Projection of Big Cities Waste Management and Cost Based on Economic and Demographic Factors in Indonesia

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Abstract : Nowadays, solid waste management continues to be a major challenge in urban areas, especially in developing country. It is triggered by population growth, economic growth, industrialization and urbanization. Indonesia itselfs categorized into developing country. Indonesia's government has many program in order to increase the economic growth. One of them is MP3EI (Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia. This program should be suppported by right waste management system. If Indonesia's waste management system can't afford the economic growth, it will trigger health and environmental problems. This study's purpose is to develop the socio-economic-environment model that can be used as a basis planning for the facility and cost of waste management systems. In this paper we used the development of Khajuria model test method. This method used six variables, which are GDP, population, population density, illiteracy, school's period and economic growth. The result showed that development of Khajuria test could explained the influence of economic and demographic factors to waste generation, 65.6%. The projection of waste generation shows that Pangkalpinang, Pekanbaru and Serang are the cities with the highest waste generation for the next five years. The number of dump truck and TPS in DKI Jakarata is the highest within another city, which is 39.37%. For the next five years, the waste management system in our study areas cost maximum 0.8% from GDP (Gross Domestic Products).

Keywords: waste generation, test model, projection, GDP.

1. Introduction

Population growth, economic growth, development of industrialization, and urbanization are caused the increasing of waste generated in the big cities significantly[7]. Wang and Wang[11] state that economic and population growth in Beijing, caused the increasing of waste generated, 2,960,000 tons in 2000 to 6.20 million tons in 2007, and it fluctuates in to 6.35 million tons in 2010. Solid waste generated globally in 1997 was around 0.49 billion tonnes with an estimated annual growth rate of 3.2-4.5% in developed countries and 2-3% in developing countries[6]. The waste management system will face critical phase because its facility unavailable to manage waste in larger quantities. Waste management system need the right infrastructure, maintenance and enhancement to run its activity. And it will make the cost more expensive and complex[10].

Indonesia categorized into developing country with middle low GDP. Indonesia's government has been done various efforts to encourage our economy growth. One of them is MP3EI [8]. If Indonesia's waste management system can't afford the economic growth, it will trigger health and environmental problems. Furthermore, we need the right strategy in waste management system. Sosio-economic-environment model can project waste generated. This projection is based on economy, demography and policy. The model system can be used as base in waste management system. Adlina[1] had done research about sosio-economy-environment model in West Java. That research used theree models, which are Khajuria, Weng and Daskalopoulus. The result showed that the accuracy of this three models compare to the real datas are 90.32% for Daskalopoulus, 67.76% for Khajuria and 68.89 % for Weng.

Khajuria et al[9] state that there are three factors affect waste generated, which are GDP, urbanization (population) and illiteracy. Beside this three factors, there are another factors, economic growth. Population density can be used as a variable. People who lives in area with high population density, usually disposal their waste into undue place, like river because the lack of waste dump[4]. Furthermore, this research used the development of Khajuria test model. Variables that used in development Khajuria model are GDP, population, population density, illiteracy, school's period and economic growth

Therefore, this study did reserach to identify the corelation between economic, demographic and social factors to waste generated in the capital city of Java and Sumatera provinces. Whereas, the aim of this study to develop socio-economy-environment model that can be used as base for planing and cost of waste management system. This model using economic, demographic and social factors to waste generated in each capital city of Java and Sumatera provinces. This study used the development of Khajuria Model.

This paper is structured as follows, in Section 2 we describe Waste Management, Influences of Economic and Demographic Factors to Waste Generated and Khajuria Test Model. In Section 3 we describe Methodology, the development of Khajuria model test to projected waste generated as basis of waste management and cost in the future. In Section 4 which is the result of an analysis of the findings of this paper. Section 5 is part of the Conclusion and Suggestion.

2. Theoretical Framework

2.1 Waste Management

Waste management is an effort to handle waste generated from human activities. This waste management is classified in to six elements, which are controling, storage, collecting, processing and disposal. The six elements interdependent with each other, forming a waste management system[10].
Local government need partners to do the integrated waste management. The society becomes the important stakeholder for waste treatment. They have to involved actively for achieving the better waste management by changing their behaviour[1].

2.2 Influences of Economic and Demographic Factors to Waste Generated

Waste generated affected by economic growth, industrialization, lifestyle and local climate. Generally, the higher economy growth and urbanization, the greater waste generated become. Level income and urbanisation have the close relevance. As income and living standards increase, consumption of goods and services will also increase. This situation will make waste generated increase. In addition , by increasing the purchasing power of the community for various types of essential commodities and the outcome of technology also made a significant contribution to the quantity and quality of waste generated[5].

