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Development of a Composite Measure of Regional Sustainable Development in Indonesia

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Abstract: Sustainable development has been the main agenda for Indonesia's development at both the national and regional levels. Along with laws concerning the national development plan and regional development that mandate a sustainable development framework, the government has issued President Regulation No. 59/2017 on the implementation of sustainable development goals. The issuance of these recent regulatory frameworks indicates that sustainable development should be taken seriously in development processes. Nevertheless, several factors affect the achievement of sustainable development. This paper investigates how economic, social, and environmental factors could be integrated into regional sustainable development indicators using a new composite index. The index is calculated based on a simple formula that could be useful for practical implementation at the policy level. Three measures of indices are developed: arithmetic, geometric, and entropy-based. The indices are aggregated to be used for comparison purposes among regions in terms of their sustainability performance. Lessons learned are then drawn for policy analysis and several recommendations are provided to address challenges in the implementation stages.

Keywords: regional sustainable development index; sustainable development; composite index; regional development goals

1. Introduction

Sustainability issues are ubiquitous in development agendas at the global and national levels. Recently, implementing sustainable development agendas has become the concern of regional-level governments [1,2]. Sustainability implementation at the regional level is important for five reasons. First, as stated by Nijkamp and Ouwersloot [3], implementing a sustainable development agenda at the regional level is more operational than implementing it at the national level, since the scope of a region is more manageable. Second, as Graymor, Sipe, and Rickson [4] state that assessing sustainability at the regional level is essential for understanding and achieving sustainability. Thus, it is also important to monitor the progress of sustainability and the future development of regional planning [5]. Third, implementing sustainable development at the regional level is a vehicle for integrating sustainable development principles into regional development and regional planning principles [6,7]. Fourth, using nation-wide indicators for a large country such as Indonesia might conceal the performance of sustainability at the regional level [8]. Fifth, implementing sustainable development at the regional level is key to having clear and uniform operational objectives for the implementation of sustainable development at the national level [9].

Regional sustainable development (RSD) can be referred to in various ways. Clement, Hansen, and Bradley [6] refer to RSD as "the integration of sustainable development principles into regional development practice" (p. 3). The integration concept is echoed by Malik and Ciesielka [10], who emphasize the importance of integrating sustainability principles into strategies and development programs within the regions. Nijkamp and Ouwersloot [1] refer to RSD in different contexts such as spatial and welfare contexts. In terms of the spatial context, RSD refers to both the potential and the constraints of natural resources and the environment to support development within regions. This notion of RSD is similar to the definition provided by Jovovic, Draskovic, Delibasic, and Jovovic [11] and Streimikiene [12], who emphasize the importance of the environment to support sustainable development in regional development. From the perspective welfare point of view, RSD refers to development that ensures that the regional population can attain an acceptable level of welfare both in the present and in the future.

In Indonesia, the implementation of sustainable development agendas has been mandated to the lower level of regional authority: making RSD now an issue for regional authorities [7]. Measuring sustainable development at this level remains challenging [11], as several factors hinder the development of sustainable regional development indicators. First, there are complexities of measurements of various indicators of sustainability, and it is a multifaceted business [13]. Second, a lack of capacity at the regional level makes it difficult to assess the state of sustainable development based on various indicators. Third, the available existing methods of measuring RSD are too complex to be implemented in developing countries such as Indonesia due to variations in data availability.

Given these gaps, there is an urgent need to develop a simple composite method that can be used and implemented easily to assess the state of the sustainable level of regional development. Fauzi and Oxtavianus [14] have developed a composite method for measuring sustainable development at the regional level in Indonesia. However, the method is limited to only three indicators using the linear aggregation system: (1) economic growth, (2) the human development index (HDI), and (3) the environmental quality index (EQI). These indicators represent the economic, social, and environmental dimensions, respectively. However, in Indonesia, other indicators such as poverty, inequality, and unemployment are considered very important indicators of RSD. Such indicators are also often used to assess the performance of regional authorities at the national level. Inequality, for example, is a pressing issue in Indonesia, because more than 80% of the country's economic growth is contributed by the islands of Java and Sumatra. Similarly, poverty is also a very important issue and has become one of the main targets for development achievement. This paper attempts to fill this gap by developing a simple composite index of sustainable development that accommodates not only general socio-economic and environmental dimensions such as economic growth, HDI, and EQI, but also incorporates important indicators considered to be key performance indicators of the regions (e.g., poverty and inequality). The paper differs from previous measurements of RSD indicators in Indonesia such as Bakri, Rustiadi, Fauzi, and Adiwibowo [7], as by the construction of the composite indicator, three different approaches are used to develop an aggregate indicator.

2. Literature Review

The sustainable development index can be measured by a variety of methods. For example, Shi, Ge, Yuan, Wang, Kellett, Li, and Ba [15] classify the measurement into two broad categories: a single indicator system and a comprehensive indicator system. The single indicator system uses a composite indicator to describe the progress of regional development such as the human development index. The comprehensive system assesses regional sustainable development using multi-hierarchy indicators by means of various tools and techniques. While the latter method considers the regional sustainable level widely, the data needed to perform the analysis are not often available. The calculation is also often complex and difficult, which might hinder its implementation in the context of developing countries. In addition, despite some criticism of the composite indicator such as Sharpe [16] and Naldo, Saisana, Saltelli, and Tarantola [17], it is favorable for policy makers due to its capacity to capture a complex system into a single meaningful indicator [18–20]. For this reason, this study uses a single composite indicator system, since it works well in the context of Indonesia.

Various composite indices for sustainable regional development have been found in the literature in the contexts of both developed and developing countries. In the context of developed countries, for example, Salvati and Carlucci [21] created a composite index to assess the performance of sustainable development at the municipal level. They used 99 indicators and principal component analysis (PCA) to produce the rank of municipality according to the composite index of sustainable development. Even though their model is relatively workable by means of the PCA method and can capture regional disparities, the variables they chose might not be easily available in the context of developing countries.

Another composite index of regional sustainable development for a developed country was developed by Nagy, Benedek, and Ivan [22] in the Romanian context of metropolitan areas. The researchers [22] constructed the composite index based on 16 sustainable development goals (SDGs) using a simple arithmetic average of aggregation and a Min–Max standardization method of normalization of data. The corresponding scores for each local metropolitan area were then transformed in spatial representation using the Geographic Information System (GIS) technique.

