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CO_2 Emission Contribution Analysis of Rice Distribution Channels in Indonesia

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Abstract

According to Horrigan (2002), the food industry accounts for 10% of all fossil fuel consumption in the United States. Based on this, an effective rice distribution effort is needed as an effort to achieve food security. Moreover, the effective distribution channels will reduce the impact of CO2 emissions in the air. This study examines how the rice distribution channels in Indonesia and the amount of CO2 emissions resulting from these activities. This study using substitution analysis technique based on equation and conversion value of CO2 residue based on the type of transportation mode. The results show that the total emissions from rice distribution activities are 36.007,97 tons km or 0,026% of the total emissions generated by transportation activities.

Keywords:
Rice Distribution, CO_2 Emission, Transportation

Introduction

Indonesia is the world's fourth most populous nation (World Bank, 2018). It can give a negative or positive impact, one of the negative impacts is the problem of food security. Based on Government Regulation no. 17 of 2015, food security is the matter which consist of availability, affordability, and equity. Another opinion states that food security is basically a condition of the fulfillment of energy needs for the community in a wide regional scope, to households (Pinstrup-Andersen, 2009; Rivani, E. 2012). Indonesia as an archipelagic country, one of the obstacles in food security is related to distribution activities. Generally, in the implementation of logistics activities, transportation activities are the activities that spend the most funds, which is around 46,5% - 58,6% of the total logistics costs. It shows that distribution system efficiency is very helpful in efforts to meet food security, because the higher distribution costs, the higher basic costs and it will increase the selling price. The high selling price will potentially weaken the society's reach to fulfill food needs, where affordability of access to food is one aspect of food security (FAO, 2006; Nugroho, C.P & Mutisari, R. 2016).

The importance of the distribution channels efficiency is also applied in the theory of industrial location by Max Weber, where the consideration of the placement of industrial locations is based on considerations of distance and geographical conditions between sources of raw materials, markets, and labor. Distribution efficiency in the context of achieving food security is how far the origin of rice circulating in an area is imported.

Based on 2016 statistics Indonesia data, several provinces in Indonesia still supply rice from more distant provinces. For example, North Sumatra Province: where the demand of rice is supplied from South Sulawesi Province as much as 12,7%. This case study can be explained through the food miles approach which was initiated by the SAFE Alliance in 1994 (Saunders. Et al, 2006).

There are three indicators in this approach, namely accessibility, cost, and environment (Kemp, K. et al, 2010). The food industry accounts for 10% of all fossil fuel consumption in the United States. In addition, it is also stated that 80% of energy use in the food industry is related to processing, distribution, cooling, and preparation activities (Horrigan. 2002; Hill. 2008). Rigby and Bown (2003) also mention that based on 2001 sustain data there are three general categories of CO_2 emission production in the UK, namely (a) 4,2 tons by household activities, (b) 4,4 tons produced by private vehicle activities, and (c) 8 tons produced by packaging activities.

Those explanation shows that distribution activities are one of the largest contributors to CO_2 emissions. This article aims to identify distribution channels for fulfilling rice in all provinces in Indonesia and calculate the contribution of the rice distribution sector for CO_2 emissions in Indonesia as one of the environmental impacts that occur.

Methods

This study uses positivistic approach, while the analytical technique used is descriptive analysis based on literature reviews and studies. This study uses a distribution database conducted by BULOG, because based on the annual report of BULOG, the duties of BULOG are generally divided into two, namely commercial tasks and public tasks. Based on this, the distribution of rice carried out by BULOG can describe the general condition of rice distribution in Indonesia.

To calculate CO_2 emissions in rice distribution activities, using the following equation:

$$E = B \times J \times C$$

Explanation:

E: Amount of CO_2 Emissions produced (kg per ton-km)

B: Amount of rice distributed from Provinces A-B (tons)

J: Distance between Provinces A-B (km)

C: Conversion value of CO_2 residue based on the type of transportation mode (kg per tonne-km).

The conversion value (C) of CO_2 residue can be seen in tables 1 and 2 below:

Table 1. Value of CO_2 Residual Conversion of Land Transportation Modes

Transportation Modes	Conversion Value of CO_2 (kg per ton-km)
Truck	0,18
Train	0,018

Source. Davis dan Diegel (2007)

Table 2. Value of CO_2 Residual Conversion of Sea Transportation Modes

Transportation Modes	Conversion Value of CO_2 (kg per tonne-km)
Ferry	0,011
Container Ship	0,014

