



Evaluating Implementation of Green Economy in Indonesia: Evidence From K-Medoids Cluster

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Abstract. The Environmental degradation and climate change are currently major challenges in the pursuit of sustainable economic growth. The green economy can serve as a key solution to address these challenges. This study aims to assess the progress of green economy implementation through the clustering of provinces in Indonesia. The data for this study were obtained from the Central Bureau of Statistics, utilizing nine variables derived from three aspects of the green economy: social, economic, and environmental. The K-Medoids method was employed in the cluster analysis to identify clusters for green economy implementation in Indonesia, based on the best model obtained through the Davies-Bouldin Index value. The modeling results indicate that the optimal clustering model for the provinces of Indonesia comprises three clusters. These clusters are categorized as provinces needing improvement in all aspects (Cluster 1), provinces requiring improvements in social and economic aspects (Cluster 2), and provinces that need to address environmental aspects (Cluster 3). The primary priority for provinces in Cluster 1 and Cluster 3 is to enhance human resource quality and reduce poverty rates. Meanwhile, provinces in Cluster 2 should focus on mitigating the negative environmental impacts of industrial activities. Both central and regional governments must implement carbon emission reduction programs, environmental conservation initiatives, foster collaboration among stakeholders, and conduct thorough monitoring and evaluation.

Keywords: Clustering, Green Economy, K-Medoids

1 Introduction

The global economy is currently facing numerous complex challenges, ranging from the COVID-19 pandemic to conflicts between nations that have led to geopolitical tensions, along with the ongoing issue of climate change. Countries around the world, especially developed and developing nations, are grappling with the challenges of climate change and environmental pollution in their pursuit of sustainable economic growth [1]. This situation arises because economic growth is often not accompanied by improvements in environmental quality [2]. The current environmental degradation leads to reduced land productivity and disrupts ecosystem balance, causing a decline in food production and an increase in mortality and morbidity rates [3]. The impact of climate change can also exacerbate poverty levels, indirectly raising the cost of food, housing, and healthcare [4].

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A similar scenario is unfolding in Indonesia, where economic growth shows positive progress toward recovery across nearly all sectors. This growth is driven by various economic policy relaxations and aggressive development incentives, which have stimulated increased economic activity. However, behind the achievements in economic growth, there are negative externalities impacting the natural environment and its resources [5]. The effects of economic growth must consider the well-being of future generations. The Brundtland Report noted that unchecked economic growth would place an excessive burden on the planet in the future [6]. Therefore, measuring the impact of economic growth on the environment is crucial since it is the environment that provides the resources needed for the production of goods and services [7].

The green economy emerges as a critical solution in supporting sustainable development amidst climate change instability. Green economy-based growth can contribute to the efficient use of resources, mitigate and reduce air pollution, create broader and more inclusive job opportunities, and facilitate the achievement of sustainable development goals [8]. Shifting the economic structure toward a green economy in developing countries like Indonesia can trigger long-term economic production stability and prosperity [9]. The creation of economic growth and investment, accompanied by environmental quality improvements and social inclusivity, is a key factor in the transition to a green economy. Therefore, the implementation of a green economy is an imperative for developing nations like Indonesia. The focus should be on applying the concept of a green economy in economic growth activities and processes. This can also serve as an evaluation tool to assess the impact of economic growth on future generations.

Green economy growth is not merely about the pace of economic expansion, but also about the quality of growth. This includes growth that delivers benefits across economic, social, and environmental dimensions and improves the quality of life for all segments of society [10]. Extensive research has been conducted on the factors used to measure economic growth, as there are many indicators that can influence it.

Therefore, the author seeks to measure Indonesia's economic growth from a green economy perspective, using several indicators that impact economic growth. These indicators are aligned with the Green Economy Index (GEI), which aims to assess the effectiveness of economic transformation toward sustainable and environmentally friendly development. There are at least 15 indicators reflecting green economic development, grouped into three main pillars: environmental, economic, and social [11].

The adoption of a green economy is a necessity for regions across Indonesia. The shift in economic structure toward a green economy in developing regions can trigger long-term economic stability and prosperity [12]. The creation of economic growth and sound investment must be accompanied by improvements in environmental quality and social inclusivity, which are the key elements of the transition toward a green economy [13].

The implementation of a green economy must be complemented by strategies to develop appropriate policies, considering the significant contribution of the national GDP and the presence of numerous industrial hubs. The formulation of effective strategies should be tailored to the conditions and needs of each region to ensure that the implementation is effective and maximized.

Mapping or clustering can be a useful method to assist in policy formulation by observing the characteristics of different regions. Clustering is a statistical method that divides data into several groups, revealing patterns of relationships between regions or groups [14]. The K-Medoids method is used to reduce the sensitivity of partitioning to extreme values in the dataset, as medoids are not based on the mean values of each cluster [15]. The K-Medoids method is similar to K-Means, but K-Means is highly sensitive to outliers, which K-Medoids can address [16].

The mapping criteria using green economy indicators are based on variables representing the three pillars of the green economy: social, economic, and environmental aspects. The findings from this study can be utilized by provincial and regional governments, as well as other relevant stakeholders, to evaluate and monitor the implementation of the green economy in Indonesia.

2 Literature Review

2.1 Green Economy

Economic growth should ideally rest on three main aspects: Economy, social, and environment. This is essential for economic sustainability under the concept of "growth without damaging the economic model base." Economic growth within the green economy framework enables the reduction of carbon emissions and pollution, increases energy and resource efficiency, and prevents the loss of biodiversity and ecosystems [17]. The green economy can serve as a solution to economic scale problems by utilizing available energy and materials [18]. The GDP growth of a region can continue if the use of green products is maximized. The concept of the green economy must involve policymakers, economists, and business actors to guide sustainable development policies.

Several studies have attempted to formulate inclusive green growth and determine its forming indicators [19]. Some of these studies have limitations, as the indicators used are not yet comprehensive enough to accommodate the essential indicators in depicting inclusive green growth [20]. The green economy indicators, which consist of 15 indicators and three main pillars, are believed to influence economic growth.