A composite index of regional sustainable development in a different context was also developed by Liang, Si, and Zhang [2] using 46 indicators representing the economic, social, and environmental systems of regional development. The focus of the paper was to establish an evaluation index system at the provincial level that can be evaluated yearly using the information entropy model. The entropy model for each sub-system (i.e., economic, ecological/environmental, and social) was then combined to assess the progress of sustainable development in the province over time. Even though the model has advantages in terms of describing the flow of change in regional development based on the entropy information for each sub system, it might have shortcomings when it is applied in the context of developing countries where time series data and complete indicators are lacking.

An evaluation index of regional sustainable development using a different approach was found in Li, Tang, Han, and Bethel [23] for evaluation at the provincial and municipal levels along the Yangtze River-Economic Belt. The index was constructed based on the Data Envelopment Analysis (DEA) method to describe the spatio-temporal characteristic of regional sustainable development. Twenty-nine indicators representing the inputs and outputs component of regional development were used and both the super Slack-Based Measure (SBM) model and Malmquist Productivity models were employed. Even though the model differs from other composite indexes previously discussed, the comprehensive index obtained from the DEA model could be interpreted in a similar fashion as the traditional composite index. The model provides a comprehensive evaluation in terms of its capability to assess the contribution of input and output variables toward regional sustainability, as well as its feature on projection on the optimal input and output required to achieve sustainability. Nevertheless, the combination of using both subjective and objective weight factors might hinder the application of the model in other contexts.

In the Indonesian context, in addition to the two regional sustainable assessments previously developed by Fauzi and Oxtavianus [14] and Bakri, Rustiadi, Fauzi, and Adiwibowo [7] as discussed in Section 1, Pravitasari, Rustiadi, Mulya, and Fuadina [24] constructed regional sustainable development to assess the sustainable performance at the regency or municipal level. The researchers used 30 indicators of regional development and factor analysis as a method of measuring sustainability combined with the cluster map method to classify the regions in terms of sustainability without making a single composite index. This study used more indicators than previous Indonesian regional studies and effectively used the cluster map to categorize the regions into high, moderate, and low levels of sustainability. However, the data used was only from 2014. Therefore, it cannot accurately describe the result of a long-term process of development in the region. In addition, some indicators such as distance to the market and distance to the bank might not reflect economic sustainability, as more people now use the internet for banking and market transactions.

This study attempts to bridge between the complexity of the measurement, as previously described, and data availability at the provincial level. In addition, it can easily be understood by policy makers. It is also hoped that given readily available data at the provincial levels, the continuity of the assessment can be carried out by local authorities given the simplicity of the method. In addition, this study tries to compensate for the current partial assessment of provincial performances such the EQI used by the Ministry of Environment and Forestry and the HDI and Economic Growth by the Ministry of National Planning. The composite index can accommodate the disparities among regions with respect to economic, social, and environmental indicators.

3. Methodology

This study utilizes secondary data on provincial levels to develop a composite index of regional sustainable development indicators. A time series data of economics, social, and environmental indicators from 2013 to 2017 from 33 provinces in Indonesia were used. Even though there are 34 provinces in Indonesia, one of the provinces (North Kalimantan or North Borneo) was excluded from the calculation because it is a new province that was formerly a part of East Kalimantan. The regional sustainable development index (RSDI) was constructed using six performance indicators of regional development that represent three dimensions: (1) the economic growth rate (EGR), (2) the open unemployment rate (UNP), (3) the poverty rate (POV), (4) the human development index (HDI), (5) the Gini index (GI), and (6) the environmental quality index (IKLH). The first two indicators represent the economic dimension, the next three represent the social dimension, and the last indicator represents the environmental dimension.

The three indicators that are not in the form of indexes—EGR, UNP, and POV—were normalized first using the formulas described in Equations (1)–(3), respectively, where the maximum and minimum values for each indicator were the highest and lowest values during the period 2013–2017.

$$\text{IEG} = \frac{(EGRi - EGRminimum)}{(EGRmaximum - EGRminimum)} \quad (1)$$

$$\text{IUNP} = \frac{(UNPi - UNPminimum)}{(UNPmaximum - UNPminimum)} \quad (2)$$

$$\text{IPOV} = \frac{(POVi - POVminimum)}{(POVmaximum - POVminimum)} \quad (3)$$

These indicators are listed in Table 1. Since some indicators are considered “bad” or “non-beneficial” indicators for development, such as poverty, inequality, and unemployment, they have to be adjusted (reversed) so that they will conform to the positive interpretation of Indonesia’s regional sustainable development or the RSDI. For example, since poverty is a bad indicator, the indicator should be reversed as 100-IPOV. Similarly, for inequality measured as per the Gini index, the reversed indicator is 100-GI.

Table 1. Indicators for developing a composite index of regional sustainable development.

Dimensions	Indicators	Label	Adjustment
Economics	Economic growth rate	IEG	No
	Unemployment rate	IUNP	(100-IUNP)
Social	Poverty	IPOV	(100-IPOV)
	Gini index	GI	(100-GI)
	Human development index (HDI)	HDI	No
Environment	Environment quality index (EQI)	EQI	No

In order to calculate the composite indicators for each province, this study used the average data from the five-year period 2013–2017, so that the resulting composite indicators could be interpreted as an achievement of short-term regional development. In Indonesia, short-term regional development is evaluated every five years. Therefore, using the average of five years of data should result in a meaningful signal regarding the sustainability of the region.