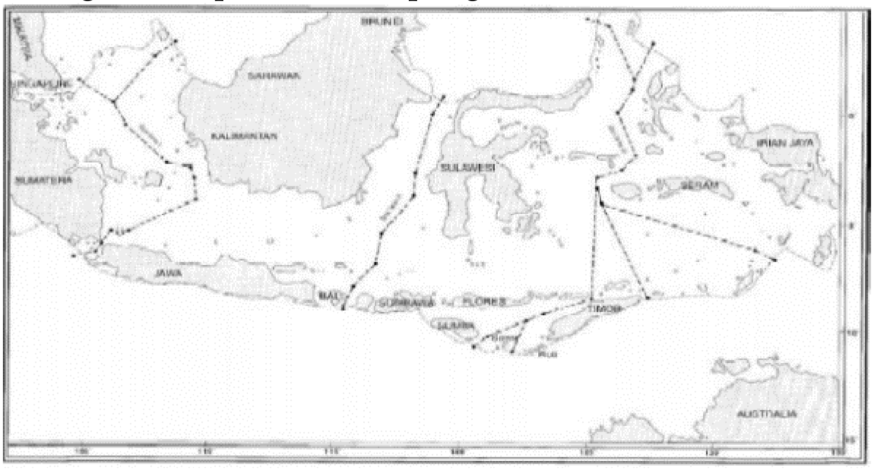
Source. Corbett dan Koehler (2003)

Results

Rice Distribution Channels in Indonesia

Indonesia is a maritime country with an area of 6,315,222 Km^2, in which the administrative area of Indonesia is only 1,900,000 Km^2 (Verstapen, 2013). Then, the very strategic geographical position of Indonesia makes Indonesia one of countries traversed by international shipping. It shows that sea transportation will be more efficient and cheaper than air transportation. The map of the archipelagic sea lanes in Indonesia can be seen in Figure 1.

Figure 1 Map of The Archipelagic Sea Lanes in Indonesia



Source. IMO (2010)

Based on the result analysis, there are several typologies of rice distribution in Indonesia. This typology is based on the distance traveled and the amount of rice fulfillment in each province in Indonesia. The typology of rice distribution can be seen in Table 3 and figure 2.

Table 3. Typology of Rice Distribution in Indonesia

Province	Distance (Km)	Typology
Aceh	3.021	Near Surplus
North Sumatera	2.654	Near Surplus
West Sumatera	2.074	Near Surplus
Riau	9.178	Remote Deficit
Jambi	4.489	Moderate Deficit
South Sumatera	1.725	Near Surplus
Bengkulu	2.980	Near Deficit
Lampung	3.010	Near Surplus
Kep. Bangka Belitung	7.893	Remote Deficit
Kep. Riau	6.104	Moderate Deficit
DKI Jakarta	1.468	Moderate Deficit
West Java	1.631	Near Surplus
Central Java	911	Near Surplus
D.I Yogyakarta	130	Near Deficit
East Java	1.697	Near Surplus
Banten	1.025	Near Deficit

Bali	1.298	Near Surplus
West Nusa Tenggara	673	Near Surplus
East Nusa Tenggara	5.347	Moderate Deficit
West Kalimantan	8.593	Remote Deficit
Central Kalimantan	4.871	Moderate Surplus
South Kalimantan	4.363	Moderate Surplus
East Kalimantan	3.215	Near Deficit
North Kalimantan	10.940	Remote Deficit
North Sulawesi	8.873	Remote Surplus
Central Sulawesi	1.240	Near Surplus
South Sulawesi	6.489	Moderate Surplus
South East Sulawesi	2.507	Near Surplus
Gorontalo	4.924	Moderate Surplus
West Sulawesi	839	Near Surplus
Maluku	6.764	Moderate Deficit
North Maluku	14.697	Remote Deficit
West Papua	11.774	Remote Deficit
Papua	8.955	Remote Deficit

Source. Analysis (2019)

In general, provinces in Indonesia have six typologies of rice distribution, namely: near surplus, near deficit, moderate surplus, moderate deficit, remote surplus, and remote deficit. The largest typology percentage is near surplus of 38%, that means as many as 13 provinces in Indonesia which are rice surplus areas have long distribution channels that are relatively close, but the second largest percentage is typology remote deficit, amounting to 20%. It means that 7 provinces in Indonesia which are rice deficit areas have long distribution channels. This shows that the rice distribution channel in Indonesia is still not effective, so the potential for CO_2 emissions to be generated will be higher following the vehicle mileage. The percentage of rice distribution typology in Indonesia can be seen in Figure 3.

