarsana and Wahyuni, 2011). The Intergovernmental Panel on Climate Change (IPCC) has provided guidance to estimate Greenhouse Gas Emission

(GHG). The calculation method followed in IPCC guidelines for calculating GHG emissions or uptake is multiplication of human activity information within a certain period of time (activity data) and emissions or uptake per unit of activity (emission or uptake factors, FE).

Rice fields are ideal soils for cultivation for rice crops, either once a year or even throughout the year. Inundated soil is an ideal condition for producing methane (Sass and Cicerone, 1999). The practice of rice cultivation in rice fields also determines the level of methane produced and released into the atmosphere (Schutz et al., 1990). The figure below shows the development of methane emissions resulted from rice cultivation activities in Java in the period of 2001-2015.

The figure provides information related to CH_4 methane emission from rice cultivation in Java. In the period 2001-2015, the emissions generated from the rice cultivation activities in Java have increased. The growth rate of methane emissions from rice paddy is 1.10% per year. This condition shows that the level of methane emission in 2015 is greater than the methane emission in 2001. The value of methane emissions (CH_4) generated from rice cultivation in 2001 is 1,158,627 tons, whilst in 2013, it increases into 1,771,437 tons.

The level of methane emission (CH_4) value from rice cultivation activity is in

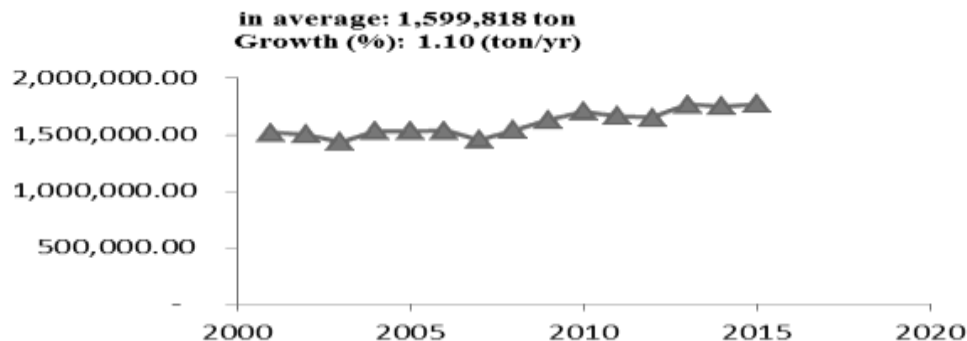


Figure 1. The development of the estimated value of methane emissions (CH_4) from rice field cultivation activity in Java Island in 2001-2015.

Table 1. Urea Fertilizer Application in Each Type of Plants

Type of Plants	Urea Dose (kg/ha)
Crops	
Paddy	284
Corn	333
Soybean	161
Peanuts	156
Green beans	127
Cassava	243
Sweet potatoes	222
Horticultural Crops	
Vegetables (non-specific)	207
Plantation Crops	
Rubber	523
Coconut	200
Coffee	316
Tea	631
Cocoa	906
Sugarcane	928
Tobacco	207
Clove	371

Source: Agricultural Census, 2013 (processed)

Java is determined by the area of rice cultivation (this research uses the harvested area approach). A number of mitigation technologies in the effort of reducing the level of methane emissions in rice paddy can be done by applying the system without tillage, replacing powdered urea fertilizer

with ammonium sulphate or tablet urea fertilizer, applying direct seeding plant (Wihadjaka, 2015), applying intermittent irrigation, and replacing rice varieties with superior rice variety and low emission (Kartikawati *et.al.*, 2011).

In addition to rice cultivation activities in the fields, urea fertilization application onto agricultural land may also lead to greenhouse gas emission, i.e. carbon dioxide gas (CO_2). The urea fertilizer application on agricultural land has caused the release of CO_2 trapped during the fertilizer production.