The development of the composite regional development index was carried out using three types of measurements. First, the regional sustainable development composite index is the linear average of all six indicators. This index is called the RSDI arithmetic average. Second, the RSDI is formed using the geometric mean of all six indicators. We used this geometric mean because the data is spread unevenly among the provinces in Indonesia. Therefore, using the geometric mean alleviates the deficiency of the linear measurement. The use of both linear and geometric measurements is in line with methods of constructing composite indicators by the Organization for Economic Co-operation and Development or OECD [25], an intergovernmental organization of 36 countries. The geometric measure of the RSDI is shown in Equation (4).

$$\text{RSDIg} = \sqrt[6]{IEG \times HDI \times EQI \times (1 - IPOV) \times (1 - GI) \times (1 - IUNP)} \quad (4)$$

It is commonly known that multiple indicators might have a different weight toward the composite index. Policy makers, for example, might place more emphasis on economic indicators compared to environmental indicators. Similarly, society might be more concerned about environmental and social indicators than it is about economic indicators. Neither the arithmetic nor the geometric RSDI took this disparity into account. In order to overcome this deficiency, the third measure of the RSDI was developed by incorporating weight factors. As stated by Greco, Ishizaka, Tasiou, and Torrisi [26] and OECD [25], incorporating weighting in the construction of composite indicators is beneficial for two reasons. First, it describes the importance of the criteria or indicator toward the composite index, which is known as "explicit importance." Second, it describes the "trade-off" between the pairs of criteria toward the aggregation process, which is known as "implicit importance."

In this study, the weighting of the factors was calculated using Shannon entropy [27]. Using the entropy method to calculate weight is more objective than the subjective method of weight calculation such as the Analytical Hierarchy Process (AHP). Therefore, the index calculated using entropy weight is more reliable and robust compared to an index calculated using subjective weight such as that of Bai, Wang, Huang, and Du [28]. The entropy weight was calculated using the following procedures. First, the indicators were normalized using Equation (5):

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (5)$$

The entropy is then the product of Equation (6):

$$E_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij} \quad (6)$$

where $k = \frac{1}{\ln(m)}$.

Finally, the weight of the indicator is calculated using Equation (7):

$$w_j = \frac{(1 - E_j)}{n - \sum_{i=1}^{n} E_j} \quad (7)$$

In contrast to the other two methods, the RSDI based on the entropy method did not require the data to be calibrated or converted (such as reversing the "bad" indicator). The RSDI entropy used the raw data to calculate both the weight factor and the composite index. Once the weight factors were calculated, the index was calculated by multiplying these weights (w_j) with the raw data (x_{ij}). The index resulting from this calculation is called the RSDI-E. Finally, all three methods of calculating the index were aggregated using the additive aggregation method [29–31] by taking the mean of all those measures, as has been practiced in other cases [32–34]. Figure 1 describes the process of developing the composite index using the three methods.

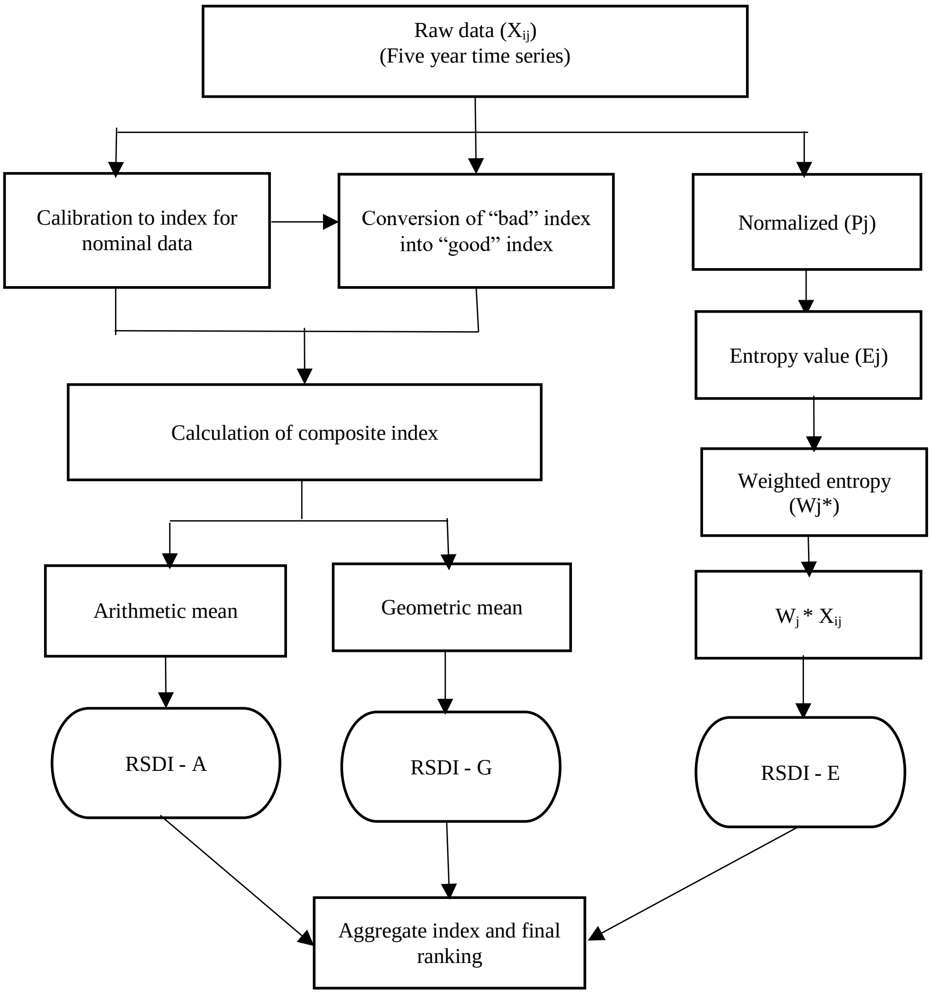

Figure 1. Flow chart of the development of the composite regional sustainable development index. (RSDI = regional sustainable development index.)

4. Results and Discussion

4.1. Formation Indicators for the Regional Sustainable Development Index

Table 2 provides the average value of six indicators contributing to the RSDI for each region. All of these indicators have been calibrated and converted in the index form of positive indexes. As shown in Table 2, Central Sulawesi has the highest economic growth index within the period 2013–2017, while East Kalimantan has the lowest economic growth index. High economic growth in Central Sulawesi is attributed to the fast growth of the mining sector and quarrying, which increased 1.5-fold from Rp9.223 trillion (US$614.9 billion) in 2015 to Rp14.314 trillion (US$954 billion) in 2017. In addition, processing industries, especially processing industries for mining products and base metal, contributed significantly to the economic growth in the region from being non-existent in 2014 to Rp7.4 trillion in 2017 (US$0.49 billion). The region of Central Sulawesi is known as a nickel-rich province and since 2015, nickel exploration in the Morowali Regency has increased significantly. The growth of the mining sector in Central Sulawesi has been driven primarily by two factors. First, the central government ban on exporting mining raw materials has driven the development of smelting industries in the area. Second, an increase in foreign direct investment and mining and smelting sectors has boosted economic growth in the area.