Figure 2 The Map of Rice Distribution in Indonesia

Sustainability: Theory, Practice and Policy
Volume 1, Issue 1, October 2021 (95-110)
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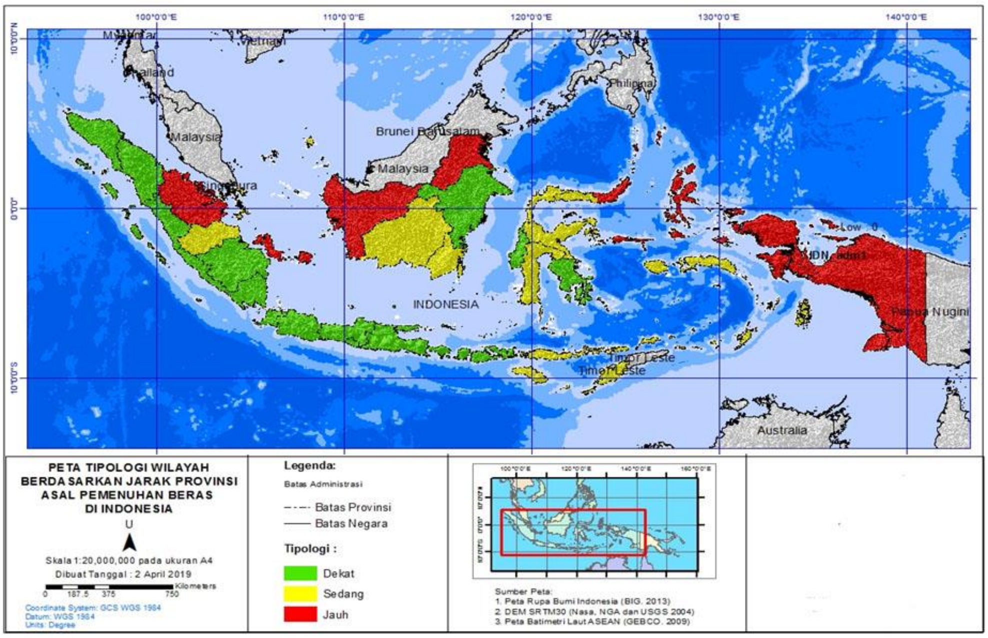
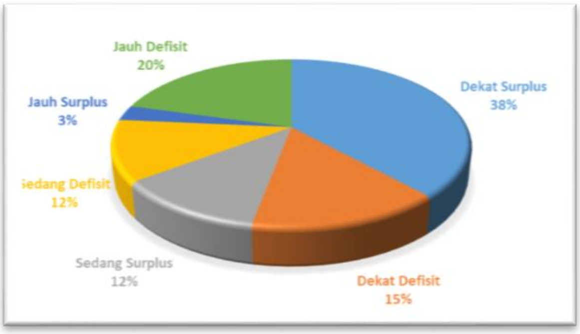


Source. Analysis (2019)

Figure 3 The Percentage of Rice Distribution Typology in Indonesia



Source. Analysis (2019)

Carbon (CO_2) Gas Emissions from Rice Distribution Activities

Increased mobility activities using fossil fuel vehicles are often the main source of increasing CO_2 emissions in the air. This fact of course also has an impact on global warming. Besides it, CO_2 emissions from vehicle activities can also endanger health such as respiratory infections, decreased lung, heart, and cancer performance (Sugiarti, 2009). Several alternatives to overcome this have been suggested and implemented. Some alternatives that can reduce air pollution due to vehicles are reducing vehicle operations, replacing diesel-fueled vehicles with gasoline, and using filters on motorized vehicles (Sutanhaji et al. 2015). Another alternative mentioned by (Shen, L. 2018) is optimizing commodity distribution channels. This alternative not only reduces distribution costs, but also reduces the resulting carbon (CO_2) emissions. The following is a discussion of carbon gas (CO_2) emissions resulting from rice distribution activities.

Davis and Diegel (in Kissinger, 2012) stated that for trucks the CO_2 emissions emitted were 0,18 kg per ton kilometer and for trains as much as 0,018 kg CO_2 per ton kilometer, while for ferries, CO_2 emissions are released as much as 0,011 kg per ton kilometer and for container ships as much as 0,014 kg CO_2 per ton kilometer (Corbett and Koehler in Kissinger, 2012).

By using the conversion that has been described, it can be calculated the amount of CO_2 emissions resulting from the flow of rice trade in Indonesia. The following is a formula for calculating the amount of CO_2 emissions in this study.

$$E = B \times J \times C$$

Explanation:

E: Amount of CO_2 Emissions produced (kg per tonne-km)

B: Amount of rice distributed from Provinces A-B (tons)

J: Distance between Provinces A-B (km)

C: Conversion value of CO_2 residue based on the type of transportation mode (kg).

