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THE INFLUENCE OF ECONOMIC AND DEMOGRAPHIC FACTORS TO WASTE GENERATION IN CAPITAL CITY OF JAVA AND SUMATERA

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Abstracts: Population growth, industrialization, urbanization and economic growth, resulting an increase of municipal solid waste. The purposes of this study were to analyze the relationship between economic, social and demographic variable and waste generation and to identify patterns associated local waste development in Java and Sumatra. This study was to analyze the relationship between economic and demographic variabels against waste generation. Then performed khajuria and Daskalopoulus model test and also cluster, quadrantt and Klassen typology analysis to determine the pattern of characteristics and waste generation in Java and Sumatra. The test result of Daskalopoulos model was waste generation in Java and Sumatra can be explained 20.6% by consumption expenditure per category. The test result of Khajuria model was waste generation in Java and Sumatra can be explained 21.8 % by value of the total population, GDP, and illiteracy. There are three Pattern of waste generation based on the characteristics and economic activity. The first pattern is a group of cities with low waste generation that is characterized by low economic growth and port/trade and trade/plantation as economy activity. The second pattern is a group of cities with high waste generation, low economic growth and high consumption and industry/trade as economy activity. The third pattern is characterized by high waste generation, high economic growth, and high GDP and also industry/trade as economic activity.

Keywords: Waste generation, Test model, Cluster analysis, Economic activity

INTRODUCTION

Solid waste management continues to be a major challenge in urban areas throughout the world, especially in the cities of developing countries. Population growth, industrialization, urbanization and economic growth, resulted in a significant increase of the amount of municipal solid waste worldwide (Kaushal *et al*., 2012). In addition, consuming behaviour of various kinds of staples and technology results also provide a major contribution to the quantity and quality of waste generated (Jaelani *et al*. 2011).

Solid waste has shown positive correlation with economic development on a world scale (Kaushal *et al*, 2012). Solid waste produced globally in 1997 was about 0.49 billion tons with an annual growth forecast from 3.2 to 4.5% in developed countries and 2-3% in developing countries (Johari et al., 2012). Research conducted in the developing city Kowur, India showed that the solid waste in this city increased

by 3274.5 kg per day compared to previous years (Bhavannarayana *et al*., 2011). Waste management in Beijing, China shows that the economic development and population growth have increased from 2.96 million tons of waste in 2000 to 6.20 million tons in 2007, fluctuating to 6.35 million tons in 2010 (Wang and Wang, 2013). Some theories suggests that there is a direct relationship between the level income of a country with the amount of waste generated. Countries with low income levels will produce less waste than high-income countries (Hoornweg and Bhada-Tata, 2012). Indonesia belongs to the category of developing countries with mid-low levels income. Indonesia's government has a program to increase the economy. Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia (MP3EI) is a roadmap that is arranged the economy's transformation to a stimulate economic activity and also increase economic growth by improving competitiveness.

Indonesia's government develops a concept to support MP3EI program, namely Koridor Ekonomi Indonesia. Government have already identified six economic corridors which covers most areas of Indonesia, specifically: East-West Sumatra Java Sea, Northern Java, Borneo, Sulawesi, East Java-Bali-Nusa Tenggara, and Maluku Islands and Papua (Ministry of Finance Republic of Indonesia, 2011).

MP3EI program has positive and negative effects. The positive impact is able to incerase economic growth and level income. While the negative impacts is increasing the amount of waste. As was mentioned earlier that economic growth is directly affect to the amount of waste generated. If the waste management system in Indonesia is not able to compensate, it can lead to health and environmental problems. Therefore, it needs a proper strategy in terms of waste management.

Model of socio-economic-environment can estimate the amount of waste in accordance with the conditions of economic, demographic, and interversi policy implemented. This model can be used as a basis for planning the capacity of the facility waste management systems (Adlina, 2013). Weng (2009) created a model of socio-economic system-environment for waste management that takes into account aspects of lifestyle changes in terms of socioeconomic, demographic, and interversi policy implemented. While Daskalopoulus *et al.* (1998) uses a variable population and living standards in a country as the main variable affecting the quantity and composition of waste generation. In addition, GIS application can also be used. This application can simplify system management, monitoring and controling during the process of collecting and transporting waste. Studies using GIS applications have been done in the city of Can Tho, Vietnam by Thanh *et al* (2009).