As for East Kalimantan, the low average economic growth in this region during the period 2013–2017 is due to a fall in the price of main commodities such as oil and coal during the period 2014–2016. Oil and coal were the engine of growth for East Kalimantan during the last two decades. Thus, the fall in the price of these commodities has had a huge impact on economic growth in East Kalimantan. This province experienced a negative economic growth rate during the period 2014–2016.

Table 2. Indicators for measuring the composite regional sustainable development index.

Province	IEG	100-IPOV	HDI	100-GI	EQI	100-IUNP
Aceh	14.7	51.9	69.4	66.5	74.1	20.7
North Sumatra	28.5	76.0	69.5	68.2	66.0	48.1
West Sumatra	29.7	87.7	70.0	67.4	64.8	47.6
Riau	14.2	83.8	70.8	63.8	56.4	42.2
Jambi	29.1	82.5	68.9	66.1	62.5	67.6
South Sumatra	27.1	64.2	67.5	63.7	65.2	62.0
Bengkulu	28.7	51.7	68.7	63.9	70.8	72.1
Lampung	28.1	63.0	67.0	65.4	58.8	62.0
Bangka Belitung	24.9	94.8	69.0	71.1	65.1	68.9
Riau Islands	28.6	91.1	73.7	63.2	70.0	42.5
Jakarta	31.4	99.4	79.0	58.6	38.2	33.1
West Java	29.1	80.1	69.5	59.3	51.7	20.2
Central Java	28.2	64.5	69.4	62.4	59.3	59.1
Yogyakarta	27.8	63.6	77.6	57.4	50.7	80.1
East Java	30.0	69.3	68.9	60.6	58.4	69.5
Banten	30.2	92.9	70.4	60.7	51.4	13.7
Bali	32.5	96.5	73.2	59.2	66.7	96.3
West Nusa Tenggara	38.3	53.5	65.1	63.3	61.9	63.3
East Nusa Tenggara	27.6	36.8	62.7	64.6	62.4	79.1
West Kalimantan	28.2	83.5	65.4	64.5	71.7	68.2
Central Kalimantan	34.6	92.2	68.5	65.7	72.0	72.5
South Kalimantan	25.9	96.1	68.4	65.7	59.9	66.4
East Kalimantan	10.5	89.9	74.2	66.0	76.0	32.9
North Sulawesi	32.5	82.8	70.5	59.5	66.7	35.1
Central Sulawesi	46.4	62.6	66.9	63.7	72.8	74.2
South Sulawesi	37.5	78.1	69.1	58.2	68.8	57.6
Southeast Sulawesi	34.8	65.8	68.7	60.9	72.4	71.3
Gorontalo	35.2	49.3	65.8	57.2	71.5	72.1
West Sulawesi	36.4	70.9	62.9	64.2	70.0	84.7
Maluku	30.4	45.0	67.1	66.0	74.3	13.0
North Maluku	32.6	88.6	65.9	68.9	75.5	62.2
West Papua	27.4	20.4	61.8	59.2	83.8	46.8
Papua	34.3	10.0	57.5	58.2	81.5	77.5

Table 2 reveals some differences among provinces in terms of other indicators. Among all 34 provinces, Papua and West Papua have the highest index of poverty (or the lowest in terms of 100-IPOV), the lowest HDI, and the biggest income inequality. During the period 2013–2017, the average poverty rate in Papua and West Papua reached 28.8% and 25.8%, respectively. The average poverty rates in rural areas were even higher (37.4% in Papua and 36.9% in West Papua). In Indonesia, the poverty rate is often broken down into two components: (1) the poverty gap index that measures the gap between the expenditure of poor people relative to the poverty line, and (2) the poverty severity index that measures the spread of expenditure among poor people. In this regard, the two provinces of Papua and West Papua have a high poverty gap index (4.2 in Papua and 6.7 in West Papua) and a high poverty severity index (2.0 in Papua and 2.3 in West Papua).

If we look at other social indicators such as the human development index (HDI), again Papua and West Papua have the lowest score among other provinces (i.e., 57.5 and 61.8, respectively), while Jakarta has the highest HDI (79.0) followed by Yogyakarta (77.6). This implies that the human development performance in terms of income per capita, birth life expectancy, average school year, and the average high school length in Papua and West Papua remains very low. In addition, Papua and West Papua are also facing the biggest income inequality as can be seen from the Gini index within the period 2013–2017, which reached 41.7 in Papua and 40.3 in West Papua, respectively.

In contrast to economic and social indicators, environmental indicators are often shown in a different direction, especially if we are comparing provinces within Java and outside of Java. For example, West Papua and Papua have the highest score on the environmental quality index (EQI), while West Java has the lowest score. The Ministry of Forestry and Environment develops the EQI based on three main indicators: (1) air quality, (2) water quality, and (3) land coverage areas. Therefore, it is not surprising to see a higher EQI score for West Papua and Papua. Both provinces have a substantially large amount of forest land with forest coverage. Similarly, water and air quality in the two provinces are still in good condition due to the low population density and fewer manufacturing industries (except the giant mining company of Freeport), which are usually the biggest contributors to air and river pollution. This is not the case for West Java, which has an EQI score of 51.1. Most rivers in this province are highly polluted due to a high population density (1320.31 people per square km), the presence of manufacturing industrial areas (chemical, textile, foods, and metal machinery), and a rapid increase in residential areas. In addition, West Java is also experiencing a significant increase in the number of vehicles and various health and education service facilities. All of these contribute significantly to lowering the green space, increasing wastes (solid and liquid waste and dangerous materials), and increasing air and water pollution.

If we look at the last indicator for the RSDI (i.e., open unemployment), West Java has the highest score followed by Aceh and East Kalimantan. West Java is the most populous province in Indonesia, and it is one of the favorite destinations for migrants in addition to Jakarta. The demographic bonus that is happening in this province since 2011 has contributed to an increase in the labor force, but the job markets have not been ready to absorb the surplus of labor. The result has been an increase in open unemployment.