The amount of CO_2 emissions calculated by statistical data on the rice trade in Indonesia can be seen in Table 4 below:

Table 4. Analysis of Carbon Gas Emissions (CO_{-2}) Rice Distribution Activities in Indonesia

No	Province	Mileage (km)	Transportation Mode	Emission (ton km)	Total Emission (ton km)	CO_2 Emission Classification
1	Aceh	3.021	Truck	543,78	543,78	Low
2	North Sumatera	2.654	Truck	477,72	477,72	Low
3	West Sumatera	2.074	Truck	373,32	373,32	Low
4	Riau	8.356,9	Truck	15.042,42	15.945,64	High
		821.11	Ferry	903,221		
5	Jambi	4.431	Truck	797,58	798,22	Medium
		58	Ferry	0,638		
6	South Sumatera	1.667	Truck	300,06	300.70	Small
		58	Ferry	0,638		
7	Bengkulu	2.951	Truck	531,18	531,50	Small
		29	Ferry	0,319		
8	Lampung	2.981	Truck	536,58	536,90	Small
		29	Ferry	0,319		
9	Kep. Bangka Belitung	5.192	Truck	934,56	964,27	Medium
		2.701	Ferry	29,711		
10	Kep. Riau	5.692	Truck	1.024,56	1.029,09	Medium
		412	Ferry	4,532		

Sustainability: Theory, Practice and Policy
Volume 1, Issue 1, October 2021 (95-110)
ISSN: 2808-4829

Continued of Table 4

No	Province	Mileage (km)	Transportation Mode	Emission (ton km)	Total Emission (ton km)	CO_2 Emission Classification
11	DKI Jakarta	1.468	Truck	264,24	264,24	Low
12	West Java	1.631	Truck	293,58	293,58	Low
13	Central Java	911	Truck	163,98	163,98	Low
14	D.I.Y	130	Truck	23,4	23,4	Low
15	East Java	1.668	Truck	300,24	300,56	Low
		29	Ferry	0,319		
16	Banten	996	Truck	179,28	179,60	Low
		29	Ferry	0,319		
17	Bali	1.220	Truck	21,96	22,818	Low
		78	Ferry	0,858		
18	NTB	526	Truck	94,68	96,30	Low
		147	Ferry	1,617		
19	NTT	4.084	Truck	735,12	749.01	Medium
		1.263	Ferry	13,893		
20	West Kalimantan	6.162	Truck	1.109,16	1.135,90	Medium
		2.431	Ferry	26,741		
21	Central Kalimantan	3.389	Truck	610,02	626,322	Low
		1.482	Ferry	16,302		
22	South Kalimantan	2.881	Truck	518,58	534,882	Low
		1.482	Ferry	16,302		
23	East Kalimantan	2.291	Truck	412,38	422,76	Low
		944	Ferry	10,384		
24	North Kalimantan	9.502	Truck	1.710,36	1.725,19	High
		1.348	Ferry	14,828		
25	North Sulawesi	7.261	Truck	1.306,98	1.324,71	High
		1.612	Ferry	17,732		
26	Central Sulawesi	1.240	Truck	22,32	22,32	Low
27	South Sulawesi	4.071	Truck	732,78	759,38	Medium
		2.418	Ferry	26,598		
28	South East Sulawesi	1.701	Truck	306,18	315,05	Low
		806	Ferry	8,866		
29	Gorontalo	4.118	Truck	741,24	750,11	Medium
		806	Ferry	8,866		
30	West Sulawesi	839	Truck	151,02	151,02	Low
31	Maluku	882	Truck	158,76	223.46	Low
		5.882	Ferry	64,702		
32	North Maluku	1.0403	Truck	1.872,54	1.919,77	High
		4.294	Ferry	47,234		
33	West Papua	9.153	Truck	1.647,54	1.689,77	High

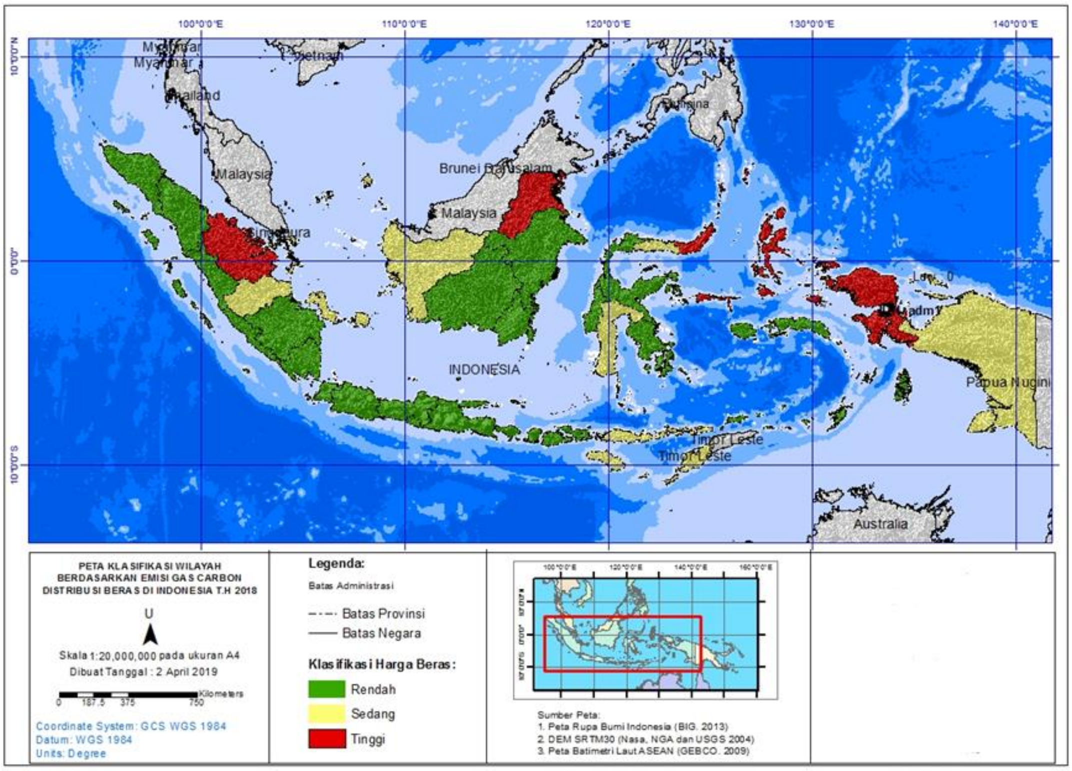
Sustainability: Theory, Practice and Policy
Volume 1, Issue 1, October 2021 (95-110)
ISSN: 2808-4829