Theoretically, demand for energy can improve economic conditions of a country and is expected to produce technology efficient and friendly to the environment. Unfortunately, economic growth in the developing and less developed countries are caused the increasing of CO_2 globally[2].

2.3 Khajuria Test Model

Khajuria et al.[9] stated there are three factors that can influence waste generated. The three factors are :

- Urbanisation (population)
  The last decades, waste generated increase significantly in developing countries. It is caused by urbanisation that triggered the population growth in urban areas.
- GDP
  Economic growth caused the changing of society's life style. That life style increase the consumption of society and it caused the increasing of waste generated.
- Illiteracy
  Illiteracy can influence waste generated because the ignorance of society about waste processing made the increasing of waste generated.

3. Research Methodology

The study areas are Banda Aceh, Medan, Pekanbaru, Padang, Palembang, Bengkulu, Jambi, Pangkalpinang, Tanjungpinang, Bandar Lampung, Serang, DKI Jakarta, Bandung, Semarang, Yogyakarta and Surabaya. There are six independent variables which are population, population density, GDP, economic growth, literacy rate and school's period. Whereas the dependen variable is waste generated.

Secondary datas collected through the relevant department. There are five departments, Central Bureau of Statistics, Regional Office of Sanitary Agency, Ministry of Public Works, Environmental Agency and Ministry of Environment.

Method used is linear model of development Khajuria test that is assumed the linear realtion between waste generated and factors that influences it.

$$\mathbf{WG = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6} \quad \mathbf{(1)}$$

WG is waste generated, x_1 is population, x_2 is GDP, x_3 is literacy rate, x_4 is school's period, x_5 is economic growth dan x_6 is population density. Whereas a is constant and b is coeficient from each factors.

4. Result and Discussion

4.1The Development of Khajuria Test Model

First the development of Khajuria tested to all of the capital cities simultaneously**. Table 1.** shows the result of development Khajuria Test Model for all of the capital cities. The analysis result of SPSS shows that this test model has *R square* 0.656. It means that independent variables has capability to explain the variance of dependent variable 65.6%.

Next, this model tested separately for each of that capital cities. It is meant to know the differences between this two treatment. The result of development Khajuria model for each cities show the better result. Population, GDP, population density, economic growth, litiracy rate, and school's period capable to explain waste generated above 50%. It happened because the characteristic of these cities are different. So that, the development of Khajuria model can't be used in the capital cities of Java and Sumatera Provinces generally.

Table 1. Coeficient of variable from development khajuria test model

Variable	Coefficient
Constanta	-44.877
Population	-1.819×10^{-7}
GDP	-5.07×10^{-9}
School's period	-2.518
Litiracy rate	.0.733310
Population density	0.000104
Economic growth	0.065944

4.2The Projection of Waste Generated

The projection of waste generated is done by using **Equation 2**. This equation is formed by the development Khajuria test model's result from the first treatment. Population variable not included because this variable has significant value greater than the other variables.

WG = -44,877 - 5,076 x 10^{-9}GDP + 0,40 Literacy Rate - 2,518 School's period + 0,000104 Population Density + 0,066 Economic Growth (2)

The projection of waste generated in Pekanbaru and Semarang were done using **Equation 3** and **Equation 4**. Those equatians were formed by the development Khajuria test model's result from the second treatment. This is because significant values of that two cities from the second treatment better than the first treatment.

WG = -490,2 - 4 x 10^{-6} Population – 1,69 x 10^{-7} GDP + 4,87 Literacy Rate + 0,80 School's Period – 0,035 Economic Growth (3)

WG = -61,29 + 8,47 x 10-8 GDP - 0,49 Literacy Rate - 5,05 School's Period – 0,00054 Population Density – 0,20 Economic Growth (4)

Table 2. shows the increasing of population and waste generated for each cities per five years. This table proves that the increasing of waste generated linear with the increasing of population. Population in Pangkalpinang, Serang and Pekanbaru have increased two times in 2030, as well as the waste generated.

The increasing of waste generated per five years for each cities shown in **Figure 1**. Pangkalpinang, Pekanbaru and Serang have the highest waste generated per five years. It stated before that waste generated increase as the population increase. The population of Pangkal Pinang, Pekanbaru and Serang shown in **Table 2** have increase about two times.