The green economy is closely related to the concept of sustainable development. In terms of the framework, sustainable development is the long-term goal, while the green economy is part of the actions to achieve sustainable development. The concept of sustainable development encompasses three aspects: social, economic, and environmental, where these aspects cannot be separated in the development process. Sustainable development requires alignment in crucial activities such as investment, technological development, resource utilization, and institutional frameworks, all directed toward enhancing the present and future potential to meet human needs.

2.2 Clustering

Clustering is a branch of data mining that operates under an unsupervised learning model. It involves the process of dividing data into groups or clusters based on the level of similarity. Clustering is the task of partitioning data or vectors into a number of

groups or clusters according to their respective characteristics. Data with similar characteristics will group together in clusters with relatively high similarity, where the similarity within a cluster will be maximized. In contrast, data with different characteristics will be placed in different clusters with minimal similarity [21].

Clustering in data mining is useful for discovering distribution patterns within a dataset, which are essential for data analysis. Object similarity is generally obtained from the proximity of attribute values that describe the data objects, and these objects are usually represented as points in a multidimensional space [22]. In general, clustering methods are divided into two types: Hierarchical Clustering and Non-Hierarchical Clustering. In Hierarchical Clustering, the number of groups to be formed is not predetermined. Non-Hierarchical Clustering, on the other hand, involves determining the number of clusters beforehand, so that objects are grouped into k predefined clusters [23].

2.3 Previous Research

Previous research on the green economy was conducted by Gao et al. (2023), Where the study examined the relationship between public-private partnership investment in the energy sector (PPPIE) and carbon emissions in selected Asian countries. The study, which employed the Nonlinear Autoregressive Distributed Lag (NARDL) model, found a positive relationship between the quality of investment in the PPPIE sector and the increase in carbon emissions in several countries. In Indonesia and Russia, the relationship occurred over the long term, while in Turkey and China, the opposite relationship was observed. In the short term, the impact of PPPIE shocks can be analyzed through two different effects: positive changes in PPPIE contributed to improving environmental quality in Russia, Indonesia, and Turkey. On the other hand, negative changes in PPPIE not only had adverse effects in Indonesia but also had positive impacts in India, Russia, and Turkey [24].

Endriani et al. (2016) Identified sectors in Indonesia that meet three criteria within the green economy framework: social, economic, and environmental aspects. The identification was carried out using the Social Accounting Matrix (SAM) approach, with three indicators: output multiplier index, emissions multiplier index, and Theil index. The empirical findings of this study indicate that 11 sectors are in line with the three pillars of the green economy.

Research on the implementation of the green economy at the regional level in Indonesia was conducted by Waluyo et al. (2022). The study aimed to examine the direct and indirect influence of the green economy on the sales of MSMEs (Micro, Small, and Medium Enterprises) in Mojokerto through economic growth. The results showed a direct positive impact of the green economy on MSME sales and economic growth. Additionally, economic growth also positively influenced MSME sales, suggesting that MSME actors should be more active in promoting their products and incorporating green economy principles into their businesses.

Susanti and Wicaksono (2019) Examined green economic development through an agricultural base in Central Java using a descriptive analysis method. The study found that Central Java has not fully implemented the green economy concept. This is due to an increase in the use of inorganic fertilizers, which rose from approximately 72.33% in 2013 to 78.05% in 2018. This increase in the use of inorganic fertilizers and

pesticides was accompanied by a rise in the prevalence of modern diseases, as well as a decline in rice productivity.

3 Research Method

3.1 Data

This study uses secondary data from 2023, obtained from the Central Bureau of Statistics (BPS). The data includes various variables such as poverty, unemployment, life expectancy, Gross Regional Domestic Product (GRDP), labor productivity in the industrial sector, investment, the ratio of land area to total area, emissions index, and paddy land productivity. Table 1 presents the dataset used, consisting of 9 variables based on Green Economy aspects, covering 34 provinces in Indonesia. The data comprises variables related to Green Economy aspects, including social, economic, and environmental dimensions. The social aspect includes poverty, unemployment, and life expectancy variables. The economic aspect includes GRDP, labor productivity in the industrial sector, and investment. Meanwhile, the environmental aspect includes the ratio of land area to total area, emissions index, and paddy land productivity. Specifically, the Emissions Index for each province is derived from the Indonesia Emissions Index, provincial GRDP, and Indonesia's GDP using the following formula [25]

$$\text{Provincial Emissions Index} = \frac{\text{Indonesia's Emissions Index} \times \text{Provincial GDRP}}{\text{Indonesia's GDP}}$$

Table 1. Research Variables Dataset

Variable	Operational Definition of Variable	Data Source
Poverty	Poverty rate percentage (%)	BPS
Unemployment	Open unemployment rate (%)	BPS
Life_Expectancy	Life expectancy rate	BPS
GDRP	GRDP value (constant prices in Rp)	BPS
Industrial_labor	Labor productivity in the industrial sector (Rp)	BPS
Invesment	Investment value (Rp)	BPS
Forest	Percentage of forest area to total area (%)	BPS
Emission	Provincial Emissions Index	Calculated Result
Paddy_land	Paddy land productivity (Ku/ha)	BPS

3.2 K-Medoids Clustering

The K-Medoids algorithm, also known as Partitioning Around Medoids (PAM), does not rely on the average (mean) of all data points in each cluster. The aim is to reduce outliers or sensitivity in the clusters formed from the dataset. The key difference between the K-Medoids algorithm and the K-Means algorithm is that K-Medoids uses objects as representatives (medoids) of the cluster center for each cluster, while K-

Means requires the mean as the cluster center. The steps for the K-Medoids algorithm are as follows:

- Initialize the cluster centers for k (Number of clusters)
- Allocate each data point (object) to the nearest cluster using the Euclidean distance formula as shown below:

$$euclidean(a, b) = \sqrt{\sum_{i=1}^m (a_i - b_i)^2} \tag{1}$$

- Randomly select objects within each cluster as candidates for new medoids.
- Calculate the distance of each object within the clusters to the candidate medoids.
- Compute the total deviation (S) by calculating the difference between the new total distance and the old total distance. If $S < 0$ swap the object with the cluster data to form a new set of k objects as medoids.
- Repeat steps 3 to 5 until no changes occur in the medoids, thus obtaining the final clusters and their members.