4.2. Scores and Rank of the Regional Sustainable Development Index

Table 3 depicts the scores and ranks of the RSDI for 33 provinces in Indonesia using three different measurements. As can be seen from Table 3, provinces with high scores on the RSDI, or ones that are put in a higher-ranking position, tend be stable using all three methods of measurement. This is the case for Bali (71.5), Central Kalimantan (67.5), and West Sulawesi (65.26). Similarly, provinces with a lower score on the RSDI (therefore having a lower rank) also tend be consistent from all methods of calculation. This is the case of West Papua (46.15), Aceh (44.39), and Maluku (43.94). In general, it can be said that using weighting factors to measure the RSDI by means of Shannon entropy provides robust results compared with non-weighting factors. The ranking position by means of RSDI entropy is much closer to the aggregate ranking. This implies two things. First, it emphasizes the importance of weighting factors of indicators that contribute to the composite index [18,26]. Second, the weighting factor could capture the trade-off among indicators that contribute to sustainable development. The distribution of the final ranking of the RSDI is depicted in Figure 2, while the spatial distribution of the RSDI across the region is shown in Figure 3.

Table 3. Scores and ranks of the RSDI for all 33 provinces.

Provinces	Arithmetic Mean		Geometric Mean		Entropy		Aggregate	
	RSDI-A	Rank	RSDI-G	Rank	RSDI-E	Rank	RSDI	Rank
Bali	70.75	1	66.62	1	77.22	1	71.5	1
Central Kalimantan	67.59	2	64.94	2	70.05	2	67.5	2
West Sulawesi	64.87	5	62.89	4	68.03	3	65.3	3
North Maluku	65.62	3	62.84	5	66.16	6	64.9	4
Bangka Belitung Island	65.62	4	61.07	6	67.73	4	64.8	5
Central Sulawesi	64.44	6	63.71	3	65.09	8	64.4	6
South Kalimantan	63.72	7	59.50	11	66.32	5	63.2	7
West Kalimantan	63.58	8	60.39	8	65.16	7	63.0	8
Jambi	62.79	9	59.91	10	64.31	9	62.3	9
South East Sulawesi	62.32	10	60.59	7	62.95	10	62.0	10
South Sulawesi	61.55	11	60.00	9	61.62	12	61.1	11
West Sumatra	61.19	13	57.94	12	60.07	14	59.7	12
Riau Island	61.53	12	57.50	13	59.73	15	59.6	13
DI Yogyakarta	59.55	14	56.35	19	61.98	11	59.3	14
East Java	59.44	15	57.24	14	60.87	13	59.2	15
Bengkulu	59.31	17	56.70	16	58.84	16	58.3	16
Gorontalo	58.51	18	56.82	15	58.56	17	58.0	17
North Sumatra	59.38	16	56.52	18	57.36	19	57.8	18
South Sumatra	58.29	19	55.81	20	57.80	18	57.3	19
West Nusa Tenggara	57.58	22	56.67	17	56.83	21	57.0	20
Lampung	57.40	23	55.22	21	57.08	20	56.6	21
Central Java	57.14	24	54.96	22	56.56	22	56.2	22
North Sulawesi	57.85	21	54.58	23	55.12	25	55.8	23
DKI Jakarta	56.60	25	51.30	25	55.79	23	54.6	24
East Nusa Tenggara	55.54	26	52.24	24	55.76	24	54.5	25
East Kalimantan	58.26	20	47.55	27	54.54	26	53.4	26
Riau	55.19	27	48.37	26	53.73	27	52.4	27
Papua	53.16	29	43.96	31	51.01	28	49.4	28
Banten	53.21	28	45.12	29	49.07	29	49.1	29
West Java	51.64	30	46.44	28	47.58	30	48.6	30
West Papua	49.89	31	44.74	30	43.82	31	46.2	31
Aceh	49.56	32	41.91	33	41.71	32	44.4	32
Maluku	49.31	33	42.45	32	40.05	33	43.9	33

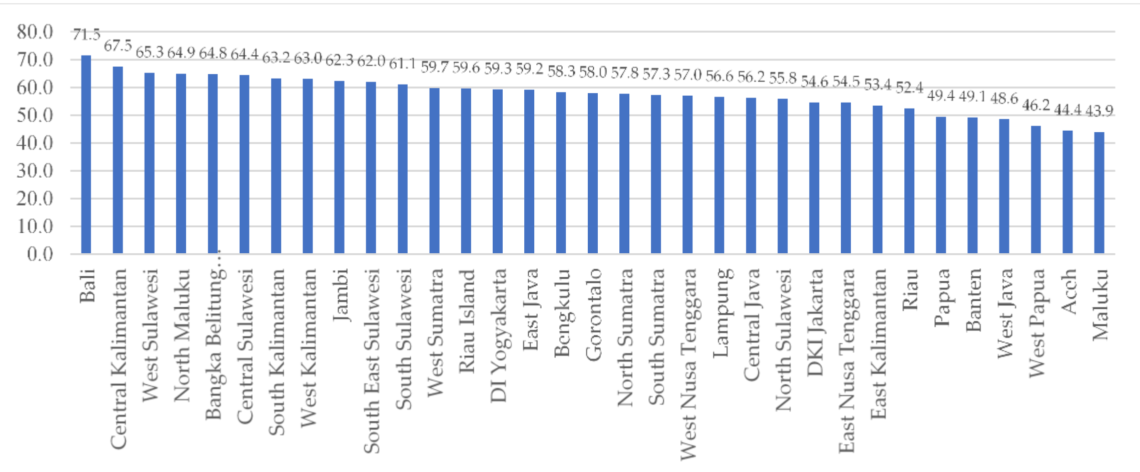

Figure 2. Distribution of RSDI scores based on rank position (aggregate).

