Construction of *Green City Index* in Indonesian Metropolitan Districts/Cities

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Abstract. Urbanization in Indonesia resulted in population density in urban areas, which has the potential for economic growth, marked by increased population income followed by changes in consumption patterns that will cause environmental problems in urban areas. Seeing environmental issues that occur in urban areas, it is necessary to have a green city concept city planning as a sustainable city planning solution without damaging the environment. The measurement of green city achievement has yet to be carried out in Indonesia. This study aims to measure the Green City Index (GCI) in metropolitan districts/cities in Indonesia using Partial Least Squares-Structural Equation Modeling (PLS-SEM). It examines the GCI achievements in Indonesian metropolitan districts/cities. The GCI is formed by a socioeconomic dimension of two indicators and an environmental dimension of eleven indicators. Generally, the highest GCI achievements are in the Bogor District, with a score of 74.3 percent. Bangkalan District achieved the highest socioeconomic dimension index, and Bogor District completed the highest environmental dimension index. In addition, there is a significant and negative relationship between GCI and the Human Development Index (HDI) and economic growth. It is hoped that the government and the community can pay attention to the balance of the environment in their activities.

1. Introduction

The rapid economic growth experienced by society in the order of urban life makes urban life much better than rural areas. This motivates rural communities to urbanize. Urbanization has an impact on the concentration of the population in urban areas. In 2018, 55 percent of the world's population lived in urban areas, which is projected to reach 68 percent by 2050 (United Nations, 2019). This condition also occurs in developing countries, one of which is Indonesia. According to data from The Inter-Census Population Survey (SUPAS), which is held by Statistics Indonesia (BPS), it was recorded that 54 percent of Indonesia's population lived in urban areas in 2015, and in 2035, the population was predicted to reach 67 percent (BPS, 2018a). The high concentration of people in urban areas has the potential for economic growth, which is marked by an increase in population income followed by changes in consumption patterns. As a result, the consumption of energy needs for electricity, transportation, and cooking in urban communities is higher than in rural areas. Since there is high population density in urban areas, it will cause problems in slum settlements, environmental pollution, scarcity of clean water, traffic jams, accumulation of garbage, and other issues (Fakrulloh dan Wismulyani, 2016).

In identifying the problems that occur in urban areas, the government seeks to collect social and environmental indicators. The Official News of Statistics released the percentage of poor people in urban areas in March 2018 of 7.02 percent, down to 6.89 percent in September 2018 (BPS, 2019). The decrease in the number of poor people shows that the welfare of the urban population is increasing. However, behind these conditions, there is still an increase in slum households in urban areas. Based on the 2018 Environmental Statistics Publication, the percentage of slum households in urban areas in Indonesia increased by 0.04 percent compared to 2017. In addition, based on environmental indicators, the rate of Indonesian urban homes that use safe drinking water sources increased by 0.73 percent compared to 2017 in the previous year. However, the percentage of urban households with access to proper sanitation services in 2018 decreased by 0.19 percent (BPS, 2018b).

By observing environmental problems that occur in urban areas, it is necessary to do sustainable urban planning. Richard (1987) introduced the concept of an environmentally friendly city or eco-city by looking at sustainable development in multidimensional terms, namely technology, economy, ecology, and the green movement. Then, in the 1990s, another sustainability theory was developed by Campbell (1996) by looking at urban development based on social, economic growth, and environmental dimensions. After the two concepts emerged, a plan for a sustainable green city was developed as a sustainable urban planning solution without damaging the environment.

Through the United Nations (UN) organization, a green city has become a formulated target in the eleven Sustainable Development Goals (SDGs). Every country will create cities and settlements that are inclusive, safe, resilient, and sustainable in every country by 2030. The SDGs target in realizing a sustainable city is in line with the policy direction and strategy of the National Medium-Term Development Plan (RPJMN) 2015-2019, namely the development of green cities that are climate and disaster-resilient. Previously, the green city development plan in Indonesia had been built since 2011 through the Green City Development Program (P2KH), which is the General Spatial Planning-Ministry of Public Works. The program is a step taken by the government to fulfill the provisions of the Spatial Planning Law (UUPR) related to Green Open Space (RTH) while at the same time responding to the challenges of climate change in Indonesia. However, the program still needs to measure the achievements of green cities in Indonesia.

Until nowadays, the measurement of environmental quality in Indonesia is still limited using environmental quality indicators, namely the Environmental Quality Index (IKLH) by the Ministry of Environment and Forestry (KLHK) and the Environmental Indifference Behavior Index (IPKLH) by the Statistics Indonesia (BPS). However, these two measures have yet to describe the quality of the environment inter-districts/cities with a green city concept. Brilhante and Klaas (2018) provide an alternative to measuring green cities using the Green City Conceptual Framework (GCCF), which consists of socioeconomic and environmental dimensions. In addition, several researchers worldwide have measured the achievement of sustainable cities using a composite index.