Based on the table 1 can be seen that in general the use of urea fertilizer by farmers exceeds the dose recommended by the ministry of agriculture. As a result a lot of actual fertilizer wasted because it is no longer needed by the plant. In addition, the excess N on the ground will also lead to increased production of methane on the ground. The use of inorganic fertilizers to be more efficient should be based on the

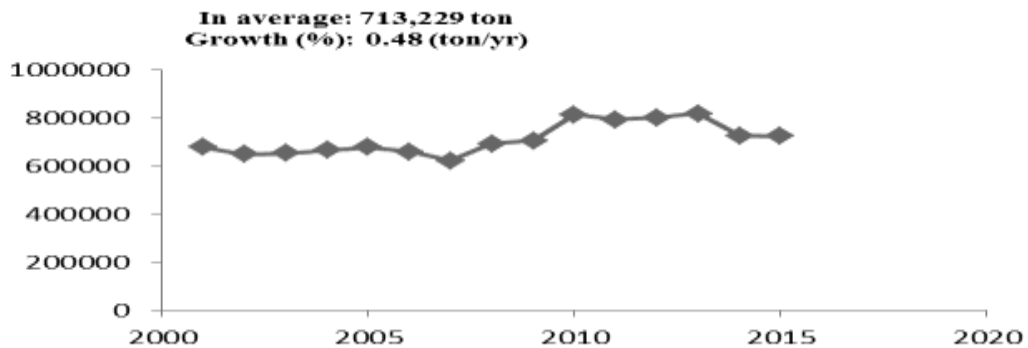


Figure 2. The development of the estimated value of carbon dioxide(CO₂) emissions from the use of urea fertilizer in Java Island in 2001-2015

needs of the plant. This can be seen from leaf color i by using leaf color chart.

The figure displays information related to estimation of carbon dioxide (CO₂) emissions resulted from urea fertilizer application in Java. In the period 2001-2015, carbon dioxide (CO₂) emission from urea fertilizer application in Java Island has increased. The growth of carbon dioxide emission from urea fertilizer application is 0.48% per year. Based on this, it can be seen that value of carbon dioxide (CO₂) emission resulted from fertilizer application in 2015 is higher (678,940 tons) in comparison with carbon dioxide emission at the same source in 2001 (726,301 tons).

The value of carbon dioxide emission (CO₂) is determined by several components, including cultivation area (this research used the harvested area approach) for each crop. Besides, other components determining the level of carbon dioxide emission is the application dose of urea fertilization onto crops. Average farmers

apply fertilization dose, especially urea, which exceeds the dose recommended by the government. One of consequences is the greater emission of carbon dioxide yielded from urea fertilization activity.

Based on the table 2, it is known that the CH₄ emission factor value derived from the fermentation of the enteric of livestock is the most produced by the dairy cows at 61 kg /animal/ year. While the cattle that produce CH₄ least seen from the emission factor of pigs with emission factor value of 1 kg / animal / year. This emission factor

Table 2. Value of CH₄ Emission Factor from Enteric Fermentation according to Livestock Types (EF_T)

Types of Livestock	Emission Factor CH ₄ (kg/animal/year)
Beef Cattle	47
Dairy Cattle	61
Buffalo	55
Sheep	5
Goat	5
Pig	1
Horse	18

Source: IPCC, 2006

Table 3. Estimates of Methane Emissions (CH₄) from Livestock Enteric Fermentation (ton)