The Davies-Bouldin Index (DBI) was first introduced by scientists David L. Davies and Donald W. Bouldin in 1979. This index is used to measure the validity of clusters in clustering methods. DBI aims to maximize the distance between clusters and minimize the distance between data points and the cluster center. A smaller DBI value indicates better clustering results. The formula for calculating the Davies-Bouldin Index is as follows [26]:

$$DBI = \frac{1}{k} \cdot \sum_{i=1}^k \max_{i \neq j} (R_{i,j}) \tag{2}$$

Where:

$$R_{ij} = \frac{SSW_i + SSW_j}{SSB_{i,j}}$$

$$SSS_i = \frac{1}{m_i} \sum_{j=i}^{m_i} d(x_j, c_i)$$

$$SSB_{i,j} = d(c_i, c_j)$$

Here, SSW (Sum of Squares Within-cluster) represents the sum of the distances of data points to the cluster center, while SSB (Sum of Squares Between-cluster) is the distance between cluster centers, $R_{i,j}$ measures the comparison between cluster i and cluster j , k represents the number of clusters, c_i is the centroid of cluster i , m_i is the number of data points in cluster i , $d(x_j, c_i)$ is the Euclidean distance of each data point to the centroid, and $d(c_i, c_j)$ is the distance between centroids.

4 Result and Discussion

4.1 Descriptive Statistics

The first step involved conducting a descriptive statistical analysis on the 9 variables used across all provinces in Indonesia, as shown in Table 2. Based on the economic sector, the average values are as follows: Gross Regional Domestic Product (GRDP) is

361,285.24, labor productivity in the industrial sector is 94.49, and investment is 113,018,869.41. For the environmental sector, the average values are: percentage of forest land relative to total area is 7.98, the emission index is 2.21, and productivity of paddy fields is 46.15. Finally, for the social aspects used, the average poverty rate is 7.09 percent, the open unemployment rate is 4.57 percent, and life expectancy is 73.12 years.

Table 2. Descriptive Statistics

Variable	Mean	Variance	Std Deviation	Minimum	Maximum
Poverty	7.09	7.67	2.77	3.54	14.21
Unemployment	4.57	1.98	1.41	2.67	7.52
Life_Expectancy	73.12	3.69	1.92	68.17	75.81
GDRP	361285.24	274358633272.91	523792.55	31648	2050466
Industrial_labor	94.49	5537.84	74.42	24.94	400.7
Investment	113018869.4	2134294521385070	146092248.9	6976166	547602400
Forest	7.89	163.66	12.79	0.53	77.67
Emission	2.21	10.24	3.20	0.19	12.53
Paddy_land	46.15	66.69	8.18	30.35	60.41

Additionally, the spatial distribution of the variables used across each province is shown in Figures 1(a) to 1(i). The spatial distribution of these variables demonstrates considerable variability. It can be observed that as the color intensity increases in a province for each variable, the higher the value of that variable in the respective province.