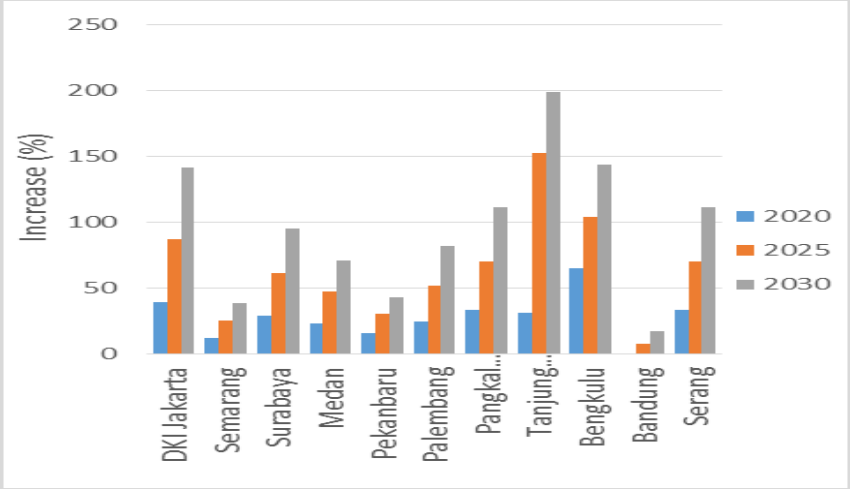

Figure 1. Increasing of waste generated per next five years

Table 2. Projection of population and waste generated per the next five years

City	Population (x 10^6 people)			Waste Generated (x 10^3 m^3/h)		
	2020	2025	2030	2020	2025	2030
DKI Jakarta	12,3	13,6	14,9	45.8	61.5	79.4
Serang	0,9	1,1	1,2	2.9	3.8	4.7
Semarang	1,8	1,9	2,1	6.1	6.8	7.5
Surabaya	2,9	2,9	3,0	8.1	10.1	12.2
Medan	0,3	0,3	0,4	1.7	2.0	2.4
Pekanbaru	1,3	1,6	1,8	4.1	4.6	5.0
Palembang	1,7	1,8	1,9	4.2	5.1	6.1
Bengkulu	0,4	0,5	0,6	0.5	0.8	1.1
Pangkal pinang	0,3	0,4	0,5	2.0	2.5	3.0
Tanjung pinang	0,3	0,3	0,3	0.6	1.1	1.7
Bandung	2,6	2,7	2,8	1.5	1.6	1.8

4.3 The Projection of Dump Truck and Temporary Waste Dump (TPS)

The higher waste generated, the higher the need of dump truck and TPS. **Figure 2**. shows that DKI Jakarta needs more dump truck and TPS than other cities. It is because the increasing of waste generated in DKI Jakarta is the highets among the other cities.

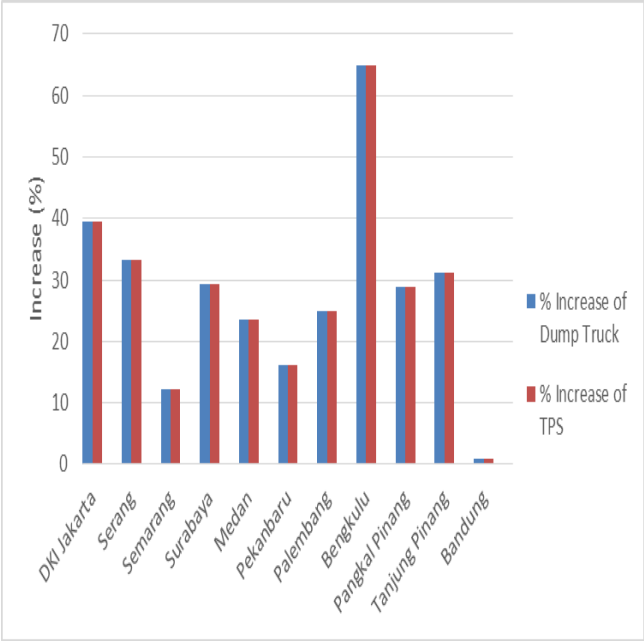

Figure 2. Increase of dump truck and TPS per the next five years

4.4 Ratio of Waste Management Cost to GDP

Brunner and Fellner[3] states that the developed countries spend around 0.4% of the gross domestic product (GDP) for the cost of waste management. As for the developing countries about 0.2-0.4%. In this study the calculation of waste management cost based on KSNP-SPP 2006 rules. KSNP-SPP 2006 rules divides the cost into several stages. Table 3. shows the stages required in waste management along with the fees charged per ton of waste generated. First, the cost in 2015 is conversed because there's changes of inflation value from 2006 to 2015.