34	Papua	3.839 4.226 4.729	Ferry Truck Ferry	42,229 760,68 52,019	812,70	Medium
	Total			**36.007,97**	**36.007,97**	

Source. Based on BPS rice trade distribution analysis and BULOG's Movenas (2019)

Based on table 4, if information on distribution of areas with the classification of CO2 emitters is obtained, information will be obtained as shown in Figures 4.

Figure 4 Classification of the Amount of CO_2 Emissions from Rice Distribution Activities in Indonesia

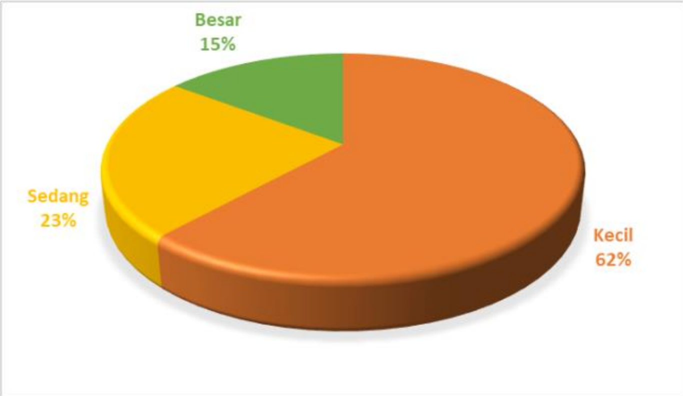


Source. Analysis (2019)

Discussion

In general, emissions resulting from rice distribution activities in Indonesia are categorized as low classification, amounting to 62%, while the percentage of areas with medium classification in contributing CO_2 emissions is 23%, and high classification is 23%. It can be seen on figure 5.

Figure 5 Percentage of Typology of Emissions from Rice Distribution Activities in Indonesia



Source. Analysis (2019)

Provinces that contribute the least carbon gas emissions are the Special Region of Yogyakarta Province. The province that contributed the most carbon emissions was Riau Province with a total emission of 15,945.64 tons kilometers. Several provinces that contribute carbon gas emissions with a medium to high classification are in eastern Indonesia. Provinces that contribute high carbon gas emissions are caused by the inability of the province's rice production to meet its local needs, so it must bring in rice from other provinces. Ideally, the province will bring rice from the surrounding area, but in this case the province in this category brings rice from more distant areas. It shows that there are still areas that are less effective in distributing rice and the selected distance is relatively long. The factor that causes a region to import rice is the ability of the region to meet the availability and import tariffs (Ilyas, A. et. al, 2020). This also applies to provincial decisions in determining rice supply areas to meet local needs. The spatial distribution of rice supply areas for each province in Indonesia can be seen in table 5.

Table 5. Spatial distribution of rice supply areas in Indonesia

No	Province	Region of Rice Fulfillment				Category
1	South Sumatera	South Sumatera (%) 85.63	Lampung (%) 0.25	DKI Jakarta (%) 6.05	West Java (%) 8.07	
2	East Java	Central Java (%) 0.06	East Java (%) 99.9	South Sulawesi (%) 0.04		**Near Surplus**
3	Central Sulawesi Tengah	Central Sulawesi (%) 84.8	South Sulawesi (%) 13.66	West Sulawesi (%) 1.54		
4	Bengkulu	West Sumatera (%) 0.49	South Sumatera (%) 1.74	Bengkulu (%) 29.85	Lampung (%) 66.94	**Near Deficit**
5	D.I	Central Java (%)	D.I Yogyakarta			