Research on modeling socio-economic-environmental was done by Adlina (2013) to the area of West Java. The study used three test models, which are Khajuria, Daskalopoulus and Weng test models. The results showed that the accuracy of each test this model with the original data were 90.32% for Daskalopoulus, 67.76% for

Khajuria and 68.9% for Weng. Based on this, the research is going to identify economic and demographic factors on waste generation in Java and Sumatra. Java and Sumatra was chosen because both of this area belong to the economic corridor MP3EI program.

The purpose of this study is to develop a system of environmental-economic model that can be used as a basis for planning the capacity of the facility waste management systems. The objectives of this study are to analyze the corrrelation between economic and demographic variables on waste generation in Java and Sumatra, and to identify the local patterns that are related to the development of waste in Java and Sumatra.

RESEARCH METHODOLOGY

Cities which included to the research's coverage area are Banda Aceh, Medan, Pekanbaru, Padang, Palembang, Bengkulu, Jambi, Pangkal Pinang, Tanjung Pinang, Bandar Lampung, Serang, DKI Jakarta, Bandung, Semarang, Yogyakarta, and Surabaya. Variables that used in this research are total of population, population density, consumer price index, Gross Domestic Product (GDP), population growth rate, economic growth rate, school's period, literacy rates, and people development index.
Data collect conducted in the provincial and city level. Secondary data collect focused on datas which related to the data of population, economic growth, social, and environment. Data collect conducted by getting data from relevant departments, those are BPS and Dinas Kebersihan. A statistical data processing by using statistic software from IBM SPSS Statistics 20.

The evaluation of tipology, city classification was analyzed using cluster analysis, quadrantt analysis, and classen typology analysis. Cluster analysis was analyzed based on waste generation, city's characteristic, and economic activity. After getting the cluster from those three analysis, ANNOVA analysis and discriminant was done to know the differences between the clusters. Then the results of cities's classification based on waste generation compared to the SNI.
City classification can also be done by using quadrant analysis and classen typology. Quadrantt analysis compares the relationship between population density and waste generation. Meanwhile classen typology analysis is used for covering the description of the pattern and economic growth structure of each cities. Then to find the patterns of waste generation from each cities, comparison the result of cluster analysis, quadrant analysis, and classen typology was applied.

To find the relevancy between consumer price index, Gross Domestic Product based on Constant Price, and total of population variables towaste generation, Regression Analysis was done. Test model conducted in this research as a baseline for waste management. Daskalopoulus et al. (1998) projected waste generation by linking it with consumption outcome that has been divided by the kinds of consumption. The

model described in the equation below

$MSW = \beta \times RTCE_n$..... **(Equation 1)**

MSW is waste generation and RTCE is related total consumption expenditures. With β as the coefficient of each variables.
Meanwhile Khajuria et al. (2010) projected waste generation based on total of population, GDP, and illiteracy. Khajuria model can be described like equation below :
$WG = \alpha + ((\beta_1 \times X_1) + (\beta_2 \times X_2) + (\beta_3 \times X_3))$..... **(Equation 2)**

Which WG is waste generation, x_1 is total of population, x_2 is GDP, and x_3 is illiteracy. With β as the coefficient of each variables and α is constant.
Then development of Khajuria model was done. Economic growth and illiteracy rate factors were added to linear model Khajuria, so it formed like **Equation 3.**

$WG = a + (b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5)$.....**(Equation 3)**

which WG is waste generation, x_1 is total of population, x_2 is GDP, x_3 illiteracy rate, x_4 is school period ,and x_5 is economic growth. Meanwhile a is constant and b is coefficient of each factors. The projection of waste generation can be done based on the discriminant equation obtained from the discriminant analysis. Projection of waste generation is done every five years.

RESULTS AND DISCUSSIONS

The Evaluation of City's Typology

The city classification based on the economic activity, group of city with economic activity focused on Industry/Trade is the city with quietly high waste generation. Whereas for the group of city with economic activity that focused on trade/plantation, the production of waste generation is medium. Then group of city with economic activity that focused on Port/Trade, the production of waste generation is low. Analysis discriminant showed there are three variables that make the difference between these clusters, which are population density, consumer price index and economic growth. **Figure 1** showing the map of city classification based on the economic activity for each cities.