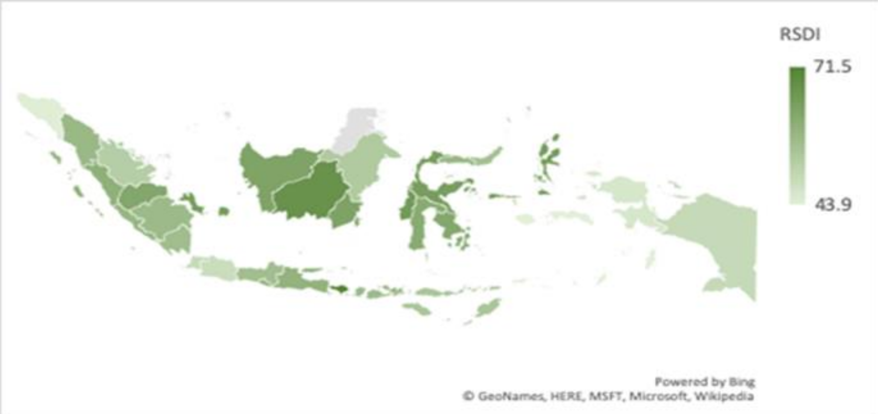

Figure 3. Spatial distribution of RSDI scores (aggregate).

Figure 4 illustrates how close each measurement of the RSDI is to the RSD aggregate index. As can be seen from Figure 4, in general, all three measurements of the RSDI could provide an accurate measure of regional sustainable development for most provinces. Some provinces such as Aceh, Papua, East Kalimantan, and Maluku have substantial differences among three methods of RSDI measurement. These provinces tend to have higher scores in linear measurement without weighting factors, and they tend to have lower scores using entropy weight factors. This implies that, for these provinces, placing weight on indicators has a significant effect on the RSDI score.

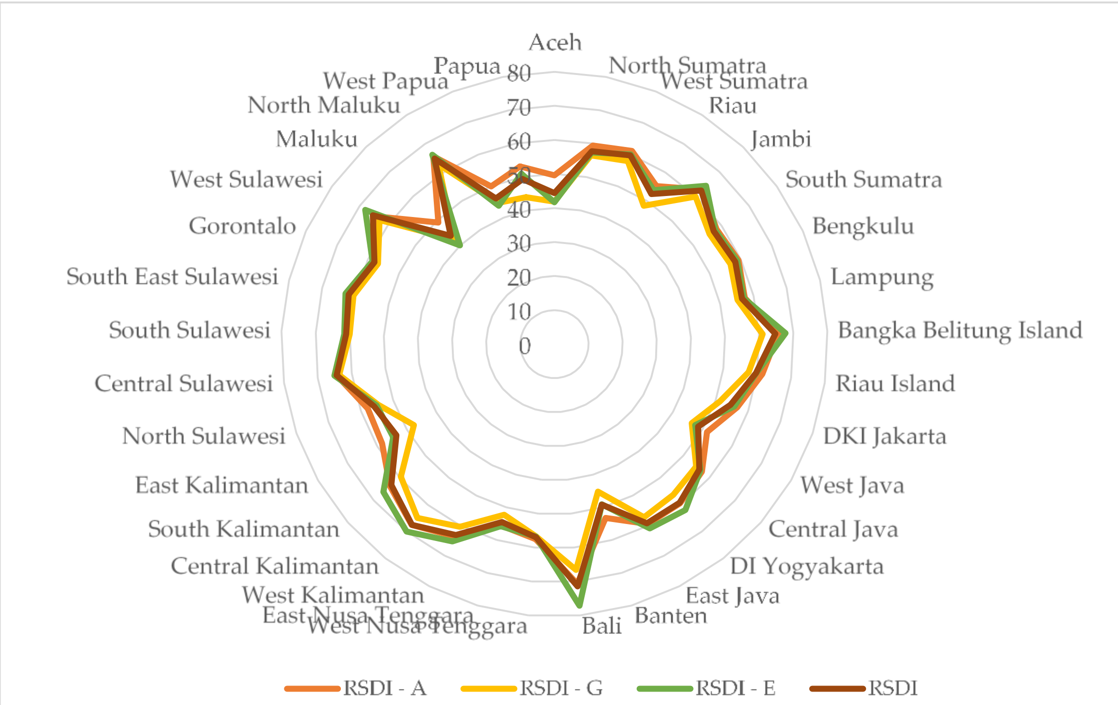

Figure 4. Radar diagram of RSDI scores across provinces.

Figure 5 and Figure 6 present the RSDIs of provinces on the island of Java and those outside Java and compare their contributing indicators. The purpose of this decomposition is to provide a clear comparison between Java and Sumatra, which contribute more than 60% to Indonesia's GDP and the rest of Indonesia. It is well known that provinces in Java and Sumatra tend to be more advanced in terms of economic development than the rest of Indonesia. This is because most of the infrastructure in the country such as highways, ports, and electricity grids is concentrated in Java. Figure 5 provides data regarding whether such advantages would be reflected in the RSDI for the provinces on Java.

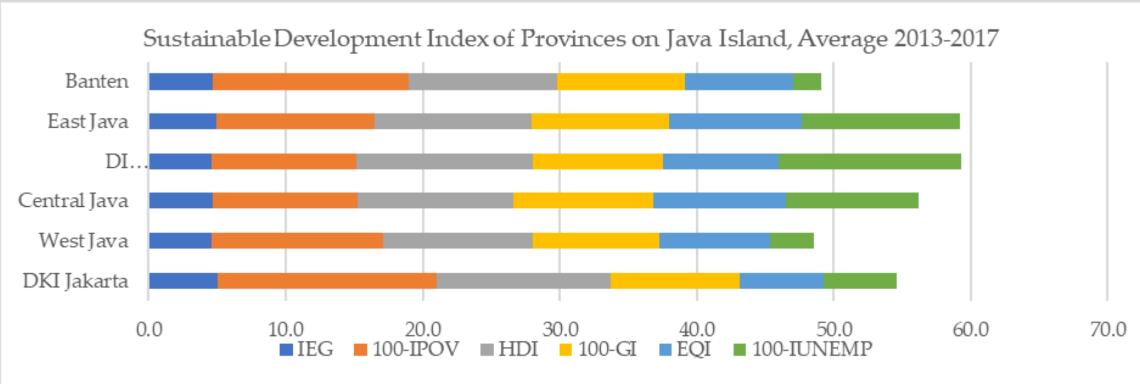

Figure 5. The RSDI and its components in provinces on Java.

As can be seen from Figure 5 and Figure 6, higher RSDI scores for provinces outside Java are attributed to higher scores in the environmental component (i.e., the EQI) compared with those for provinces inside Java. One of the contributing factors of higher EQI scores in provinces outside Java is the number of green areas such as forested areas, which is one of the indicators of EQI. The number of forested areas in Sumatra, Kalimantan, and Papua is much higher compared with the number in Java. Therefore, the provinces on these islands tend to have a higher EQI score compared to provinces on other islands in Indonesia.