	Yogyakarta		(%)		
		61.91	38.09		
6	East Kalimantan	East Java (%)	East Kalimantan (%)	South Sulawesi (%)	
		7.65	8.81	83.54	
7	NTT	East Java (%)	NTT (%)	South Sulawesi (%)	**Moderate Deficit**
		60,9	36,39	3,32	
8	Central Kalimantan	DKI Jakarta (%)	NTT (%)	East Java (%)	**Middle Distance Surplus**
		14,87	2,26	32,31	
		Central Kalimantan (%)	South Kalimantan (%)		
		47,24	3,32		

Continued Table of 5

No	Province	Region Of Rice Fulfillment			Category
9	South Kalimantan	DKI Jakarta (%)	West Java (%)	East Java (%)	**Moderate Surplus**
		1,38	0,04	19	
		Central Kalimantan (%)	South Kalimantan (%)		
		27,99	51,59		
10	South Sulawesi	DKI Jakarta (%)	West Java (%)	East Java (%)	**Moderate Surplus**
		0,03	0,03	0,05	
		South Sulawesi (%)	South East Sulawesi (%)		
		99,38	0,51		
11	Gorontalo	DKI Jakarta (%)	South East Sulawesi (%)	South Sulawesi (%)	**Moderate Surplus**
		0,02	21,09	5,33	
		Gorontalo (%)			
		73,56			
12	Jambi	North Sumatera (%)	West Sumatera (%)	Jambi (%)	**Moderate Deficit**
		0,5	2,88	23,47	
		South Sumatera (%)	Bengkulu (%)	DKI Jakarta (%)	
		43,49	1,02	0,04	
		Central Java (%)			
		28,6			
13	Riau Island	North Sumatera (%)	Riau (%)	South Sumatera (%)	**Moderate Deficit**
		3,2	0,01	0,57	
		DKI Jakarta (%)	West Java (%)		
		41,83	20,46		

Sustainability: Theory, Practice and Policy
Volume 1, Issue 1, October 2021 (95-110)
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14	Maluku	DKI Jakarta (%)	East Java (%)		**Moderate Deficit**
		11,33	36,04		
		South Sulawesi (%)	Maluku (%)		
		14,95	26,35		
15	Riau	North Sumatera (%)	West Sumatera (%)	Riau (%)	**Remote Deficit**
		4	0,78	71,19	
		Lampung (%)	DKI Jakarta (%)	West Java (%)	
		0,21	6,53	3,92	
		East Java (%)	South Sulawesi (%)		
		1,31	12,06		