Year	Beef Cattle	Dairy Cattle	Buffalo	Goat	Sheep	Pig	Horse
2002	201.868	21.134	31.901	34.861	35.195	174	974
2003	203.036	22.062	31.491	34.615	35.899	182	968
2004	205.238	21.426	32.691	37.133	37.638	224	1.003
2005	207.507	21.296	25.627	37.204	38.155	233	829
2006	207.703	21.732	25.489	38.106	41.319	215	890
2007	221.231	22.255	25.360	39.472	43.791	191	898
2008	228.864	23.318	25.244	41.999	48.019	200	855
2009	270.331	28.411	24.969	45.017	47.288	186	696
2010	281.451	29.149	25.187	47.185	48.343	194	717
2011	313.457	35.999	19.958	48.452	54.924	215	773
2012	326.738	36.799	19.814	50.962	62.659	231	821
2013	302.653	27.429	16.397	53.013	69.147	250	759
2014	318.973	30.193	17.155	54.046	75.271	223	718
2015	330.387	31.175	16.949	55.179	79.920	218	695
In average	254.630	26.204	24.760	43.460	50.128	207	839
Growth (%)	3,65	2,98	-4,68	3,38	6,22	1,86	-2,47

Source: Secondary Data Analysis, 2017

value is then multiplied by the existing livestock population in Java Island, so that will be obtained CH₄ emission value from the fermentation of enteric cattle in each livestock each year.

Based on the table 3, it can be seen that methane (CH₄) in 2002 is mostly produced by enteric fermentation of beef cattle, i.e. 201,868 tons, whilst the livestock producing the least amount of methane (CH₄) from enteric fermentation is 174 tons. Such condition remains unchanged by 2015. That is, methane emission from enteric fermentation of beef cattle still dominates the livestock methane emission contribution in terms of enteric fermentation in Java, whereas pigs contributes to smallest methane emission in Java in terms of livestock's enteric fermentation. If viewed from the average number per year for each livestock, the

largest one is methane emissions (CH₄) from beef cattle is 254,630 tons per year; while the smallest emission comes from pigs, by 207 tons per year .

Overall, the level of methane (CH₄) emission from enteric fermentation of beef cattle in Java has increased by 3.65% per year. This value is in line with the increasing beef cattle population from 2002 to 2015. As for pigs, the positive growth happening is 1.86% per year. Buffalo and horse in Java experience the growth of negative methane (CH₄) emission per year. It is parallel with the declining buffalo and horse population in Java. It happens because of the difficulties in providing suitable land for buffaloes and horses in Java, in addition to their more complicated raising methods - in comparison with beef cattle or sheep's, making the breeders have less interest in raising buffalos and horses.

Table 4. CH₄ Factor Value of Manure according to Types of Livestock (EF_T)

Types of Livestock	CH ₄ Emission Factor (kg/animal/year)
Beef Cattle	1.00
Dairy Cattle	31.00
Buffalo	2.00
Sheep	0.20
Goat	0.22
Pig	7.00
Horse	2.19
Local chicken	0.02
Broiler Chicken	0.02
Laying hens	0.02
Ducks	0.02
Muscovy Ducks	0.02

Source: IPCC, 2006

Based on the table 4 can be seen that the value of CH₄ emission factor generated from the highest livestock manure produced by the dairy cattle that is equal to 31.00 kg/animal/year while CH₄ emission value of the lowest emission factor produced from poultry group of 0.02 kg/animal/year. The value of emission factor is then multiplied

by the population of livestock and poultry which will be obtained CH₄ emission value resulting from cattle and poultry manure.

The highest methane (CH₄) emission from livestock manure in 2002 produced by dairy cattle of 10.740 tons; whilst livestock producing the lowest livestock manure emission is horses by 118tons. Such condition is relatively unchanged until 2015, where dairy cows still contribute to the largest methane (CH₄) emission. And horse manure is still the lowest contributor of methane emission from livestock manure. If viewed from the average emission of methane produced, dairy cows produce an average methane emission of 13,136 tons per year, while horses produce average methane emission of 102 per year.