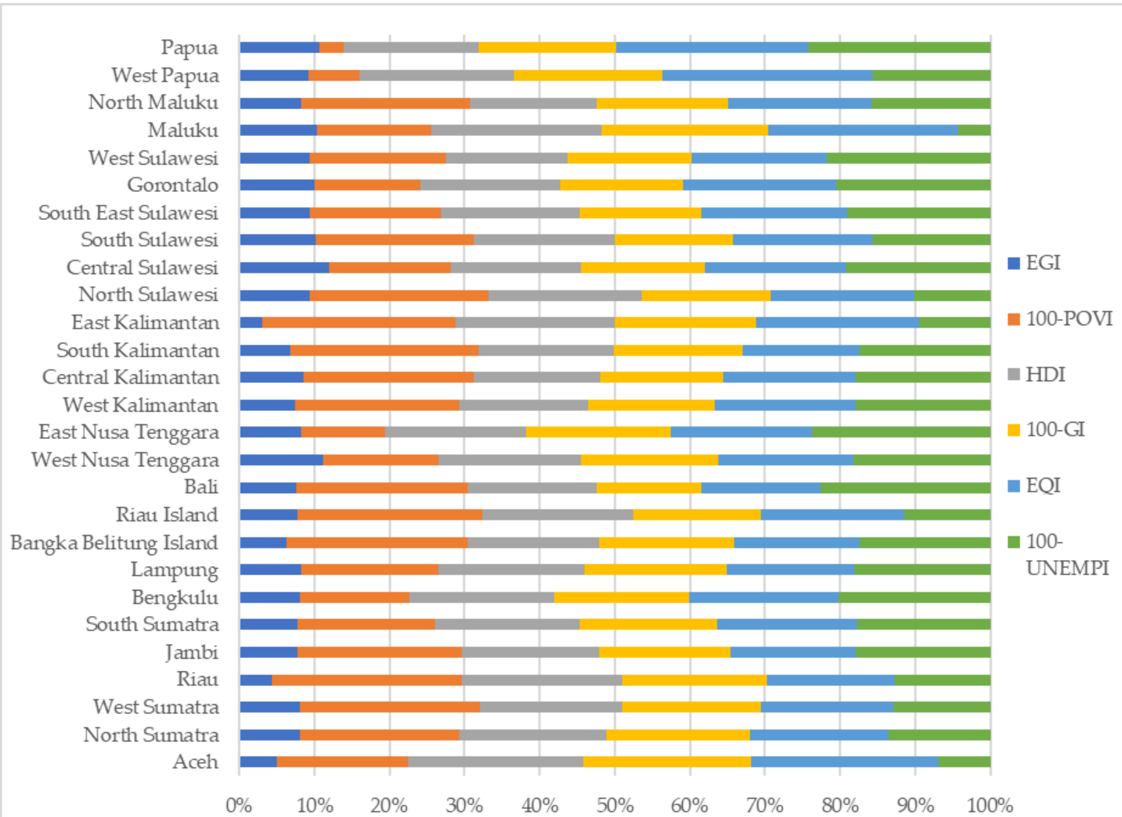

Figure 6. The RSDI and its components for provinces outside Java.

Another interesting feature concerns the economic component that contributes to the RSDI scores. Even though Java has advantages in terms of infrastructure availability, the average economic growth rate of the provinces on this island during the last five years tends to be lower than that of provinces outside Java. In the meantime, provinces outside Java such as Central Sulawesi, South Sulawesi, Gorontalo, and West Nusa Tenggara have enjoyed a higher economic growth rate during the last five years. It can be said that, in general, the eastern part of Indonesia has enjoyed a higher economic growth rate during the last five years compared to Java. Part of this higher economic growth in the east comes from the extraction of resources such as mining and an increase in tourism contributions to the economy in provinces such as West Nusa Tenggara and Bali.

The results of this analysis have profound implications for regional development, especially in Indonesia. First, looking only at separate individual indicators of development (such as income per capita and the human development index) would be biased and unfair, since provinces in Java and Sumatra would have a clear advantage over other provinces in the eastern part of Indonesia. Yet, looking at environmental indicators, provinces in the eastern part of Indonesia would have an advantage over provinces in Java and Sumatra. This has an important implication, since most government authorities focus on the economic and human development index and tend to ignore the environmental aspect of development.

Second, RSDIs would provide a clear message that incorporating “bad indicators” (such as EQI and poverty) into a single composite index would not be harmful for measuring the performance of regional authorities, especially when dealing with their performance assessment by citizens and the regional parliament. This is due to the fact that authorities are generally unwilling to expose such “bad indicators” since they would tend to undermine their achievement toward sustainable development goals.

It is worth noting that RSDIs could be used as both push and pull factors toward sustainable development [6]. Sustainable development goals (SDGs) are often considered push factors for sustainable development in the region. Indicators such as poverty and the environmental quality index are implicitly part of the SDGs. Therefore, regions with a higher RSDI would likely achieve SDGs better than regions with a lower RSDI. In terms of pull factors, declining natural resources and environmental degradation are often considered important factors to achieve sustainable development. Therefore, the RSDI would provide an alternative platform to achieve sustainable development in the regional context, since the RSDI contains those factors in its measurement. In addition, by Law 23/2009 on environmental protection and management, a Strategic Environment Assessment (SEA) should be an integrated into regional planning. Therefore, SEAs could be considered a push factor toward sustainable development. Nevertheless, up until now, the implementation of a SEA into regional planning is still facing obstacles due to complexity in the measurement of SEAs, as well as the regulations that have to be fulfilled. Therefore, the RSDI would provide an alternative platform for implementing regional planning in Indonesia in the context of sustainable development.

4.3. Sensitivity Analysis

The Indonesian regional sustainable development index that we just presented is deemed to be valid given the structure of the data and the method of constructing the composite index. As stated by OECD [25] and Freudenberg [34] complexity and large variations in selecting variables and methods of standardization might affect the final ranking of the unit being analyzed. In order to address this issue, a sensitivity analysis was carried out.