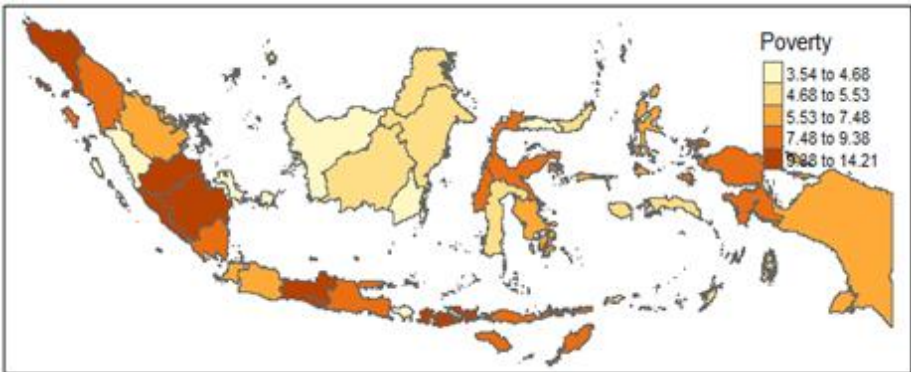


Fig. 1. Spatial Distribution Map for Poverty in Indonesia, 2023

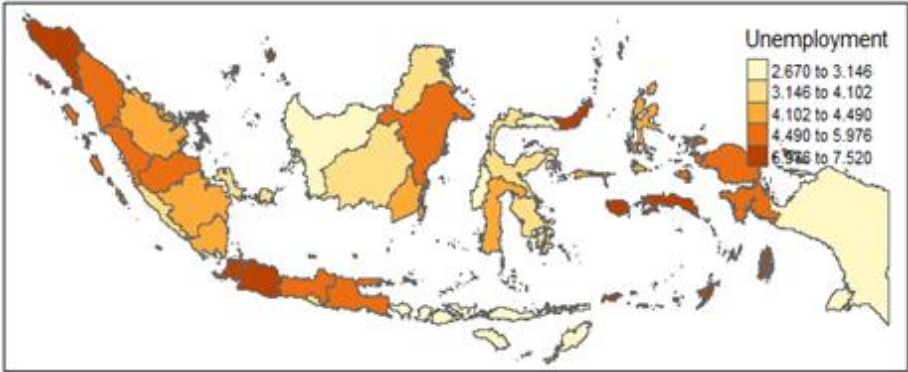


Fig. 2. Spatial Distribution Map for Unemployment in Indonesia, 2023

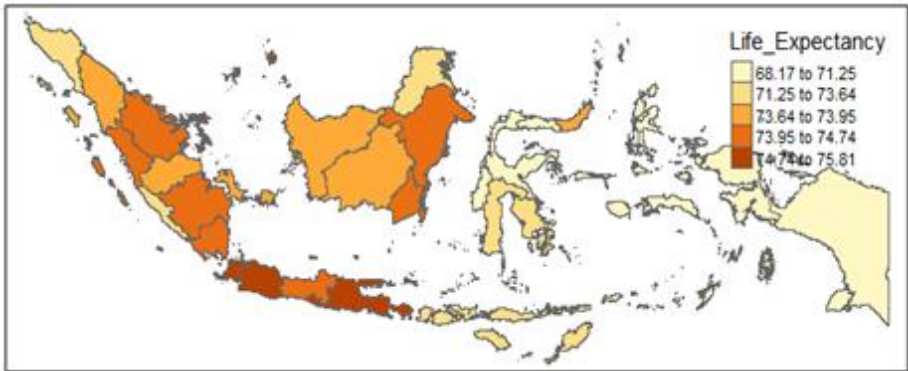


Fig. 3. Spatial Distribution Map for Life Expectancy in Indonesia, 2023

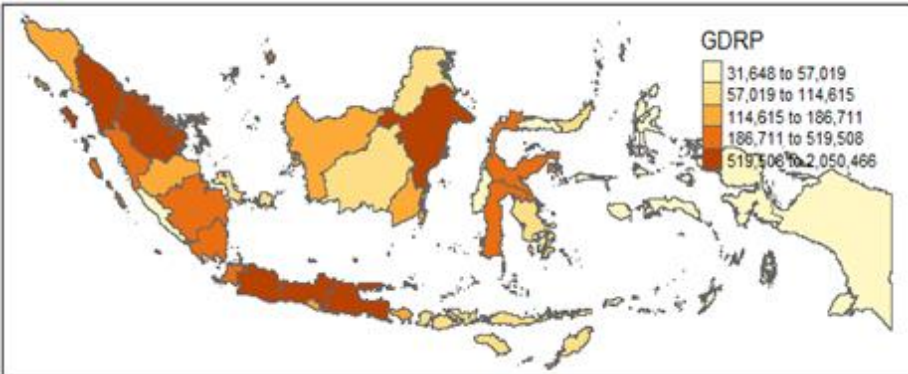


Fig. 4. Spatial Distribution Map for GDP in Indonesia, 2023

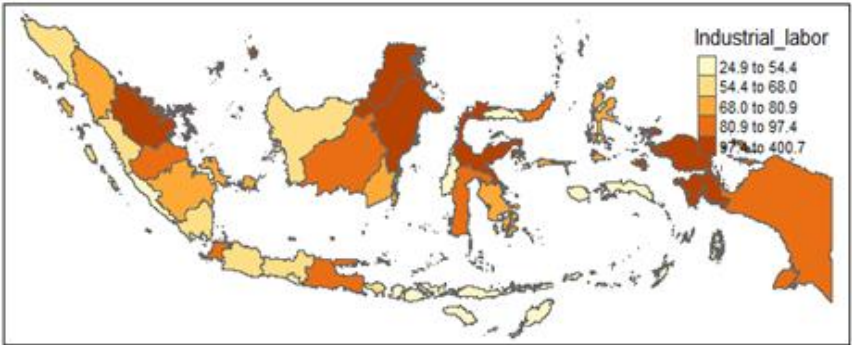


Fig. 5. Spatial Distribution Map for Industrial Labor in Indonesia, 2023

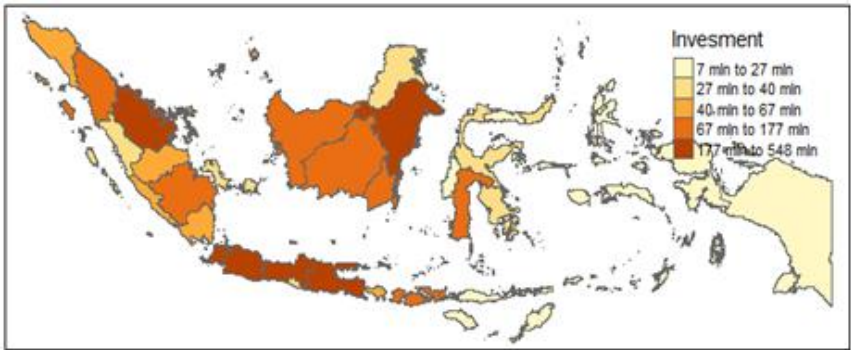


Fig. 6. Spatial Distribution Map for Investment in Indonesia, 2023

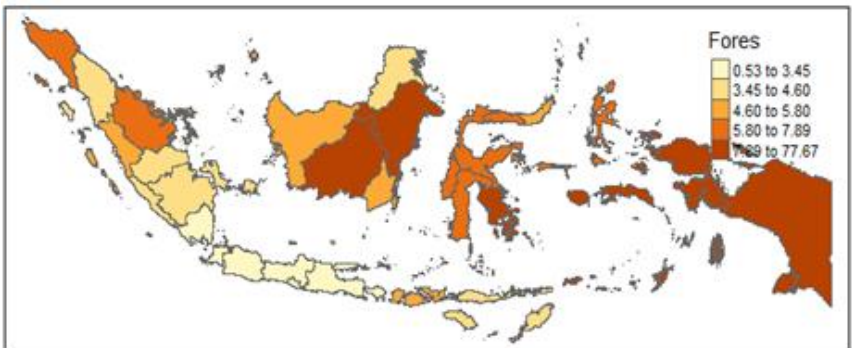


Fig. 7. Spatial Distribution Map for Forest in Indonesia, 2023

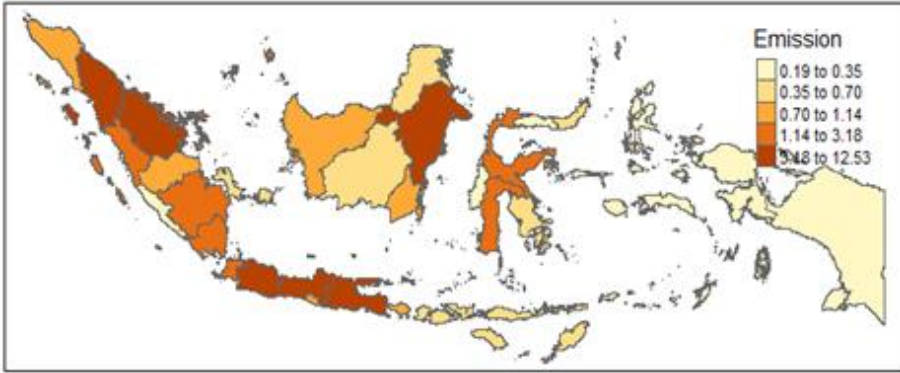


Fig. 8. Spatial Distribution Map for Emission in Indonesia, 2023

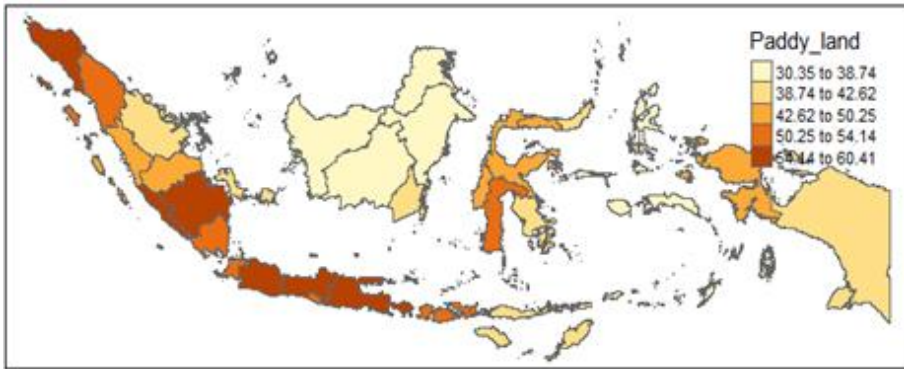


Fig. 9. Spatial Distribution Map for Paddy Land in Indonesia, 2023

4.2 Correlation Analysis

The next step involves performing a correlation analysis between variables. Correlation analysis is generally used to measure and understand the relationship between two or more variables, as well as to determine the strength of these relationships. Based on the correlation analysis results presented in Figure 3, it is observed that along the diagonal, variables show a high correlation with themselves. Furthermore, only