When viewed from the value of each livestock emission factor, dairy cow is indeed the highest methane (CH₄) emitter

Table 5. Estimates of Methane Emissions (CH₄) from Livestock Manure (ton)

Year	Beef Cattle	Dairy Cattle	Buffalo	Goat	Sheep	Pig	Horse
2002	4,295	10,740	1,160	1,533	1,407	1,224	118
2003	4,319	11,212	1,145	1,523	1,435	1,277	117
2004	4,366	10,889	1,188	1,633	1,505	1,570	122
2005	4,415	10,822	931	1,636	1,526	1,637	100
2006	4,419	11,044	926	1,676	1,652	1,511	108
2007	4,707	11,310	922	1,736	1,751	1,343	109
2008	4,869	11,850	917	1,847	1,920	1,402	104
2009	5,751	14,438	907	1,980	1,891	1,307	84
2010	5,988	14,813	915	2,076	1,933	1,359	87
2011	6,669	18,294	725	2,131	2,196	1,507	94
2012	6,951	18,701	720	2,242	2,506	1,621	99
2013	6,439	13,939	596	2,332	2,765	1,755	92
2014	6,786	15,344	623	2,378	3,010	1,562	87
2015	7,029	15,843	616	2,427	3,196	1,529	84
In average	5,417	13,316	900	1,912	2,005	1,452	102
Growth (%)	3.65	2.97	-4.68	3.37	6.21	1.86	-2.46

Source: Secondary Data Analysis, 2017

Table 6. Estimates of Methane Emissions (CH₄) from Poultry Manure (ton)

Year	Local Chicken	Laying hens	Broiler chicken	Ducks
2002	2.301	753	3.003	237
2003	2.348	817	3.072	257
2004	2.384	1.128	8.404	272
2005	2.357	1.028	3.192	275
2006	2.278	1.229	3.280	274
2007	2.300	1.394	3.532	305
2008	2.381	1.323	3.736	341
2009	2.023	1.128	4.484	409
2010	2.039	1.181	5.017	424
2011	2.180	1.517	5.435	440
2012	2.275	1.616	5.811	426
2013	2.271	1.716	6.605	413
2014	2.339	1.660	9.282	431
2015	2.362	1.761	10.123	450
In Average	2.266	1.265	5.142	346
Growth (%)	0,65	6,52	11,71	4,67

Source: Secondary Data Analysis, 2017

of livestock manure, by 31/kg/animal/year. It is one of the reasons why dairy cattle contribute the highest methane emissions coming from manure. In terms of the population, beef cattle are more widely bred in Java than the dairy cattle. Nevertheless, the emission factor from beef cattle manure is lower, making the methane emission (CH₄) from beef cattle manure become lower than that of dairy cattle.

The methane emission produced by each livestock in Java is growing. This value is in accordance with the increasing number of livestock population in Java, in the period 2002-2015. The methane emission from livestock manure experiencing positive growth is beef cattle (3.65% per year), dairy cows (2.97% per year), goats (3.37% per year), sheep (6.21% Per year), and pigs (1.86% per year). Nevertheless, there are two types of

livestock with negative methane emission growth, namely buffalo (-4.68% per year) and horses (-2.46% per year). Such condition is in line with the population of these two which tend to decline each year.

Based on the table 6, the methane emission (CH₄) yielded by poultry manure in 2002, mostly comes from broiler chicken which is equal to 3.003 tons. In contrast, the poultry producing the least manure methane (CH₄) level includes ducks, by 237 tons. Such condition does not change from year to year until 2015, where broiler chicken still have the highest methane emission (CH₄) contribution from poultry manure, by 10.123 tons. If viewed from the average value of total methane (CH₄) emission from poultry manure, broiler chicken have average methane emission of 5,142 tons per year, whereas ducks have an average methane emission of 346 tons per year.

In general, methane emission (CH₄) from poultry manure has increased from 2001 to 2015. Furthermore, each type of poultry has grown each year: local chicken by 0.65% per year, laying hens by 6.52 per year, broiler chicken by 11.71% per year, and ducks by 4.67% per year, respectively.