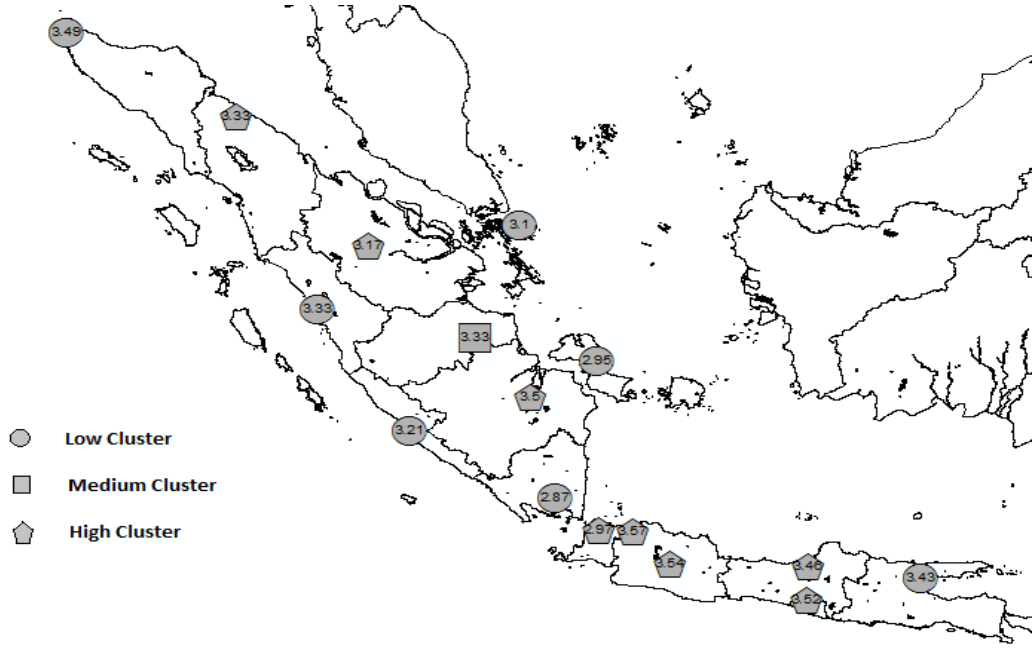

Figure 1. Map of city classification based on the economic activity.

The Classen Typology analysis like showed on **Figure 2**, obtaining the result in the form of patterns. Pattern A is fast-progressing and fast-growing regional, the city that have higher economic growth than other cities in Java and Sumatera. City that classified to pattern A have average economic growth 7.63 % and average GDP 14.67 millions. Bandung, Serang, Medan, Palembang, Tanjung Pinang, Bengkulu and Jambi are classified to this pattern. Waste generation that produced by this group of city is 3.28 l/p/d.

Pattern B is fast developing regional, which has medium economic growth. The city that classified to pattern B have average economic growth 7.11 % and average GDP 257.86 millions. DKI Jakarta and Surabaya are classified to this pattern. Average waste generation of this group of city is 3.5 l/p/d. Pattern C, quite lagging region, is a regional that has economic growth and GDP rate quietly low. The city that classified to pattern C has average economic growth 5.49 % and average GDP 8.63 millions. Yogyakarta, Banda Aceh, Pekanbaru, Bandar Lampung, Pangkal Pinang dan Padang are classified to this pattern. Average waste generation that produced by this group of city is 3.22 l/p/d.

Pattern D, growing but under pressure regional, is a regional that has high rate GDP, but the rate of economic growth is low. The city that classified to this pattern has average economic growth 6.41 % and average GDP 48.46 millions. Semarang are classified to this pattern. The average production of waste generation of this group of

city is 3.45 l/p/d.