a few variables exhibit significant correlations with other variables, such as the strong relationships between emissions and Gross Regional Domestic Product (GRDP) as well as investment. Additionally, some variables also show weak negative correlations, such as the relationship between forest area and life expectancy.

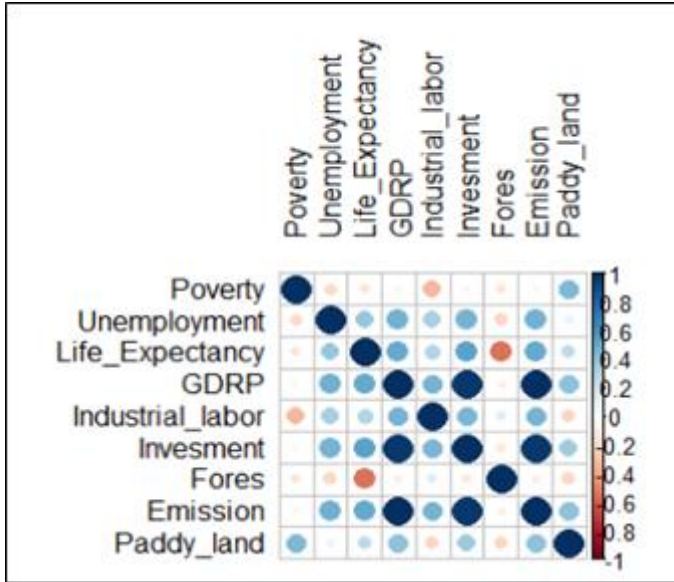


Fig. 10. Correlation Analysis

4.3 Clustering with K-Medoids

The first step in performing clustering is to determine the optimal number of clusters. In this study, the estimation of the optimal number of clusters was conducted using the Silhouette method. The results of the silhouette method are shown in Figure 6. Based on these results, it is observed that clustering regions in Indonesia using the K-Medoids method is estimated to form three clusters.

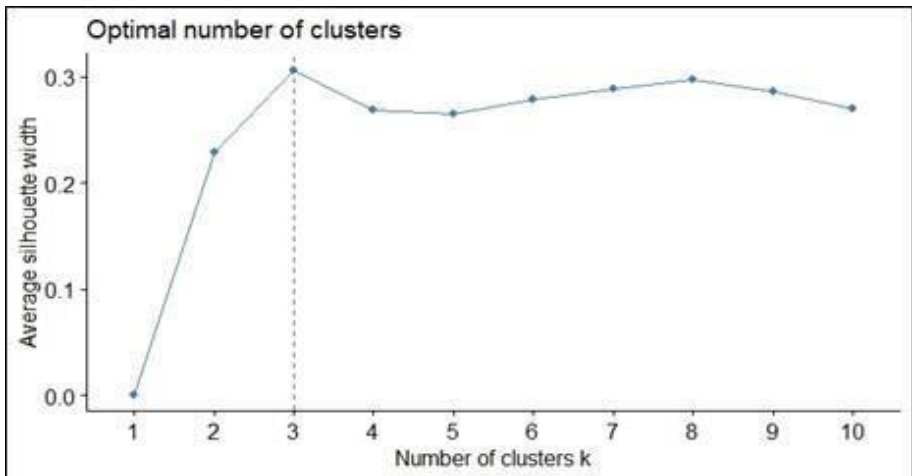


Fig. 11. Optimal Number of Clusters Using the Silhouette Method

The results from the optimal clustering using the K-Medoids method facilitate the mapping of the Green Economy across provinces in Indonesia. This is possible due to the tendency of provinces with similar characteristics to be grouped within the same cluster. Figures 4(a) through 4(d) display the plots of clustering results for provinces in Indonesia using the K-Medoids method based on the variables used for each province, starting from a clustering configuration with 2 clusters up to 5 clusters.