Research by Siemens (2009) compiled the European Green City Index (EGCI) to measure and compare environmental performance. The index is formed using the aggregate score method of all indicators using the same weight (equal weight). The dimensions used in this study consist of CO2, energy, buildings, transportation, water, waste and land use, air quality, and environmental management. In addition, research conducted by Fauzi and Oxtavianus (2014), which measures the achievement of sustainable development in Indonesia, uses the economic dimension consisting of the Gross Regional Domestic Product (GRDP) indicator, the social dimension consisting of the Human Development Index (HDI) indicator, and environmental dimension composed of the hands of the Environmental Quality Index. A paper by Siemens (2009) compiled the European Green City Index (EGCI) to measure and compare environmental performance. The index is formed using the aggregate score method of all indicators using equal weight. The dimensions used in this study consist of CO2, energy, buildings, transportation, water, waste and land use, air quality, and environmental management. The following research is by Navarro et al. (2017), which forms the Sustainability City Index (SCI) using three dimensions: the social, economic, and environmental. In this study, the weight calculation was carried out using the Principal Component Analysis (PCA) method. Another paper is by the Global Green

Growth Institute (2019), which forms the Green Growth Index (GGI) to measure performance in each country in achieving sustainable development targets using 36 indicators divided into four dimensions. The dimensions used in forming the GGI consist of the dimensions of efficient and sustainable use of resources, the dimensions of natural capital protection, the sizes of green economy opportunities, and the dimensions of social inclusion. In conducting the GGI, the study used the equal weight method.

Based on the previous explanation, this study aims to compile GCI in metropolitan districts/cities in Indonesia. Then, a descriptive analysis was carried out to see the general picture of GCI in metropolitan cities in Indonesia in 2018. The reference in selecting various indicators and dimensions refers to the GCCF by Brilhante and Klaas (2018) by adjusting data availability in Indonesia. The GCCF can measure green cities in an area by focusing on sustainable aspects, namely social, economic, and environmental. By establishing GCI in the metropolitan district/city, it is expected that it will become a pilot project for other districts/cities.

2. Theoretical Reviews

2.1 Green City

According to Ghorab and Shalaby (2016), there are three approaches to sustainable city development: green city, eco-city, and livability city. Green city is defined as a city that seeks to reduce the impact of environmental damage. The eco-city is a city that is directed towards environmental management through policies to achieve sustainability. Meanwhile, a livability city is described as an urban system that ensures the welfare and comfort of its residents. According to Lewis (2015), a green city is an extension of the sustainable urban development concept that considers water, air, and soil quality management in urban areas. Green city planning can be achieved through sustainable aspects, namely social, economic, and environmental. As stated by Pace et al. (2016), green city is a multidimensional concept that includes financial, environmental, and social aspects.

Meanwhile, a green city is one of the concepts of a sustainable city development plan by aligning the environment in response to environmental damage (Ratnasari et al., 2015). According to the Ministry of Public Works (2011), the concept of a green city or green city is a city that is described through eight attributes, namely green planning and design, green open space, green waste, green transportation, green water, green energy, green building, and green community. The green city concept in Brilhante and Klaas (2018) is the green city as a concept that can overcome the problem of city development to be more sustainable (greener), not scattered, and more livable. Brilhante and Klaas (2018) provide another alternative to measure green cities, forming a green city conceptual framework using socioeconomic and environmental dimensions. The concept is based on the Environmental Kuznets Curve (EKC) hypothesis, which is popularized by Grossman and Krueger (1995).

2.2 Partial Least Squares-Structural Equation Modeling (PLS-SEM)

Partial Least Squares-Structural Equation Modeling (PLS-SEM) is a method of analysis of Structural Equation Modeling (SEM), which is variance-based and nonparametric. The PLS-SEM approach aims to explain the multivariate relationship between latent variables. PLS-SEM has two types of relations that explain the measured variable with the unmeasured variable. The two types of relations are reflective relations and formative relations. A Reflective relation is a relation in which the indicators in the measurement reflect the measurement of the latent variable. Meanwhile, the formative relationship explains that the latent variable comprises its indicators.

In several studies with multidimensional latent constructs, PLS-SEM recommends the Hierarchical Component Model (HCM) method with a repeated indicator approach, two-stage approach, and hybrid approach (Becker et al., 2012). The use of HCM aims to minimize complex structural models, overcome the occurrence of multicollinearity between exogenous variables, and overcome correlations between formative indicators. HCM has two components: the higher-order component (HOC) and the lower-order component (LOC). Based on the relationship between HOC and LOC, HCM has different types, namely reflective-reflective, formative-reflective, formative-reflective, and formative-formative (Hair et al., 2016).

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3. Methodology

3.1. Method of Data Collection

The Green City Index (GCI) collection covers ten metropolitan areas classified by the Ministry of National Development Planning in Indonesia, consisting of 58 districts/cities. This study used cross-sectional obtained from the publications of Statistics Indonesia, including the 2018 Village Potential Statistics, Provinces in Figures 2019, the 2018 Human Development Index, and 2018 People's Welfare Statistics.

3.2. Method of Analysis

In answering research objective one, the Partial Least Squares-Structural Equation Modeling (PLS-SEM) method was used to compile the Green City Index. The steps involved in compiling the index using PLS-SEM are as follows.

1. Structural model specification (*inner model*)
   The structural model in this study used a formative model that explained the causal relationship from exogenous latent variables to endogenous latent variables.
2. Measurement model specification (*outer model*)
   The measurement model in this study used a reflective model. Namely, the indicators are a reflection of exogenous latent variables.
3. Forming a path diagram (*path model*)
   A path diagram is formed to describe the relationship between the indicator and its latent variables and the relationship between each latent variable. This research used the PLS-SEM method with a Hierarchical Component Model (HCM) reflective-formative model with a repeated indicators approach.
4. Evaluation model
   The reflective measurement model was evaluated by using the criteria of convergent validity, discriminant validity, and internal consistency. In this study, only the reflective measurement model was used. Therefore, the evaluation of the formative measurement model was not carried out. Next is the evaluation of the structural model. Based on Sarstedt (2019), the evaluation of the HCM structural model with a repeated indicators approach uses the criteria for testing collinearity between constructs, checking the R^2, path coefficient significance, and predictive relevance Q^2.