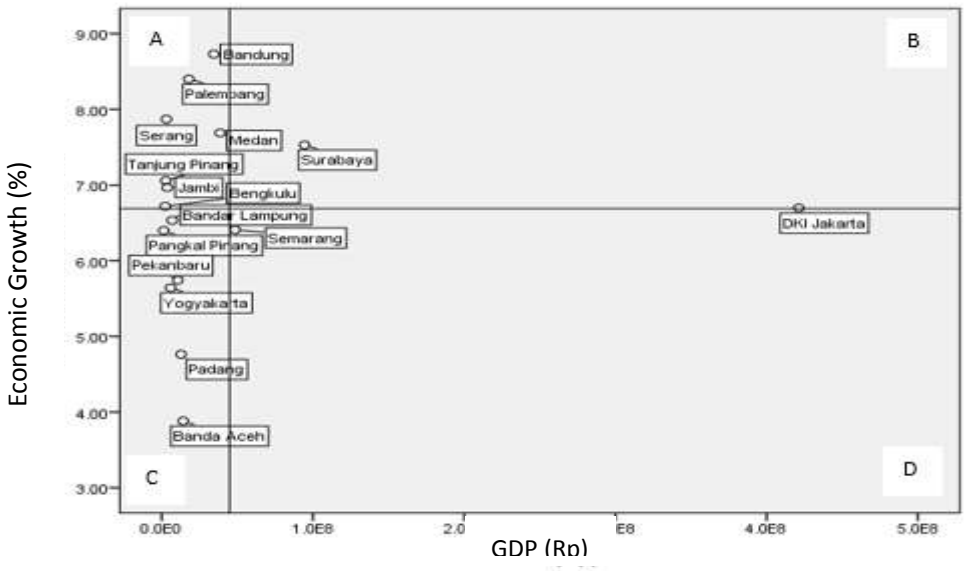

Figure 2. The classification of classen typology.

The classification based on the quadrant division of population density and waste generation can be looked at **Figure 3.** Group I is a group of city with medium waste generation (3.4 l/p/d) characterized by the medium average of population density, 2834 people/km^2 . Meanwhile group II is a group of city that have high rate waste generation (3.5 l/p/d) characterized by average population density 10984 person/km^2. Group III is a group of city that have low rate waste generation (3.04 l/p/d) characterized by the average population density 2175 person/km2. None of the sixteen cities classified into the group IV. Group IV is a group of cities that have a low waste generation and high population density.

Based on the characteristic of city, analysis cluster analyzed for two groups and three groups. Analysis cluster for two grup results showed each clusters have different characterizations**.** Cluster 1 is a group of city with the quietly low average of waste generation (3.24 l/p/d) characterized by average GDP 7.83 million and economic growth 6.21 %. Meanwhile for cluster 2 is a group of city with highly average of waste generation (3.44 l/p/d), characterized by GDP 40.50 million and economic growth 7.61 %. This analysis result showing the group of city with high waste generation have GDP and economic growth character that quietly high if compared to the group of city that have low waste generation.

Analysis cluster for three group have different characterizations**.** Cluster 1 is a group of city with the quietly low average of waste generation (3.16 l/p/d)

characterized by population density 3995 people/km2 and GDP 3.8 million. Meanwhile for cluster 2 is a group of city with highly average of waste generation (3.44 l/p/d), characterized by population density 4574 people/km2 and GDP 4.50 million. Then for cluster 3 is a group of city with quietly medium waste generation (3,38 l/p/d), characterized by average of population density 2530 people/km2 and GDP 13.88 million. This analysis result showing the group of city with high waste generation have population density and GDP character that quietly high if compared to the group of city that have low waste generation.

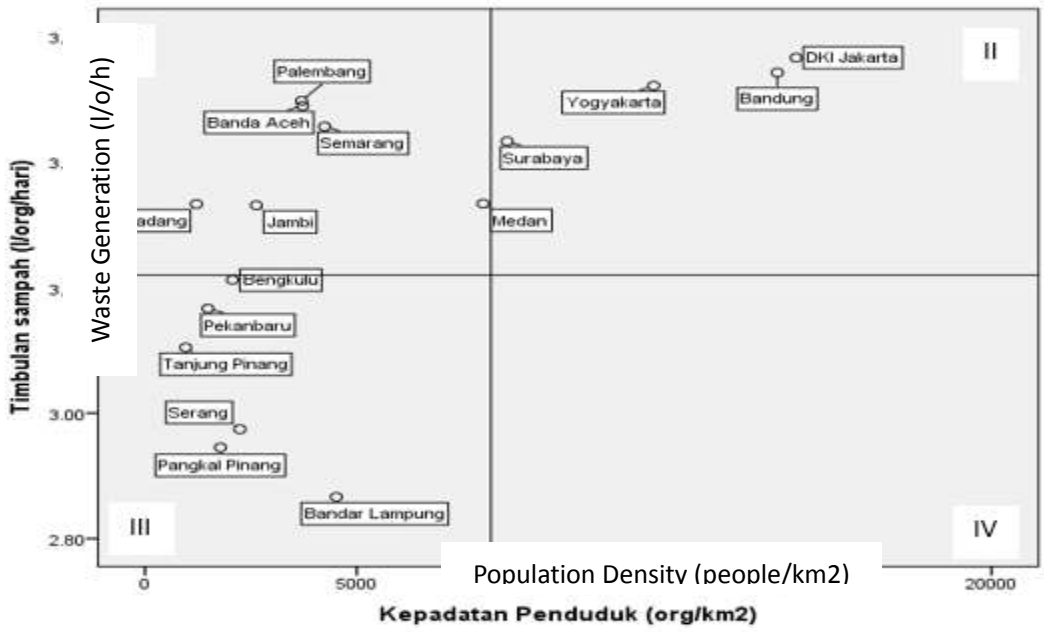

Figure 3. The classification of quadrant analysis.