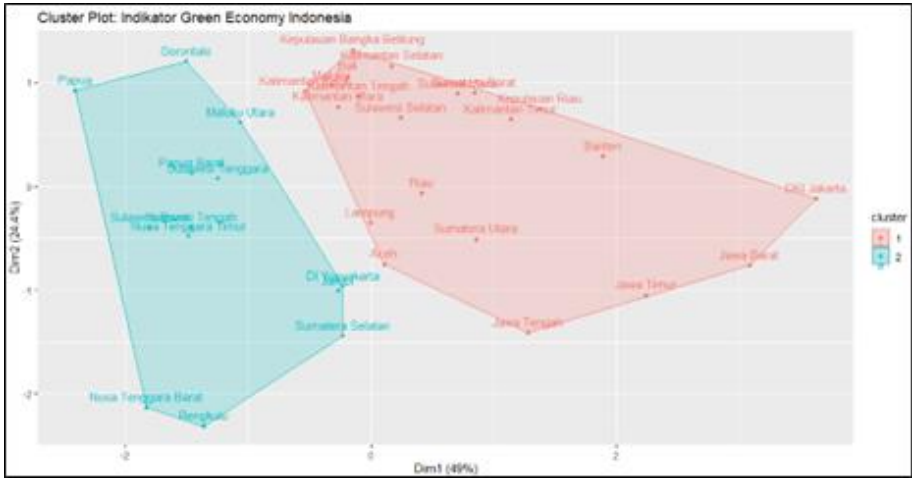


Fig. 12. Cluster Plot for K=2

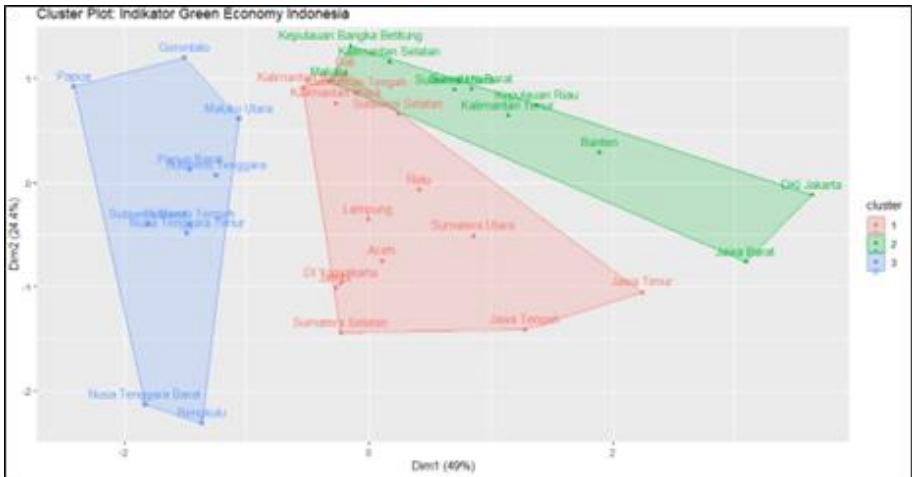


Fig. 13. Cluster Plot for K=3

K=4	0.4003080
K=5	0.3282049

Based on Table 3, the smallest DBI value is for K=3, with a value of 0.3148636. Therefore, the clustering plot used for grouping provinces in Indonesia based on Green Economy indicators is the plot in Figure 4(b), which results in three clusters.

Table 4. Classification of Each Province Resulting from Clustering

Province	Cluster	Province	Cluster	Province	Cluster
Aceh	1	South Sumatera	1	Bengkulu	3
Bali	1	North Sumatera	1	Gorontalo	3
DI Yogyakarta	1	Banten	2	North Maluku	3
Jambi	1	DKI Jakarta	2	NTB	3
Central Java	1	West Java	2	NTT	3
East Java	1	South Kalimantan	2	Papua	3
West Kalimantan	1	North Kalimantan	2	West Papua	3
Central Kalimantan	1	Bangka Belitung	2	West Sulawesi	3
North Kalimantan	1	Riau Island	2	Southeast Sulawesi	3
Lampung	1	Maluku	2		
Riau	1	North Sulawesi	2		
South Sulawesi	1	West Sumatera	2		

Based on Table 4, the K-Medoids clustering results show that the majority of provinces in Indonesia fall into Cluster 1, which consists of 14 provinces. Clusters 2 and 3 each contain 10 provinces.

Table 5. Average Variables in Each Cluster

Variable	Cluster 1	Cluster 2	Cluster 3
Poverty	7.45	4.98	8.71
Unemployment	4.33	6.02	3.45
Life_Expectancy	74.08	74.12	70.79
GDRP	431531.14	550364.60	73861.60
Industrial_labor	85.07	134.39	67.79
Invesment	130780748.57	172966851.40	28204256.60
Forest	4.27	6.25	14.60
Emission	2.64	3.36	0.45
Paddy_land	48.01	43.97	45.73

Table 5 shows the average clustering values for each Green Economy variable. It can be observed that Cluster 2, which consists of provinces with better Green Economy indicators, surpasses Clusters 1 and 3. Broadly speaking, Cluster 2 exhibits better social and economic aspects compared to the other two clusters. Meanwhile, Cluster 3 shows slightly better environmental aspects, and Cluster 1 does not excel in any aspect.

From the social aspect, Cluster 2 has an average poverty rate of 4.98%, which is lower than the overall poverty rate of provinces in Indonesia for 2023, which is 7.09%. Additionally, Cluster 2 has the highest life expectancy among the clusters at 74.12 years. However, Cluster 3 has the lowest average unemployment rate at 3.45%, which is below the national unemployment rate of 4.57% for 2023. This indicates that policy priorities for social aspects in Clusters 1 and 3 need to focus on improving social conditions, particularly in reducing poverty.

From the economic aspect, there is a significant disparity in all the variables used, such as GDP, industrial labor productivity, and investment, between Cluster 2 and Clusters 1 and 3. Cluster 2 has a GDP of 550,364.60 billion Rupiah, industrial labor productivity of 134.39 thousand Rupiah, and investment of 172,966,851.40 thousand Rupiah, which are substantially higher than those in Clusters 1 and 3. Meanwhile, in terms of environmental aspects, Cluster 3 has better variable conditions compared to Clusters 1 and 2, with an average forest area percentage of 14.60% and a provincial emission index of 0.45. Cluster 1, however, excels in paddy land productivity compared to Clusters 2 and 3, with an average value of 48.01 ku/ha.