5. Index weighting and aggregation
   The calculation of the weights refers to the Environmental Indifference Behavior Index (IPKLH) by Statistics Indonesia by using the loading factor proportion and path coefficient analysis results from PLS-SEM.

$$Indicator\ weight_{ij} = \frac{Loading\ Factor_{ij}\ x\ 100}{\sum_i^n Loading\ Factor_i\ in\ Var\ laten_j} \quad (3)$$

$$Var\ laten_j\ weight = \frac{Path\ Coefficient_j\ x\ 100}{\sum_j^k Path\ Coefficient_j} \quad (2)$$

Prior to index aggregation, it is necessary to normalize the data. The normalization method in this study was the min-max normalization, which was calculated through the following formula.

$$X_{i,j} = \frac{x'_{i,j} - x'_{\min(i),j}}{x'_{\max(i),j} - x'_{\min(i),j}} \quad (4)$$

Description:
$X_{i,j}$ = indicator value of the i-th metropolitan district/city to j-th after normal
$x'_{i,j}$ = indicator value of the i-th metropolitan district/city to j-th
$x'_{\min(i),j}$ = indicator minimum value of the i-th metropolitan district/city to j-th
$x'_{\max(i),j}$ = indicator maximum value of the i-th metropolitan district/city to j-th

After calculating the weights, the next step is index aggregation. The GCI aggregation method used linear aggregation equations. Linear aggregation was chosen as the GCI aggregation method because the calculations were simple and easy. So that the GCI calculation was carried out with the following formula.

$$GCI_j = \sum_i^1 b_i X_{ij}\ x\ 100\% \quad (5)$$

Description:
GCI_j = the j-th metropolitan district/city GCI
b_i = the i-th indicator weight
X_{ij} = indicator value of the i-th metropolitan district/city to j-th after normalization

The descriptive analysis to answer the second objective was to examine the general description of green city achievements in 58 districts/cities in the Indonesian metropolitan area in 2018. The available description was analyzed using tables, graphs, and figures. In addition, the GCI grouping was formed by referring to Faradis and Afifah's (2020) research on preparing the Provincial Infrastructure Development Index in Indonesia. The categorization formula in this study is described in the following table.

Table 1. Categorization Formula.

No	Category	Quartile	Formula
1	Low	Q1	GCI $\leq Q_{1i}$
2	Medium	Q2	Q_{1i} < GCI ≤ Q_{3i}
3	High	Q3	GCI > Q_{3i}

Source: Faradis dan Afifah (2020)

Besides tables, an overview analysis of GCI achievements is also carried out using graphs to see the ten regions with the lowest and highest GCI achievements. Then, Pearson correlation analysis and radar diagram analysis were performed to see the relationship and similarity in ranking between GCI and its constituent dimensional indices. The following analysis was the quadrant analysis between the GCI and the Human Development Index (IPM) and economic growth (PE).

4. Result and Discussions

4.1 Construction of Green City Index for Metropolitan Districts/Cities in Indonesia in 2018

The compilation of the GCI uses the Partial Least Squares-Structural Equation Modeling (PLS-SEM) method, which consists of several stages that must be passed. In the first stage, specifications were made on the structural model (inner model) and measurement model (outer model) (Figure 1).

a. Evaluation of the Reflective Measurement Model (Outer Model)

In conducting data analysis using the PLS-SEM method, the first model evaluation was carried out, namely the assessment of the reflective measurement model. The evaluation of convergent validity is seen through the value of the loading factor or outer loading, which shows the correlation of the indicator with the latent variable. A hand is claimed to be valid when it has a loading factor of more than 0.7. However, in research still in the development stage, indicators with a loading factor value of more than 0.5 are still acceptable. According to Hair et al. (2016), it is necessary to consider eliminating reflective indicators with a loading factor value between 0.4 and 0.7 if these indicators can increase the value of composite reliability and AVE to the recommended threshold value.

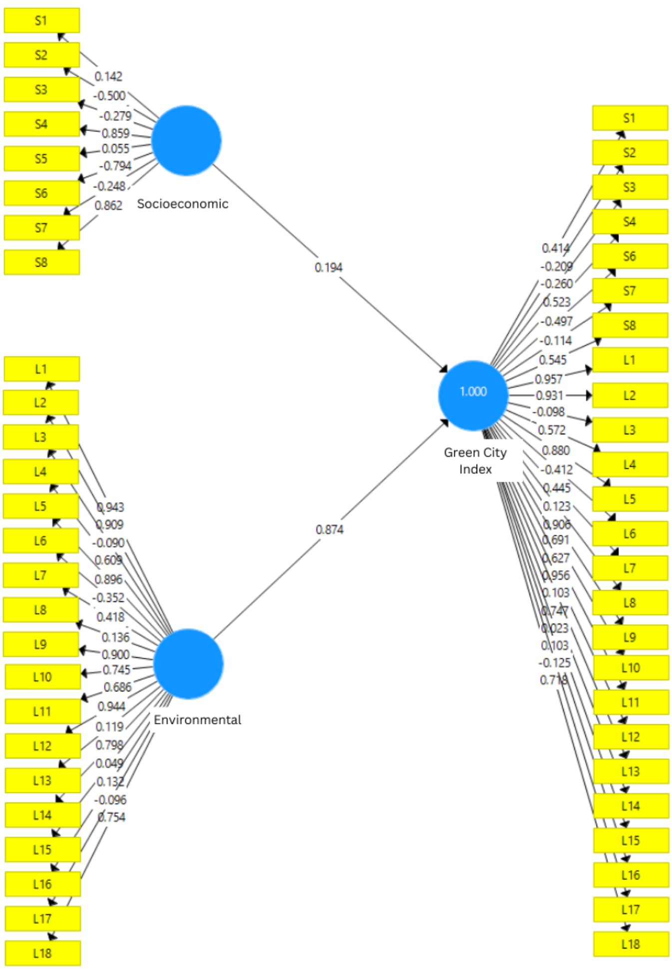

Figure 1. GCI model diagram before modification.