There are various methods to test the robustness of the composite index such as changing weighting, inclusion and exclusion variables, or the base year of the data, and using different methods of standardization by Freudenberg [34] and OECD [25]. In this study, the sensitivity analysis was first carried out by changing the data set. Instead of using a five-year average data set, the RSDI was tested using only one year of data from 2017. However, the results show that only the index two provinces (i.e., Aceh and Riau) were affected by this data set. In addition, using only a one-year data set is quite premature to assess the sustainability of the development in the region. This is due to the fact that the outcomes of development such as HDI, poverty, unemployment, and environmental quality are cumulative impacts from programs delivered in previous years. Having considered this deficiency, a sensitivity analysis was then carried out by changing the standardization method.

In order to have similar scales with the baseline results, only "the distance to reference province" method of standardization was chosen for the sensitivity analysis. Other methods such as the Z-score and standard deviation methods would result in different scales and would yield the value of zeros in some provinces, which is inappropriate to be used for calculating geometric mean. The result of the sensitivity analysis using the distance from the group leader method (labeled as RSDI2) and its comparison with the baseline (labeled as RSDI1) is presented in Figure 7.

As can be seen from Figure 7, RSDI2 has a similar pattern as the baseline (RDSI1). The only difference is that RSDI2 has a lower score compared with RSDI1. Based on this observation, we notice that the rank of the provinces according to sustainability is not altered by the new standardization method (only by the RSDI scores that change). Since what matters in regional development performance assessment is the relative position of one province in comparison to others, the results of this sensitivity analysis indicate that the composite index is relatively robust.

The sensitivity analysis provides information that other methods of standardization that are not comparable in terms of the scale such as the Z-score or standard deviation cannot be used in this measurement since the overall RSDI score is the combination of the arithmetic, geometric, and entropy-based indexes. Using such methods of standardization would result in a wide range of scores (in fact, some would have zero values) and could distort the overall performance assessment of the regions. Therefore, the RSDI method we developed can only be applied with limited standardization methods such as Min–Max (distance from the best and worst performers) and distance from the group leader.

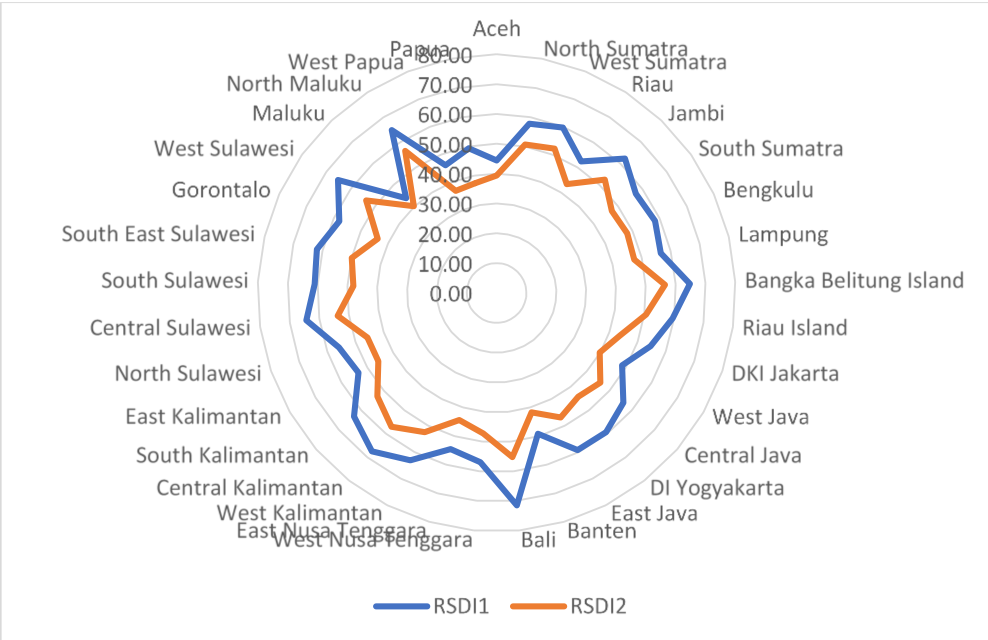

Figure 7. Sensitivity analysis of the RSDI with the two different methods of normalization.

5. Concluding Remarks

This study has developed a regional sustainable development index (RSDI) that could be used based on easily available data at the provincial level. Compared with composite indexes that have been developed previously, this study provides a more comprehensive measurement that is relatively easy to implement. The new composite index provides simple information about which component of sustainability (such as poverty, inequality, or environmental quality) contributes more or less to sustainable regional development. These components play a critical role in regional development sustainability that could be used as a proxy for assessing the successes and failures of policy makers in delivering the development programs. This is in line with regulations issued by the Ministry of Home Affairs that oversees the deliverable development program at the provincial level. Home Ministerial Regulation Number 73/2009 on the Guideline on the Evaluation of Regional Development Performance emphasizes the importance of comparing performance indicators among provinces for the purpose of development policy evaluation and the importance of assessment by means of ranking among provinces. The results of this study could be used as a benchmark in the evaluation of regional development performance, especially in the context of sustainable development.

The results of this study also highlight some important remarks that higher economic growth in a region does not always imply a higher sustainable development index in that region. Similarly, regions with a higher environmental quality index are not always associated with a higher regional sustainable development index. The weighted combinations of the economic, social, and environmental aspects provide a balanced perspective that contributes to sustainability. The index could be used as a simple indicator for policy makers both at the provincial and national levels to assess the implementation of economic, social, and environmental dimensions of sustainable development in the regions, since the process of construction of the indicator is in line with Indonesian government regulations.

Even though the composite index we developed has some advantages in terms of its simplicity, it encompasses critical indicators of regional development. In addition, although it is in line with regulation, some caveats need to be spelled out. The composite index addresses the macro aspects of regional development. It cannot be used, for example, to evaluate the achievement of SDG targets such as "life below water" or "affordable and clean energy." Some SDG indicators such as poverty and inequality are included in this composite index, but many others are not. In addition, the composite index we developed is purely a data-driven index, meaning that it is based on whatever data are presented. It does not capture why data on some indicators in some provinces behaves differently from data on the same indicators in other provinces. In other words, it does not capture the conditions in which the data were produced, such as the volatility in commodity prices, the impact of natural disasters on regional development, or the dynamic of the political situation in the regions. Further studies are needed to address such issues.

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