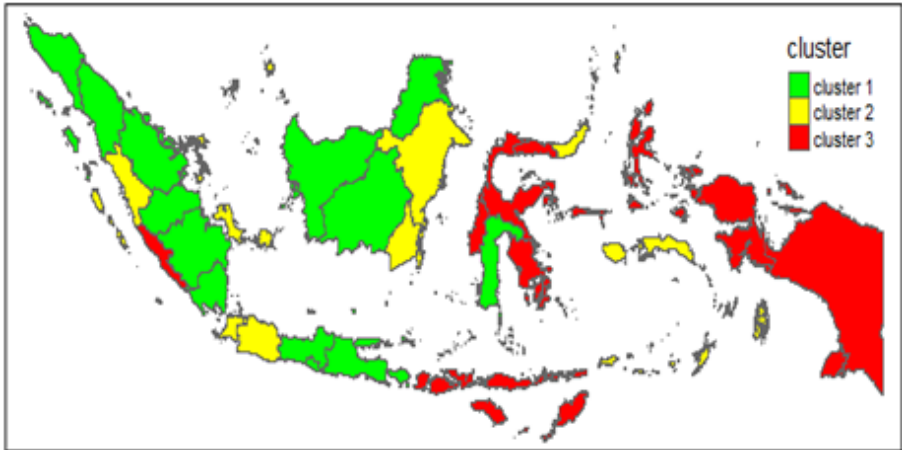


Fig. 16. Final Clustering Indicators of Green Economy in Indonesia

Based on Figure 5, it can be identified that regions in Cluster 2 with better Green Economy indicators are distributed evenly and not concentrated in a single area. This indicates a positive sign that provinces in Indonesia are starting to implement Green Economy more evenly. It is also noted that Cluster 2 is composed of provinces with high industrial processing activities, such as DKI Jakarta and West Java, characterized by a considerable number of medium-scale manufacturing enterprises and a relatively high population. In other words, provinces in Cluster 2 have the potential to become economic drivers and sources of economic growth in Indonesia. However, the high

industrial activity in the provinces of Cluster 2 is not yet balanced with improvements in environmental aspects, such as high carbon emission levels.

So far, the Indonesian Government has prepared three main strategies for low-carbon development as a crucial part of Green Economy implementation. These strategies include: implementing net zero emissions policies to reduce greenhouse gas emissions, green stimulus strategies for post-pandemic economic recovery, and low-carbon development policies to achieve the Medium-Term National Development Plan (RPJMN) 2020-2024 targets. Therefore, in response to these strategies, provincial governments in the lagging clusters need to develop strategies to ensure that the industrial sector not only contributes to economic growth but also actively participates in reducing greenhouse gas emissions resulting from industrial processes and energy use.

It is also observed that provinces in Cluster 1 and Cluster 3 are evenly distributed across Indonesia. Clusters 1 and 3 encompass regions that have not yet been able to optimize Green Economy implementation to stimulate inclusive economic growth due to low labor productivity and investment. Thus, both provincial and central governments need to assist in improving access to productivity and investment for these provinces. Another notable finding is the high poverty levels in provinces within Cluster 1 and Cluster 3, particularly in Eastern Indonesia. Therefore, poverty alleviation programs are expected to be optimally implemented in these provinces, especially those with poverty rates exceeding the national average.

5 Conclusion

5.1 Summary

This study illustrates the implementation of Green Economy based on the clustering results of provinces in Indonesia, involving nine variables representing social, economic, and environmental aspects. According to the analysis using the K-Medoids method, the clustering results for Green Economy implementation in Indonesia are divided into three clusters. Cluster 1 consists of 14 provinces, Cluster 2 comprises 10 provinces, and Cluster 3 includes 10 provinces. Another finding shows that provinces in Cluster 2 have better Green Economy indicators compared to those in Clusters 1 and 3. Generally, regions in Cluster 2 exhibit characteristics with better social and economic aspects, while Cluster 3 is only slightly better than Cluster 1 in environmental aspects.

Provinces with supportive Green Economy characteristics have the potential for better real sector growth. Therefore, special support is needed for these regions to further enhance real sector transformation. Additionally, districts/municipalities with poor environmental aspects need to be guided to reduce environmental impacts. Policies that promote sustainable practices and the use of eco-friendly technologies can help reduce environmental pollution and improve environmental quality.

5.2 Policy Recommendations

Several policy suggestions and recommendations based on this study's findings are as follows:

1. Carbon Emission Reduction and Environmental Conservation Programs: The central and regional governments should develop effective emission reduction programs, including incentives for clean energy use and eco-friendly technologies, particularly in provinces with high carbon emission levels.
2. Stakeholder Collaboration: Governments, the private sector, and non-governmental organizations should collaborate to formulate and implement policies that support sustainable real sector transformation in line with Green Economy implementation in Indonesia.
3. Monitoring and Evaluation: The government should establish an effective monitoring and evaluation system to track the impact of implemented policies and make necessary adjustments.

This study provides valuable insights into Green Economy characteristics related to real sector transformation for enhanced economic growth in Indonesia. It also offers a foundation for sustainable and inclusive policymaking across provinces in Indonesia. Proper implementation of policies based on these findings is expected to help the government achieve sustainable economic growth and strengthen the real sector through real sector transformation in Indonesia.

The limitation of this study is the use of only nine indicators representing three aspects of Green Economy implementation, whereas the Green Economy Index (GEI) includes 15 indicators. The incomplete use of all indicators is due to limited data availability and accessibility. Therefore, future research should consider using more than nine indicators or all indicators of Green Economy. Additionally, exploring different methods or combinations of clustering methods is recommended to obtain more comprehensive information on Green Economy implementation in Indonesia.