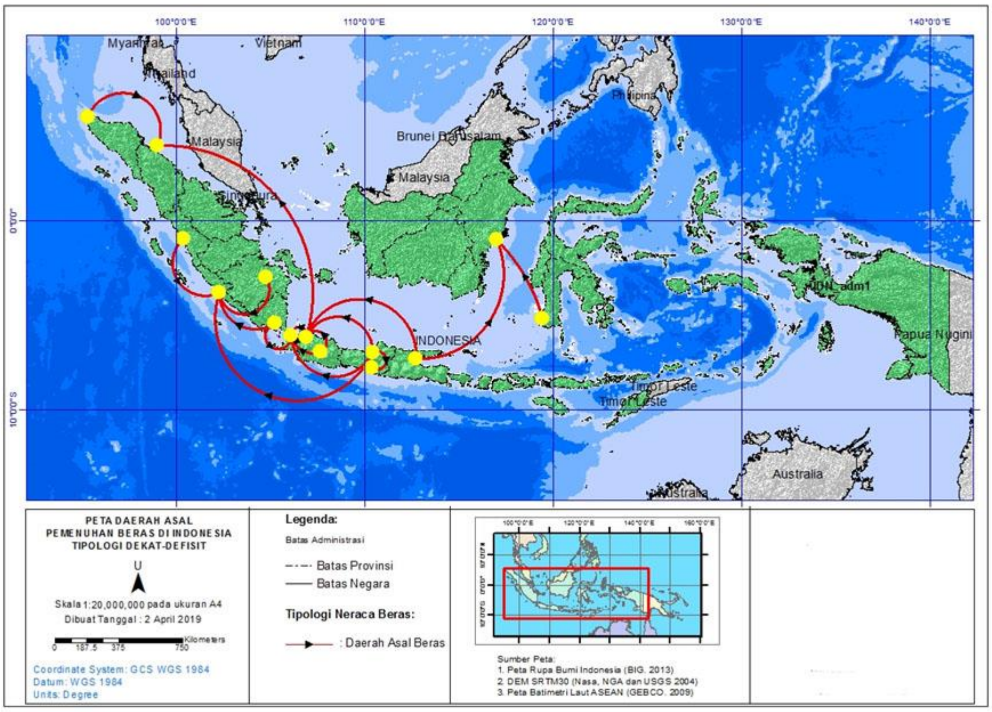
Continued Table of 5

No	Province	Region of Rice Fulfillment			Category
16	Bangka Belitung Island	South Sumatera (%)	Bangka Belitung Island (%)	DKI Jakarta (%)	**Remote Deficit**
		7,59	36,54	34,39	
		North Sulawesi (%)	South Sulawesi (%)		
		6,05	4,32		
17	West Kalimantan	DKI Jakarta (%)	West Java (%)	Central Java (%)	**Remote Deficit**
		0,63	42,73	3,83	
		East Java (%)	West Kalimantan (%)	South Sulawesi (%)	
		0,63	25,07	0,11	
18	North Kalimantan	Central Java (%)	East Java (%)	East Kalimantan (%)	**Remote Deficit**
		1,98	4,57	0,85	
		North Kalimantan (%)	South Sulawesi (%)		
		3,44	89,16		
19	North Maluku	DKI Jakarta (%)	Central Java (%)	East Java (%)	**Remote Deficit**
		0,67	0,06	0,89	
		North Sulawesi (%)	South Sulawesi (%)	South East Sulawesi (%)	
		0,18	84,6	0,02	

		Gorontalo (%)	North Maluku (%)		
		0,99	12,59		
20	West Papua	Central Java (%)	East Java (%)	South Sulawesi (%)	**Remote Deficit**
		0,09	3,76	87,27	
		Maluku (%)	West Papua (%)		
		1,71	7,17		
21	Papua	East Java (%)	South Sulawesi (%)	Papua (%)	**Remote Deficit**

Source. BPS (2016)

Figure 6 Classification of the Amount of CO_2 Emissions from Rice Distribution Activities in Indonesia

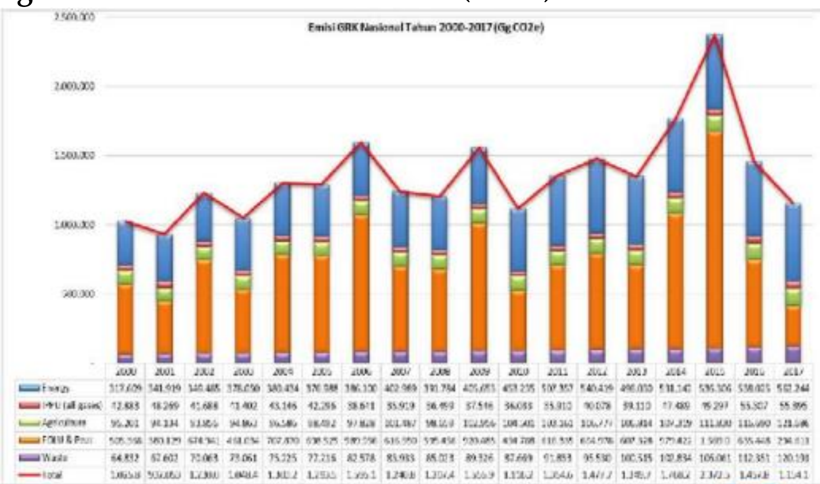


Source. Analysis (2019)

Nationally, carbon gas emissions produced from various sectors have changed, either increasing or decreasing. Based on the 2018 climate change control statistics released by the ministry of environment and forestry, it can be seen that until 2015 national greenhouse gas (GHG) emissions had increased and started to decrease in 2016 and 2018. It can be seen in Figure 7.

The graph of greenhouse gas emissions in Figure 7 is a graph shown from 5 sectors, namely energy, industrial processes and product use, agriculture, forestry and peat fires, and waste. Based on data from the Ministry of Energy and Mineral Resources, from the five sectors, carbon gas emissions from transportation activities are in the energy sector, where this sector is under the auspices of the Ministry of Energy and Mineral Resources. The Ministry of Energy and Mineral Resources (2016) states that the transportation sector is the sector that produces the largest GHG emissions compared to other sectors such as the industrial sector, commercial, household, and other sectors. The transportation sector in 2015 contributed 53%, followed by the industrial sector at 35%, the household sector at 8%, the other 3% and the commercial sector at 1%. The number of GHG emissions from the transportation sector nationally in 2015 was 137,94 million tons of CO_2. When compared with the total emissions generated from rice trading distribution activities, based on data from the origin of rice purchases, it was found that emissions from these activities were only 0,026%. It means that the contribution of CO_2 emissions from these activities is not significant.

Figure 7 National Greenhouse Gas (GHG) Emissions 2000-2017



Source. BPS rice trade distribution analysis, Author 2019

The Ministry of Energy and Mineral Resources (2016) also mentions that the cause of the transportation sector being the largest contributor to GHGs is due to the high growth in the number of vehicles that occurs each year, besides the phenomenon of online-based public transportation is also significantly contribute to increase the number of mode transportation, so that basically the amount of emissions from rice trading distribution activities is not a worrying thing compared to private transportation modes.