The Analysis of Relationship between Environmental Degradation (Greenhouse Gas Emission) and Agricultural GRDP per Agricultural Labor

In this research, the analysis of relationship between greenhouse gas emission from the agricultural sector and the GRDP per agricultural worker in Java uses The Environmental Kuznets Curve (EKC) model approach. In addition to viewing the relationship, this analysis can be used to reveal whether the agricultural actors have allocated the environmental conservation costs in their agricultural business. In the greenhouse gas emission model, the quadratic function model of GRDP per agricultural

worker is used. The model is:

$$GHG_t = C + \beta_1 GRDPAL_t + \beta_2 (GRDPAL_t)^2 + \epsilon$$

In the function above, GHG_t is the level of greenhouse gas emission from agricultural activity, GRDP AL is GRDP per agricultural worker, and ε is a stochastic disruption. The regression model selection in the panel data is at stage for determining the best estimation method among common effect, fixed effect and random effect.

Based on the table 7, p-value on chi-square's cross section is 0.0000 < α = 0,05, therefore, H₀ is rejected. That is, fixed effect model is better for use than common effect model.

Based on the table 8, p-value on chi-square's cross section is 0.0000 < α = 0,05, therefore, H₀ is rejected. That is, random effect model is better for use than common effect model.

Hausman test is used to find a better model between fixed effect and random effect models. Based on the table above,

Table 7. Chow Test Analysis Result

<i>Effect Test</i>	<i>Statistic</i>	<i>d.f.</i>	<i>Probability</i>
<i>Cross-section F</i>	796,855263	(4,68)	0,0000
<i>Cross-Section Chi-Sq.</i>	290,142690	4	0,0000

Table 8. Breusch-Pagan Test Analysis Result

	<i>Cross-section</i>	<i>Test Hyphotesis Time</i>	<i>Both</i>
Breusch-Pagan	494,0320 (0,0000)	8,574377 (0,0034)	502,6063 (0,0000)

Table 9. Hausman Test Analysis Result

<i>Test Summary</i>	<i>Chi-Sq. Statistic</i>	<i>Chi-Sq. d.f.</i>	<i>Probability</i>
<i>Cross-section random</i>	0,270501	2	0,8735

Table 10. Estimates of EKC Model of Greenhouse Gas Emission of Agriculture Sector in Java

Variable	Regression Coefficient	Probability	Model Significance (F-probability)	Adjusted-R ²
GRDP AL	1.281958	0.0001***	0.000000***	0.365779
GRDP AL ²	-547.10 ⁻⁸	0.0023**		
Constant	3,394,210	0.4425		

***= significant at $\alpha=0,01$; **= significant at $\alpha=0,05$

Source: Secondary Data Analysis, 2017

p-value is $0.8735 > \alpha = 0.05$. That is, H_0 fails to be rejected, and therefore, the random effect is better for use.

By the selection of the random effect model, then it is irrelevant to conduct Classic Assumption testing. It is because the random effect model uses the Generalized Least Square (GLS) estimation method. GLS technique is believed to overcome the time series autocorrelation and correlation between observations (cross-sectional) (Lestari and Setyawan, 2017).

The data processing results based on the model suggests the relationship between greenhouse gas emission and GRDP per agricultural worker in Java. The results can be seen in the table 10.

Based on the analysis above, it is known that the quadratic function between greenhouse gas emission and GRDP per agricultural worker in Java has F-probability of 0.0000000 and significant at $\alpha = 0.01$. These results demonstrate that the EKC model used is appropriate for forecasting. GRDP AL variable and GRDP AL² are also significant at $\alpha = 0.05$, and it indicates that there is a relationship between greenhouse

gas emission and GRDP per agricultural worker in Java. Based on the analysis result, the equation of the relationship of both of them is:

$$GHG_t = 3,394,210 + 1.281958 GRDP AL_t - 547.10^{-8} GRDP AL_t^2 + \varepsilon$$