References

1. D. Liu, Y. Zhang, M. Hafeez, and S. Ullah, "Financial inclusion and its influence on economic environmental performance: Demand and supply perspectives," *Environ. Sci. Pollut. Res.*, vol. 29, no. 38, pp. 58212-58221, 2022. <https://doi.org/10.1007/s11356-022-18856-1>.
2. M. Adamowicz, "Green deal, green growth and green economy as a means of support for attaining the sustainable development goals," *Sustainability*, vol. 14, no. 10, p. 5901, 2022. <https://doi.org/10.3390/su14105901>.
3. A. C. Dvorak, H. M. Solo-Gabriele, A. Galletti, B. Benzecey, H. Malone, V. Boguszewski, and J. Bird, "Possible impacts of sea level rise on disease transmission and potential adaptation strategies, a review," *J. Environ. Manag.*, vol. 217, pp. 951-968, 2018. <https://doi.org/10.1016/j.jenvman.2018.03.102>.
4. S. Hallegatte, M. Fay, and E. B. Barbier, "Poverty and climate change: Introduction," *Environ. Dev. Econ.*, vol. 23, no. 3, pp. 217-233, 2018. <https://doi.org/10.1017/S1355770X18000141>.
5. A. P. Rany, S. A. Farhani, V. R. Nurina, and L. M. Primada, "Tantangan Indonesia dalam mewujudkan pertumbuhan ekonomi yang kuat dan pembangunan ekonomi berkelanjutan melalui Indonesia Green Growth Program oleh Bappenas," *JIEP*, vol. 20, no. 1, pp. 63-73, 2020.
6. A. N. and N. Setiawan, "Review program pemulihan ekonomi di Indonesia," *Jurnal Anggaran dan Keuangan Negara Indonesia*, vol. 3, no. 1, 2021.

7. M. Anwar, "Green economy sebagai strategi dalam menangani masalah ekonomi dan multilateral," *Jurnal Pajak dan Keuangan Negara*, vol. 4, no. 15, pp. 343-356, 2022.
8. A. Kasztelan, "Green growth, green economy and sustainable development: Terminological and relational discourse," *Prague Econ. Pap.*, vol. 26, no. 4, pp. 487-499, 2017. <https://doi.org/10.18267/j.pep.626>.
9. S. Acharya and A. H. Sequeira, "A model of green economy for developing countries," *SSRN Electron. J.*, 2012. <https://doi.org/10.2139/ssrn.2192369>.
10. S. Djajadiningrat, Y. Hendriani, and M. Famiola, "Ekonomi hijau/green economy," *October*, pp. 131-146, 2011.
11. Global Green Growth Institute, "Mewujudkan pertumbuhan ekonomi hijau untuk Indonesia yang sejahtera," *Global Green Growth Institute*, pp. 1-21, 2015. www.gpp.bappenas.go.id.
12. S. H. H. Al-Taai, "Green economy and sustainable development," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 779, no. 1, p. 012007, 2021. <https://doi.org/10.1088/1755-1315/779/1/012007>.
13. S. Mu'min, Silahuil, and S. Anam, "Fuzzy C-means cluster analysis for evaluating implementation of green economy," *Proceeding The 10th East Java Economic Forum (EJAVEC)*, vol. 3, no. 1, pp. 87-110, 2023.
14. F. Anggoro, R. E. Caraka, F. A. Prasetyo, M. Ramadhani, P. U. Gio, R. C. Chen, and B. Pardemean, "Revisiting cluster vulnerabilities towards information and communication technologies in the eastern island of Indonesia using fuzzy C-means," *Sustainability*, vol. 14, no. 6, p. 3428, 2022. <https://doi.org/10.3390/su1406342>.
15. A. Supriyadi, A. Triayudi, and I. D. Sholihati, "Perbandingan algoritma K-means dengan K-medoids pada pengelompokan armada kendaraan truk berdasarkan produktivitas," vol. 06, pp. 229-240, 2021.
16. P. N. Safitri, R. Aristawidya, and S. B. Faradilla, "Klasterisasi faktor-faktor kemiskinan di Provinsi Jawa Barat menggunakan K-medoids clustering," *J. Math. Educ. Sci.*, vol. 4, no. 2, pp. 75-80, 2021. <https://doi.org/10.32665/james.v4i2.242>.
17. UNEP, "Green economy," 2021.
18. R. F. E. Pradani, L. E. Amalia, H. Ismawati, and I. Halifah, "Penerapan konsep green economy dalam meningkatkan pendapatan UMKM di Dusun Tahu Kabupaten Situbondo," *Jurnal Pendidikan Ekonomi (JUPE)*, vol. 11, no. 1, pp. 19-23, 2023.
19. N. Chaaben, Z. Elleuch, B. Hamdi, and B. Kahouli, "Green economy performance and sustainable development achievement: Empirical evidence from Saudi Arabia," *Environ. Dev. Sustain.*, 2022. <https://doi.org/10.1007/s10668-022-02722-8>.
20. ESCAP, "Green growth indicators: A practical approach for Asia and the Pacific," 2014.
21. D. T. Larose, *Discovering Knowledge in Data: An Introduction to Data Mining*, Journal of the American Statistical Association, vol. 10, no. 472, 2014. <https://doi.org/10.1198/jasa.2005.s61>.
22. S. Sindi, W. R. O. Ningse, I. A. Sihombing, P. P. P. A. N. Zer, F. Ilmi R. H., and D. Hartama, "Analisis algoritma K-medoids clustering dalam pengelompokan penyebaran Covid-19 di Indonesia," vol. 4, no. 1, pp. 166-173, 2020.
23. A. T. Sipayung, S. Saifullah, and R. Winanjaya, "Penerapan metode K-means dalam mengelompokkan banyaknya desa/kelurahan menurut keberadaan permukiman di bantaran sungai berdasarkan provinsi," *Brahmana: Jurnal Penerapan Kecerdasan Buatan*, vol. 2, no. 1, pp. 49-56, 2020. <https://doi.org/10.30645/brahmana.v2i1.48>.
24. B. Gao, I. Ozturk, and S. Ullah, "A new framework to the green economy: Asymmetric role of public private partnership investment on environment in selected Asian economies," *Econ. Res. Ekonomika Istrazivanja*, vol. 36, no. 1, pp. 1960-1971, 2023. <https://doi.org/10.1080/1331677X.2022.2094441>.

25. P. N. Ekasari, "Pengaruh tingkat emisi karbon (CO₂) dan tingkat kemiskinan terhadap kualitas hidup manusia (studi pada 38 Kabupaten/Kota di Provinsi Jawa Timur 2012-2016)," Universitas Sebelas Maret, 2018.
26. N. Azrahwati, M. Nusrang, M. K. Aidid, and Z. Rais, "K-means cluster analysis for grouping districts in South Sulawesi Province based on village potential," vol. 2, no. 2, pp. 73–82, 2022.

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