By doing the comparison between cluster analysis of two groups, cluster analysis of three groups, quadrant analysis of population density and waste generation, and classen typology analysis, obtainable the characterization of each cities in Java and Sumatera. Based on the classification of waste generation cluster profile, the pattern that seen in Java and Sumatera divided into three patterns. Pattern 1 is a group of city with low rate waste generation and low economic growth. The majority of main activities from this group of city focused on Port/Trade and Trade/Agriculture. Pattern 2 is a group of city with high rate waste generation, low economic growth, and high consumption. The majority of main activities from this group of city focused on Industry/Trade. Pattern 3 is a group of city with high average waste generation, economic growth, and Gross Domestic Product. The majority of main activities from this group of city focused on Industry/Trade.

City classification based on waste generation showed that city with high population density, high total of population, and high economic growth characteristics has the waste generation that also quietly high. Meanwhile the city with population density, total of population, and economic growth that quietly low, its waste generation is also low. The differentiate variables between three clusters based on discriminant result are human development index, population growth race, and illiteracy rate. Cluster with high waste generation has the average rate of 3.5 l/p/d, cluster with medium waste generation has the average rate of 3.25 l/p/d and cluster with low waste generation has the average rate of 2.93 l/p/d. **Figure 4** shows map of city classification result based on waste generation. On the figure can be seen four cities in Java are included to the group of city with high waste generation, except Serang.

Figure 4. Map based on the cities' classification of waste generation.

The result of city classification analysis based on waste generation compared to SNI 19-3964-1994, SNI 19-3983-1995, like indicated on **Table 1.** The analysis result showed average waste generation for medium group of city was qualified with SNI 19-3983-1995. Meanwhile average waste generation of large group of city was not qualified with SNI 19-3964-1994. Waste generation in large group of city could be effected by the increasing population. It happened in Bandar Lampung. Population increased because two cities (Tanjung Karang and Teluk Betung) are united. Beside the increasing population, economic growth caused waste generation increase. Economic growth of Serang is 8.55 % and it's caused the increasing of waste

generation in this city.

Table.1 The Comparison of waste generation between SNI 19-3964-1994, SNI 19-3983-1995, and analysis result.

City Classification	Total of population (person)	Waste Generation (l/p/d)		
		SNI 19-3964-1994	SNI 19-3983-1995	Analysis Result
Large	500000 – 1000000	2 – 2.5	-	3.2 ± 0.28
Medium/ Small	3000 – 500000	1.5 – 2	-	3.1 ± 0,02
Medium	100000 – 500000	-	2.75 – 3.25	3.1 ± 0.02
Small	< 100000	-	2.5 – 2.75	-

The Relation of Waste Generation to Economy and Demographic Variables

Based on regression analysis result, consumer price index is directly proportional to the waste generation. Analysis result showing that highly consumer price index of a city, so its waste generation is also quite high. Banda Aceh and Tanjung Pinang have positive regression trend, which is the progression of consumer price index will also increase the waste generation in those two cities. So it is with the relationship analysis between GDP based on constant price and waste generation. The higher GDP rate will increase the rate of waste generation. Positive regression trend happened between GDP rate and waste generation in Pekanbaru, Tanjung Pinang, and Pangkal Pinang. For analyzing the relationship between total of population and waste generation, waste generation rate is quietly increased within the increase of total of population in a regional. Exceptionally for Yogyakarta which its waste generation has decreased because of the decrease of total of population.

Test Model

Daskalopoulus model test results an equation as showed in **Equation 4.** Daskalopoulus model has R-squared 0.337. It means consumption per each category can describe waste generation in capital city of Java and sumatera by 33.7 %.

$$MSW = 7{,}517 + ((-0.003 \times RTCE_1) + (0.018 \times RTCE_2) + (-0.073 \times RTCE_3) + (0.073 \times RTCE_4) + (-0.018 \times RTCE_5) + (-0.025 \times RTCE_6)) \quad \textbf{(Equation 4)}$$

Meanwhile model test Khajuria results en equation as showed in **Equation 5.** Khajuria model has R-squared 0.219. It means total of population, GDP, and school's period can describe waste generation in capital city of Java and Sumatera by 21.9%.

$$WG = 14{,}66 + ((2.889 \times 10^{-7} \times X_1) + (-6.112 \times 10^{-9} \times X_2) +$$