Conclusion

Based on the analysis that has been done, it can be concluded that the emission of carbon gas (CO_2) generated by the distribution of rice trading activities in Indonesia is basically insignificant when compared to the total contribution of emissions generated by transportation activities as a whole. Total emissions from rice distribution activities amounted to 36.007,97 tons km or 0,026% of the total emissions generated by transportation activities.

In terms of efficiency, there are still several provinces that have inefficient rice distribution channels, such as Riau province which contributes the highest carbon gas (CO_2) emissions. Provinces with the classification of medium and high emission levels are mostly located in the central and eastern parts of Indonesia.

References

BPS. 2016. Distribusi Perdagangan Komoditas Beras Indonesia. Jakarta. Badan Pusat Statistik

Corbett, J.J., Koehler, H.W., 2003. Updated emissions from ocean shipping. J. Geophys. Res. 108 (D20), 9-19-13.

Davis, S.C., Diegel, S.W., 2007. Transportation Energy Data Book: Edition 26; ORNL-6978. Oak Ridge National Laboratory, Oak Ridge, TN.

FAO. 2006. Food Security. Policy Brief of FAO (2006): 1-4. FAO's Agriculture and Development Economics Division (ESA). (online) www.fao.org/.../pdf/pdf_Food_Security_Cocept_Note.pdf. DIakses pada 11 Februari 2019.

Horrigan, L., Lawrence, R. S., & Walker, P. (2002). How sustainable agriculture can address the environmental and human health harms of industrial agriculture. Environmental health perspectives, 110(5), 445-456.

Hill, H. (2008). Food miles: Background and marketing (pp. 1-12). Attra.

Ilyas, A., Noer, M., & Wahyuni, I. (2020). ANALISIS FAKTOR-FAKTOR YANG MEMENGARUHI KETERSEDIAAN BERAS DI INDONESIA ANALYSIS OF FACTORS THAT INFLUENCE RICE AVAILABILITY IN INDONESIA. *Jurnal Pemikiran Masyarakat Ilmiah Berwawasan Agribisnis. Juli*, *6*(2), 740-753.

IMO. (2010). Peta pengesahan ALKI. [Online]. International Maritime Organization. Tersedia dalam: http://www.imo.org/includes/blastDataOnly.asp/data_id%3D8751/200-a1-ALKII-IIIAnnexVII.pdf.

Kemp, K., Insch, A., Holdsworth, D. K., & Knight, J. G. (2010). Food miles: Do UK consumers actually care?. Food policy, 35(6), 504-513.

Kissinger, M. (2012). International trade related food miles–The case of Canada. Food policy, 37(2), 171-178.

Lupita, C. P., Sudarno, S., & Istirokhatun, T. (2013). *Analisis Pengaruh Umur Mesin, Periode Servis Dan Jarak Tempuh Terhadap Konsentrasi Emisi CO, Nox, HC Dan CO2 Pada Sepeda Motor Tipe Sport (Studi Kasus: Motor Yamaha Vixion)* (Doctoral dissertation, Diponegoro University).

Nugroho, C. P., & Mutisari, R. (2016). Analisis Indikator Ketahanan Pangan Kota Probolinggo: Pendekatan Spasial. Agricultural Socio-Economics Journal, 15(3), 166.

Pollutan Gasses and The Influence of Human Healt. *Jurnal Chemica* Vol. 10 . 50-58.

Pinstrup-Andersen, P. (2009). Food security: definition and measurement. Food security, 1(1), 5-7.

Rigby, D., & Bown, S. (2003). Organic food and global trade: is the market delivering agricultural sustainability?. University of Manchester, School of Economic Studies.

Rivani, E. (2012). Penentuan Dimensi Serta Indikator Ketahanan Pangan di Indonesia: Kaji Ulang Metode Dewan Ketahanan Pangan-World Food Program. Widyariset, XV, 1, 151-161.

Saunders, C. M., Barber, A., & Taylor, G. J. (2006). Food miles-comparative energy/emissions performance of New Zealand's agriculture industry.

Shen, L., Tao, F., & Wang, S. (2018). Multi-depot open vehicle routing problem with time windows based on carbon trading. *International journal of environmental research and public health*, *15*(9), 2025.

Sugiarti.2009. Gas Pencemar Udara Dan Pengaruhnya Bagi Kesehatan Manusia Air

Sutanhaji, A. T., Anugroho, F., & Ramadhina, P. G. (2018). Pemetaan Distribusi Emisi Gas Karbon Dioksida (CO2) dengan Sistem Informasi Geografis (SIG) pada Kota Blitar. *Jurnal Sumberdaya Alam dan Lingkungan*, *5*(1), 34-42.

Verstappen, H. Th. (2013). Garis Besar Geomorfologi Indonesia, (Diterjemahkan oleh Sutikno), Suratman (Editor). Yogyakarta: Gadjah Mada University Press.
World Bank. 2018. Population Total. (online)
https://data.worldbank.org/indicator/sp.pop.totl diakses pada 15 November 2018.