Based on the table, information about the value of regression coefficient of GRDP AL and GRDP AL² variables is earned. The coefficient value indicates that the model used has a value of $\beta_1 > 0$ and $\beta_2 < 0$. Thereby, that the relationship between greenhouse gas emission and GRDP per agricultural worker in Java forms inverted-U, and it correlates with Environmental Kuznets Curve (EKC) hypothesis. The turning point of the relationship curve between greenhouse gas emission from agricultural activities and GRDP per agricultural worker in Java is known from algebraic calculation on the first derivative equation of quadratic equation obtained in this EKC analysis. The calculation yields a turning point value when GRDP per agricultural worker is Rp. 119,363,000.00. At that level of income, greenhouse gas emission level begins to be

equal to GRDP per agricultural worker, where the greater the GRDP value per agricultural worker, the smaller the greenhouse gas emissions incurred - as the agricultural actors begin to compensate some of their income to improve the environment which relates to greenhouse gas emissions. Therefore, there should be an effort to increase the GRDP per worker and start educating agricultural actors to allocate some of their income to improve the environment.

In reality, there are several mitigation technologies as efforts to reduce greenhouse gas emission. The directions for development of adaptive technology are:

- a. Low Rice Emission Varieties
Ciherang, cisantana, tukad belian, membramo, Inpari 1, Dodokan, Way Apoburu, dan IR64 includes varieties of greenhouse gas emissions, whereas relatively old varieties such as Cisadane, IR 72, and Ciliwung include high emission varieties (Wihardjaka, 2015).
- b. Soil Tillage System
Low methane emissions on land without tillage are suspected as the amount of biomass that is returned to the soil is less than the treatment with perfect soil (Wihardjaka, 2015).
- c. Regulation of the Water Regime
The intermittent use of irrigation is the most efficient irrigation management to be able to reduce CH₄ gas emissions (Wihardjaka, 2015).

- d. Increasing the Composition of Animal Feed Concentrate

Addition of concentrate composition in animal feed followed by the tendency of decreasing of methane gas sourced from digestion. Feeding of 80% concentrate feed can decrease the concentration of methane gas from digestion up to 177 ppm or 28.5% when compared with only grass fed grass (Gustiar et.al., 2014).

- e. Low Emission Animal Feed

Selection of feed type greatly affects the size of the methane gas produced by livestock. For example cassava leaves can be used as a means of mitigating methane gas emissions because they contain nitrate salts from Ca, K and Na (Herawati, 2012).

CONCLUSION AND SUGGESTION

Conclusion

- a. In overall, greenhouse gas emissions, both CH₄ methane emission and (CO₂) emissions - resulted from rice cultivation, fertilizer application, livestock enteric fermentation, and livestock & poultry manure - were gradually increasing in the period of 2002-2015.
- b. Based on the analysis approach of The Environment Kuznets Curve, the relationship between greenhouse gas emission and GRDP per worker has inverted-U shape and in line with the

EKC hypothesis. Furthermore, it was found that it produces turning point value when GRDP per agricultural worker is Rp. 119,363,000,000.00. At that income level, the greenhouse gas emission begins to be equal to GRDP per worker, where the larger the GRDP value per agricultural worker, the smaller the greenhouse gas emission emitted.

Suggestion

The roles of all community elements and government support are needed to implement mitigation technology and agricultural adaptation to deal with impacts of greenhouse gas emission. Some methods of mitigating greenhouse gas emission reduction mainly from the livestock sector are by increasing the concentrate composition in animal feed, ranch maintenance method, the selection of low-emission feed, the management of cattle waste or manure, the processing of feed ingredients, the supplement. In addition, it is expected that the government will make an effort to improve GRDP per agricultural worker through integration policy between sub-sectors of animal husbandry, horticulture, food crops in the agricultural sector so that the inter-sub-sector production process can be more efficient and able to increase the GRDP per labor of agriculture sector so that the agricultural actors will have more awareness to allocate some of their income to improve the environment.

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