Figure 1 There are two indicators found from the socioeconomic latent variable that have an outer loading value of more than 0.4 but have a negative mark, which is the estimated life expectancy indicator (S2) and an indicator of the percentage of the population aged five years and over who accessed the internet in the last three months (S6). All indicators selected as the constituents of the GCI have a positive relationship. Therefore, both hands are eliminated from the model (Appendix 1). After the indicators that do not meet the criteria are eliminated, a diagram is obtained as follows.

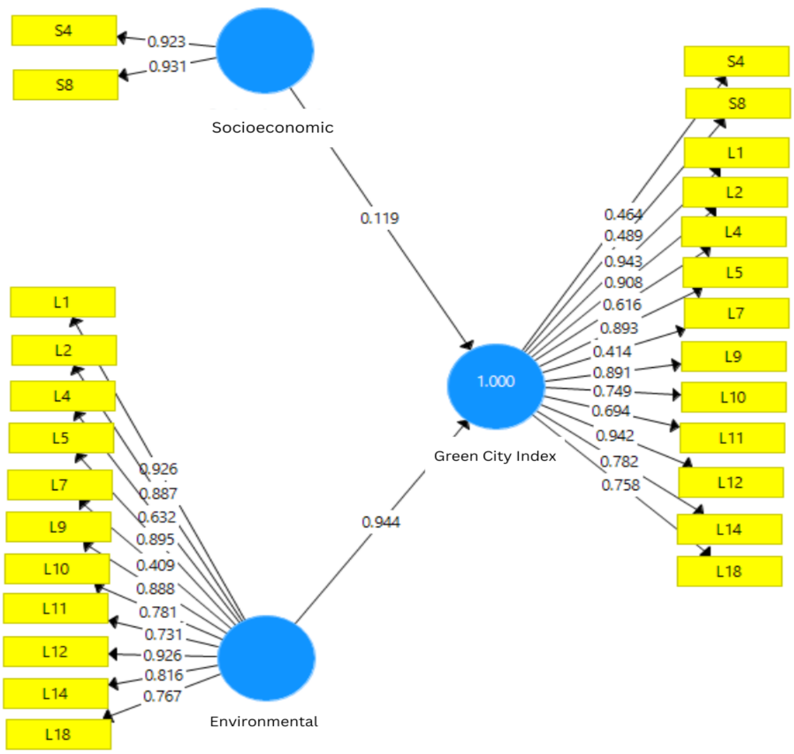

Figure 2. GCI model diagram before modification.

Figure 2 shows that the socioeconomic variables reflect two indicators, namely the percentage of per capita expenditure per month on food (S4) and the rate of poor people (S8). Based on the outer loading value, the indicator of the percentage of poor people (S8/0.931) gave the most significant contribution, which is 93.1 percent. Furthermore, environmental variables reflect eleven indicators, namely the number of villages according to the type of cooking fuel used by most families (L1), the number of villages according to the presence of electricity-using families (L2), the number of villages according to the availability of open public spaces. (L4), the number of villages according to environmental conservation activities (L5), the percentage of households according to the primary building material for the roof of the broadest house using straw/palm fiber/leaves/sago palm (L7), the number of villages according to the availability of public transportation (L9), the number of villages according to the availability of Temporary Waste Shelters (L10), the number of villages according to waste processing activities (L11), the number of villages by type of waste disposal site (L12), the number of villages by incident water pollution (L14), and the number of villages according to the incident of air pollution (L18). If the outer loading value is observed, the indicator of the percentage of people experiencing poverty (S8/0.931) provides the most significant contribution, which is 93.1 percent. Meanwhile, the number of villages according to the cooking fuel used by most families (L1/0.926) and the number of villages by type of waste disposal site (L12/0.926) contributed the most, which is 92.6 percent.

Furthermore, in Table 2, the convergent validity criteria are seen based on the AVE value, which shows the size of the indicator variance that the latent variable can explain. The requirements for a valid AVE value must have a value more excellent than 0.5, which means that more than half of the indicator variance can be explained by the latent variable. The following evaluation of the reflective measurement model measures internal consistency using composite reliability, which aims to prove indicators' consistency, accuracy, and exactness in measuring constructs. A variable is claimed to be reliable when the composite reliability value is more than 0.6. Table 2 shows that all latent variables have a composite reliability value of more than 0.6.

Table 2. Value of Average Variance Extracted (AVE) and composite reliability of latent variables.