(-0.859 x X_3))……..……....(**Equation 5**)

The development of Khajuria model results an equation as showed in **Equation 6.** This development model has R-squared 0.458. It means total of population, GDP, school period, literacy rate, and economic growth can describe waste generation in capital city of Java and Sumatera by 45,8%.

$$WG = 0.859 + ((2.66 \times 10^{-7} \times X_1) + (5.84 \times 10^{-9} \times X_2) + (-1.478 \times X_3) + (0.198 \times X_4) + (-0.061 \times X_5)$$ **(Equation 6)**

Projection of waste generation per the next five years obtained using discriminant equation as shown in **Equation 7**. The equation used to obtain a prediction cluster classification of waste generation from each city in the future. While **Figure 5** shows the increasing of waste generation per next five years.

$$Z = -12.906 X_1 + 13.793 X_2 + -2.023 X_3 + 1.932 X_4 + -1.166 X_5 + -1.559 X_6 + -0.774 X_7 + 2.740 X_8 + 0.832 X_9$$ **(Equation 7)**

Where Z is discriminant score, X_1 is total population, X_2 is GDP, X_3 is consumer price index, X_4 is economic growth, X_5 is population density, X_6 is population growth, X_7 is school's period, X_8 is people development index and X_9 is literacy rate.

The increasing of waste generation per next five years can be calculated by **Equation 8. Figure 5** showed the increasing of waste generation in each capital city of Java and Sumatera.

Total waste generation = total population x average of waste generation in each cluster…….…….(**Equation 8**)

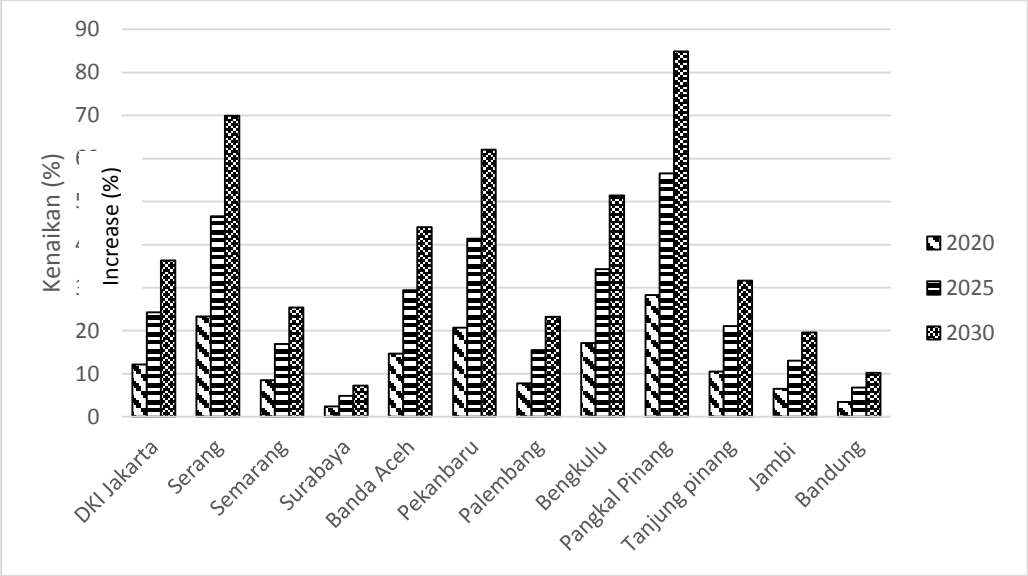

Figure 5. Increasing of waste generation per the five next years.

CONCLUSIONS

The result of city classification by doing cluster analysis, quadrant analysis, and classen typology analysis, showing there are three patterns of waste generation in 16 cities in Java and Sumatera, which are pattern 1 for low waste generation with Port/Trade and Trade/Plantation economic activity, pattern 2 for high waste generation with low economic growth and Industry/Trade economic activity. And pattern 3 for high waste generation and high economic growth and Industry/Trade economic activity.

Variables which are having effect to waste generation in 16 cities in Java and Sumatera, are economic growth, population density, Gross Domestic Product, and total of population. Daskopoulus model test that has done showing waste generation in 16 cities in Java and Sumatera only able to be explained by 33.7 % by consumption outcome in sub-category. Meanwhile, Khajuria model test, waste generation in 16 cities in Java and Sumatera can be explained by 21.9 % by Gross Domestic Product, total of population, and illiteracy.

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