Table 4. shows the cost of waste management based on Table 3. From Table 4. we can state that even the waste generated and waste management's cost have increased, the ratio of waste management's cost to GDP have decreased. Economic growth triggers the increasing of GDP. The higher GDP can cover the cost of waste management. So that, the waste management cost should not be an issue in the future.

Table 3. Componenets of waste management cost

No	Componenets	Cost per ton in 2006	Cost per ton in 2015
1	Transporting	119,268.00	208,215.13
2	Composting	103,973.00	181,513.50
3	Processing	141,684.00	247,348.43

Table 4. Projection of waste management cost based on KSNP-SPP 2006 rules

City	Year	Total Cost of Waste	GDP (x 10^6	Ratio of

		Management (Billions/year)	**Billions/ year)**	**waste management cost to GDP**
DKI Jakarta	2015	902.85	5.2	0.0012
	2020	1258.35	0,78	0.0016
Serang	2015	61.04	0.000284	0.2144
	2020	81.39	0.000442	0.1840
Semarang	2015	149.45	0.11	0.0127
	2020	167.82	0.17	0.0097
Pangkal pinang	2015	42.93	0.0000041	1.0268
	2020	55.35	0.0000065	0.8448
Tanjung pinang	2015	11.61	0.000084	0.1374
	2020	15.23	0.00012	0.1301

5. Conclusion

The development of Khajuria Model can explains waste generated and can be used to project waste generated in the future. Waste generated and waste management cost have increased but the ratio of waste mangement cost and GDP have decreased. Data base development is required to made better analysis as a basis of development waste management.

6. References

[1] Adlina, A. 2013. *Identification of Socioeconomic Factors and Population's Effects to Waste Generation In West Java*, Tesis Program Magister, ITB.

[2] Alsheyab, M. and Kusch, S. 2013. *Decoupling resources use from economic growth chances and challenges of recycling electronic communication devices*, *Journal of Economy, Business and Financing*, 1, 1, 2013, *1615-1619*.

[3] Brunner, P. H. and Fellner, J. 2007. *Setting priorities for waste management strategies in developing countries, Waste Management & Research*, 25, 3, *234-240*.

[4] Bhavannarayana, C., Prakash, K.S., and Saritha, V. 2011. *Estimation of municipal solid waste generation a case study, International Journal of Research and Reviews in Pharmacy and Applied science*, **2, 3,** *473-481*.

[5] Jaelani, A., H. I. Purwanti and M. R. Aziz. 2011. *Utilization Of Simple Composter As An Alternative Solution To Overcome The Waste In Podosugih Housing Pekalongan City*, Tesis Program Magister, Fakultas Pertanian Universitas Pekalongan.

[6] Johari, A., Ahmed, S. I., Hashim, H., Alkali, H., and Ramli, M. 2012. *Economic and environmental benefits of landfill gas from municipal solid waste in Malaysia*, *Renewable and Sustainable Energy Reviews*, 16, *2907– 2912*.

[7] Kaushal, R. J., Varghese, G. K., and Chabukdhara, M. 2012. Municipal solid waste management in india-current state and future challenges : a review, *International Journal of Engineering Science and Technology (IJEST*), **4, 04**, *1473*.

[8] Kementerian Keuangan Republik Indonesia. 2011: *Masterplan Percepatan Dan Perluasan Pembangunan Ekonomi Indonesia 2011-2025*, Lampiran Peraturan Presiden Republik Indonesia Nomor 32 Tahun 2011.

[9] Khajuria, A., Yamamoto, Y., and Morioka, T. 2010. *Estimation of municipal solid waste generation and landfill area in asian developing countries*, *Journal of Environmental Biology*, **31, 5**, *649-654*.

[10] Saraswati, E. 2007. *Institutional Development Model of Urban Waste Management Based on Community Participation (Case Study : Bandung)*, Sekolah Pasca Sarjana Institut Pertanian Bogor.

[11] Sharholy, M., Ahmad, K., Vaishya, R.C., and Gupto, R.D. 2007. *Municipal solid waste characteristics and management in allahabad*, india, *Journal of Waste Management*, **27, 4**, *490-496*.