No.	Latent Variables	Average Variance Extracted (AVE)	Composite Reliability
1.	Socioeconomic	0.859	0.924
2.	Environmental	0.642	0.950

Table 3 shows the evaluation of discriminant validity, which shows the extent to which a construct is different from other constructs. At the indicator level, the assessment of discriminant validity is cross-loading. Meanwhile, at the construct level, the assessment was carried out based on the Fornell-Larcker criteria. Discriminant validity will be fulfilled when the value of a construct's outer loading indicator is greater than the value of the outer loading indicator of another construct. In Fornell-Larcker criteria, evaluation is seen based on the AVE root value ($\sqrt{AVE}$) of a construct that must be greater than the highest correlation with other constructs. Table 3 shows that the AVE value of all constructs is greater than the correlation of the construct with other constructs.

Table 3. Value of *cross-loading* and *outer loading* and evaluation of Fornell-Larcker criteria.

Indicator	Socioeconomic	Environmental
S4	0.923	0.375
S8	0.931	0.401
L1	0.575	0.926
L2	0.593	0.887
L4	0.161	0.632
L5	0.395	0.895
L7	0.228	0.409
L9	0.442	0.888
L10	0.099	0.781
L11	0.034	0.731
L12	0.567	0.926
L14	0.098	0.816
L18	0.278	0.767
Socioeconomic	0.927	
Environmental	0,419	0.801

b. Evaluation of Structural Model (*Inner Model*)

The evaluation of the structural model (inner model) was conducted to predict the relationship between latent variables. Testing the collinearity of the constructs used in the model is necessary to ensure that the resulting path coefficient does not occur collinearity between exogenous constructs that cause bias. Based on the VIF value of the inner model of 1.213, it shows that the structural model is avoided from collinearity problems. Furthermore, the value of R^2 indicates how much the exogenous latent variable can explain the endogenous latent variable. The processing results show that R^2 is worth 1, which means that it is to the theory of the repeated indicator approach. Then, the significance test of the structural model path coefficients was carried out, which is described in the following table.

Table 4. Structural model path coefficient.

No	Latent Variable	Path Coefficient	T-Statistic	P-Value	Description
1.	Socioeconomic	0.119	47.203	0.000	Significant
2.	Environmental	0.944	5.648	0.000	Significant

Based on Table 4, the equations of the structural model formed are as follows:

$$GCI = 0.119 \text{ Socioeconomic}^* + 0.944 \text{ Environmental}^* \quad (6)$$

*significant at α = 0.05

The structural model in equation 5 shows that with a significance level of 5 percent, socioeconomic and environmental variables have a significant and positive effect on GCI. Among the two variables used, the environmental latent variable has a path coefficient value more critical than the socioeconomic latent variable. Next, through the blindfolding process, the Q^2 value of 0.552 is obtained, which is more than 0, so it can be said that the model has predictive relevance. This means that the model formed can be used to predict the observed values of the latent variables.

c. Index Weighting and Aggregation

After evaluating the measurement and structural models, the next step is determining the weights for compiling the GCI. Weighting cannot use the loading factor and path coefficient values directly as the weighting of each indicator and latent variable because it uses unequal weighting. The weighting is done by equation 1 and equation 2 so that the weight value of each latent variable is obtained as follows.

Table 5. The weight of each indicator and latent variable.

Latent Variable	Standard Weight	Indicator	Standard Weight
Socioeconomic	0.112	S4	0.498
		S8	0.502
Environmental	0.888	L1	0.107
		L2	0.102
		L4	0.073
		L5	0.103
		L7	0.047
		L9	0.103
		L10	0.090
		L11	0.084
		L12	0.107
		L14	0.094
		L18	0.089

According to Table 5, the equation of the structural model to form for metropolitan districts/cities of Indonesia in 2018

$$GCI_i = 0.112\, Socioeconomic_i + 0.888\, Environmental_i\,; \quad i: 1,2, \dots, 58 \quad (7)$$

According to index calculation by using equation 6, the GCI scores for urban districts/cities of Indonesia in 2018 are obtained as follows.

Table 6. The GCI of metropolitan districts/cities of Indonesia in 2018 to achieve the highest value.

Rank	District/City	Green City Index (%)	Rank	District/City	Green City Index (%)
1	Bogor District	74.3	30	Tangerang City	24.6
2	Lamongan District	67.6	31	Makassar City	24.5
3	Sidoarjo District	66.4	32	Minahasa Utara District	22.9
4	Bandung District	66.1	33	Barito Kuala District	20.6
5	Cianjur District	65.3	34	Tanah Laut District	20.0
6	Gresik District	63.1	35	Maros District	19.5
7	Deli Serdang District	56.6	36	Tabanan District	17.5
8	Sumedang District	48.8	37	Bogor City	17.2
9	Kendal District	47.9	38	Takalar District	17.0
10	Karo District	45.9	39	Bekasi City	16.7
11	Tangerang District	44.1	40	Bitung City	16.0
12	Semarang District	43.5	41	Manado City	14.4
13	Mojokerto District	43.5	42	East Jakarta City	13.6
14	Ogan Komering Ilir/Kayuagung District	41.5	43	West Jakarta City	13.6
15	Banyuasin/Betung Distric	40.1	44	North Jakarta City	13.3
16	Bangkalan District	39.9	45	Depok City	13.2
17	Demak District	39.1	46	Banjarmasin City	11.7
18	Bandung City	37.5	47	South Jakarta City	10.8
19	Grobogan District	37.3	48	Central Jakarta City	10.4
20	Minahasa District	36.6	49	Badung District	9.9
21	Banjar District	35.9	50	South Tangerang City	9.7
22	Semarang City	35.7	51	Gianyar District	9.0
23	West Bandung District	34.3	52	Denpasar City	8.4
24	Surabaya City	33.8	53	Binjai City	7.8
25	Bekasi District	31.2	54	Tomohon City	7.6
26	Medan City	29.9	55	Cimahi City	4.5
27	Ogan Ilir/Indralaya District	29.5	56	Salatiga City	4.4
28	Palembang City	26.6	57	Banjarbaru City	4.4
29	Gowa/Sungguminasa District	26.1	58	Mojokerto City	4.2

4.2 Overview of the Green City Index in Indonesian Metropolitan Districts/Cities Green City Index
The Green City Index (GCI) in the Indonesian metropolitan district/city is 4.2-74.3 percent. By looking at the distribution of GCI in Indonesia, the index is divided into three categories, namely low GCI, medium GCI, and high GCI. The following pie chart explains the proportion of metropolitan districts/cities according to the GCI group.

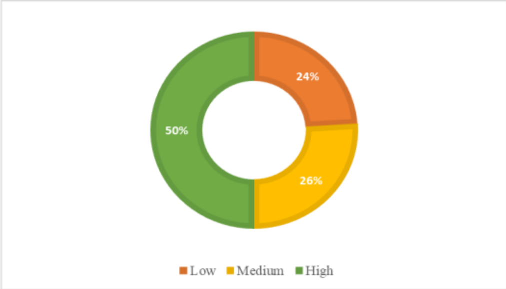

Figure 3. The proportion of metropolitan districts/cities in Indonesia is based on the GCI group.

Figure 3 shows that most GCIs from metropolitan districts/cities in Indonesia are in the medium category. Based on the administrative area, the regions that are included in the high GCI group are dominated by the districts. The three metropolitan districts/cities that achieved the highest GCI ratings were Bogor District, Lamongan District, and Sidoarjo District.

The achievement of GCI in metropolitan areas is lower due to the tendency of the influence of economic activities that are not supported by environmental balance. According to Wahyudi's paper (2017), the city's primary function is trade as a center for urban activities, while the district's primary function is agriculture as a sub-center of urban activities. The distribution of GCI and its constituent dimensional index can be presented as a radar diagram.

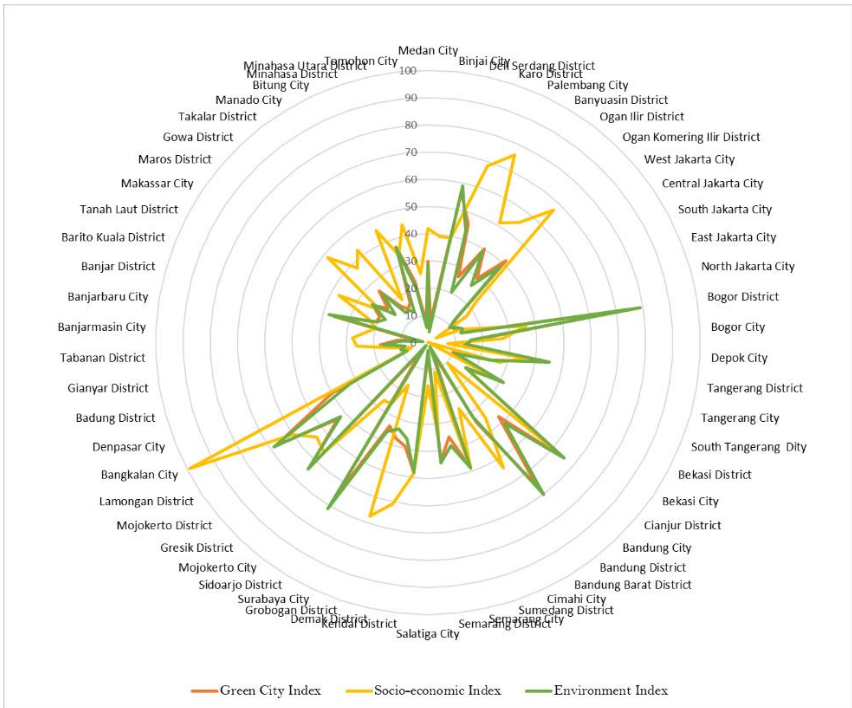

Figure 4. Diagram GCI distribution radar chart and its latent variables by Indonesian metropolitan districts/cities in 2018.

Based on Figure 4. It shows that the distribution of the values for each dimension is similar to GCI in Indonesian metropolitan districts/cities in 2018. However, if we observe closely, the environmental extent ranks similarly to GCI according to Indonesian metropolitan districts/cities in 2018. Bogor District achieved the highest environmental dimension index, while Bangkalan District achieved the socioeconomic dimension index.

a. Socioeconomic Dimension

The district/city with the highest socioeconomic index value is Bangkalan District, which is 99.0 percent, while South Tangerang City occupies the lowest score with a zero score. Of the ten metropolitan districts/cities with the highest socioeconomic dimension index, nine were achieved by the district area. In comparison, the ten metropolitan districts/cities with the lowest socioeconomic dimension index were dominated by metropolitan areas (Figure 5). According to Beni et al. (2014), socioeconomic factors such as education level, employment status, and per capita income can affect environmental conditions regarding domestic waste management.

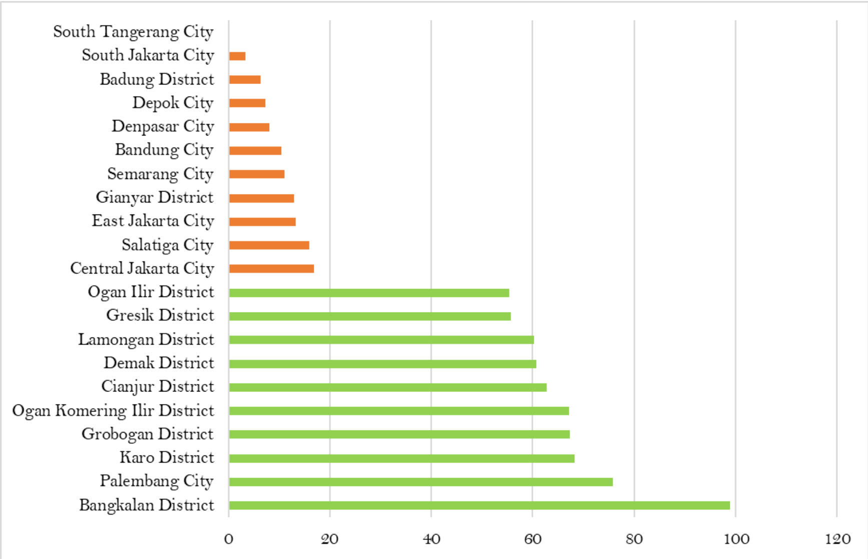

Figure 5. Indonesian metropolitan districts/cities with the lowest and highest socioeconomic index value in the Green City Index in 2018.

b. Environmental Dimension

The highest environmental dimension index value was Bogor District, 79.1 percent, while Mojokerto City occupied the lowest value of 1.3 percent. Like the socioeconomic dimension index, the metropolitan districts/cities with the highest environmental dimension index were the district areas. In contrast, the city area dominated the districts/cities area with the lowest dimension index (Figure 6).

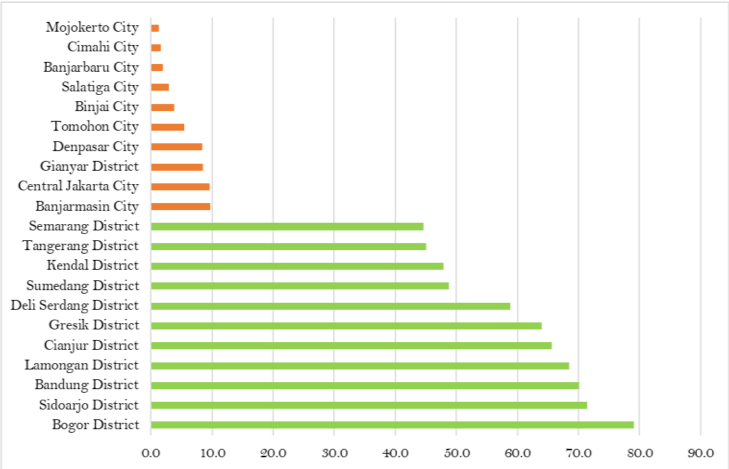

Figure 6. Indonesian metropolitan districts/cities with the lowest and highest environmental dimension values in the Green City Index in 2018.

c. The Relation between GCI, HDI, and Economic Growth

The socioeconomic dimension contributes less to the GCI than the environmental dimension. This illustrates the phenomenon of socioeconomic activities also contributing to environmental damage. As explained by the Environmental Kuznets Curve (EKC) hypothesis, economic growth will initially increase environmental degradation, but in the long term, when economic growth increases, environmental degradation will decrease (Grossman & Krueger, 1995).

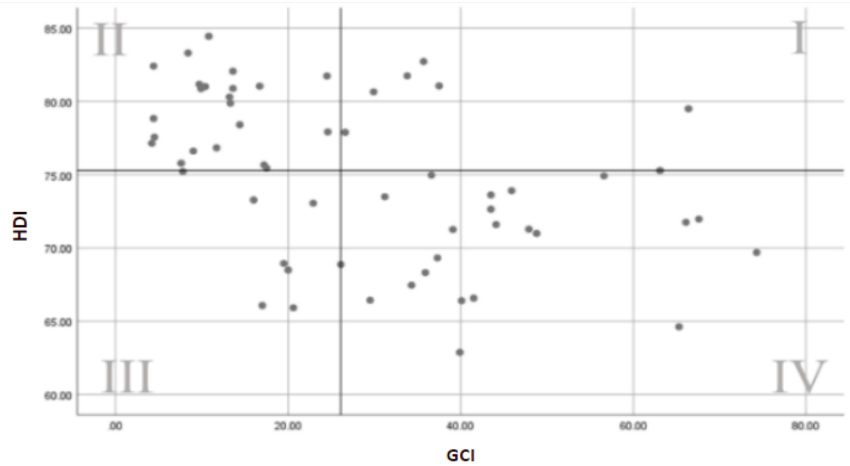

Figure 7. The relation between GCI and HDI Indonesian metropolitan districts/cities in 2018.

Based on Figure 7, a pattern explains the relationship between GCI and the Human Development Index (HDI), which has a negative and significant relationship at = 0.05. The correlation coefficient value of GCI and I is -0.445, which is included in the weak correlation. This explains that the relationship between green cities and human development has a different direction and weak relationship. Scatter plot Figure 7 shows the data distribution in the plot into four quadrants. Quadrants I and III show HDI scores in line with the GCI, and quadrants II and IV show districts/cities with GCIs not in line with the HDI. It can be seen in Figure 7 that as many as 22 metropolitan districts/cities are in quadrant II, where HDI scores are high but GCI is low. This indicates that human resource development activities in an area are suitable but still need more attention to the environmental, social, and economic balance.

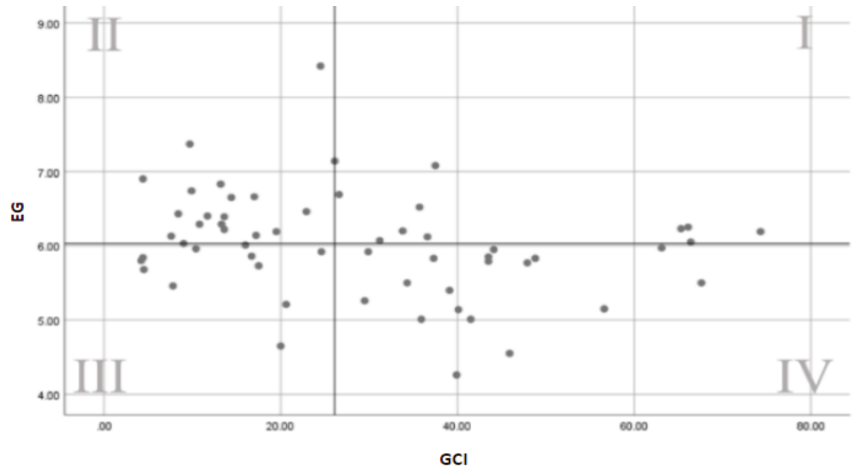

Figure 8. The relation between GCI and PE Indonesian metropolitan districts/cities in 2018.

According to Figure 8, a pattern explains the relationship between GCI and economic growth (EG) has a negative and significant relationship at = 0.05. The correlation coefficient value of GCI and EG is -0.263, which is included in the weak correlation. This explains that the relationship between green cities and economic growth has a different direction and weak relationship. Scatter plot Figure 8 shows the distribution of the data in the plot into four quadrants. Quadrants I and III show EG scores in line with GCI, and quadrants II and IV show districts/cities with GCIs that are not in line with EG. Figure 8 shows that most areas are in quadrants II and IV. Namely, when economic growth increases, the achievement of green cities decreases, and vice versa. This indicates that this study is in line with the EKC hypothesis, as proven by Nikensari et al. (2019), which shows that development activities in accelerating economic growth in a region still tend to ignore the environmental, social, and economic balance.

5. Conclusion and Recommendation

5.1Conclusion

Based on the previous result and discussion, therefore, we can conclude the achievement of the Green City Index (GCI) Indonesian metropolitan district/city in 2018

1. The construction of GCI in the Indonesian metropolitan district/city in 2018 concluded as follows:
   a. GCI is formed by two dimensions, namely socioeconomic and environmental dimensions, where the environmental dimension has the highest contribution to the compilation of GCI.
   b. The socioeconomic dimension consists of two indicators: the percentage of per capita expenditure per month on food (S4) and the rate of poor people (S8).
   c. The environmental dimension consists of eleven indicators, namely the number of villages according to the type of cooking fuel used by most families (L1), the number of villages according to the presence of electricity-using families (L2), the number of villages according to the availability of open public spaces (L2) L4), the number of villages according to environmental conservation activities (L5), the percentage of households according to the primary building material for the roof of the house, the widest is straw/palm fiber/leaf/sago palm (L7), the number of villages according to the availability of public transportation (L9), the number of villages according to the availability of temporary waste collection sites (TPS) (L10), the number of villages according to waste processing activities (L11), the number of villages according to the type of waste disposal site (L12), the number of villages according to the incident of water pollution (L12). L14), and the number of villages according to the incident of air pollution (L18).
2. The overview of the GCI formed according to the Indonesian metropolitan districts/cities in 2018 is obtained as follows:
   a. Based on the administrative area, the regions that are included in the high GCI group are dominated by the districts. The three metropolitan districts/cities with the highest GCI are Bogor District, Lamongan District, and Sidoarjo District.
   b. The highest socioeconomic dimension index is Bangkalan District, while the highest environmental dimension index is Bogor District.
   c. Based on the Environmental Kuznets Curve hypothesis, when human resource development and economic growth are high, the GCI achievement of a region is low. This means that every development effort still needs to pay attention to environmental sustainability.

5.2 Recommendation

Based on the research results obtained, recommendations that can be given in this study are as follows.

1. Government agencies should conduct periodic GCI surveys. Therefore, development activities run in a balanced manner.
2. Administratively, GCI's achievement in cities is lower than in districts. Therefore, the city government should pay more attention to development by maintaining the balance of the dimensions of the GCI constituents in carrying out regional planning.

3. The environmental dimension has the biggest contribution to GCI, so it is hoped that the community and government can pay attention to the environmental balance in carrying out all their activities.

Appendices

Appendix 1. The eliminated indicators from the model

No	Indicators	Details
1	S1	Total population (people)
2	S2	Estimated life expectancy (years)
3	S3	GRDP by per capita expenditure at current prices (millions of rupiah)
4	S5	Open Unemployment Rate (TPT) (%)
5	S6	Percentage of population aged 5 years and over who accessed the internet in the last 3 months (%)
6	S7	Population growth rate (%)
7	L3	Percentage of households by district/city that use the main fuel for cooking LPG(%)
8	L6	Population density (km^2)
9	L8	Road length by district/city (km)
10	L13	Percentage of households by type of proper drinking water source (%)
11	L15	Percentage of households with access to safe drinking water sources (%)
12	L16	Percentage of households with access to proper sanitation (%)
13	L17	Amount of clean water distributed by PDAM (m^3)

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