

Spatial patterns and inequality of Blue Economy sustainability in Indonesia: Evidence from the 2024 Indonesia Blue Economy Index

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Abstract

The blue economy has become a strategic approach to integrating marine resource utilization with environmental sustainability and societal well-being, yet its performance remains uneven across regions. This study aims to analyze the spatial distribution and dependence of blue economy sustainability across 34 Indonesian provinces using the 2024 *Indonesia Blue Economy Index* (IBEI). *Exploratory Spatial Data Analysis* (ESDA) was conducted using *Global Moran's I* and *Local Indicators of Spatial Association* (LISA) with a *Queen contiguity* spatial weight matrix. The results show that IBEI scores range from 11.61 to 66.51, with a mean of 37.24, while *Moran's I* of 0.290 indicates positive spatial autocorrelation. LISA identifies South Sulawesi as *High-High*, South Sumatra and Lampung as *Low-Low*, West Sulawesi as *Low-High*, and the Riau Islands as *High-Low*. These findings demonstrate distinct spatial configurations of blue economy inequality and provide a basis for differentiated regional policies tailored to the spatial characteristics of each province.

Keywords: *Indonesia Blue Economy Index*; Spatial inequality; Spatial autocorrelation; Blue economy clusters; Blue economy sustainability.

Abstrak

Ekonomi biru menjadi pendekatan strategis untuk mengintegrasikan pemanfaatan sumber daya laut dengan keberlanjutan lingkungan dan kesejahteraan masyarakat, tetapi kinerjanya menunjukkan ketimpangan antardaerah. Penelitian ini bertujuan menganalisis distribusi dan ketergantungan spasial keberlanjutan ekonomi biru pada 34 provinsi di Indonesia berdasarkan *Indonesia Blue Economy Index* (IBEI) 2024. Penelitian menggunakan *Exploratory Spatial Data Analysis* (ESDA) melalui *Global Moran's I* dan *Local Indicators of Spatial Association* (LISA) dengan matriks bobot spasial *Queen contiguity*. Hasil menunjukkan IBEI berkisar 11,61–66,51 dengan rata-rata 37,24, sedangkan *Moran's I* sebesar 0,290 mengindikasikan autokorelasi spasial positif. LISA mengidentifikasi Sulawesi Selatan sebagai *High-High*, Sumatera Selatan dan Lampung sebagai *Low-Low*, Sulawesi Barat sebagai *Low-High*, serta Kepulauan Riau sebagai *High-Low*. Temuan ini menunjukkan bahwa ketimpangan ekonomi biru memiliki konfigurasi spasial yang berbeda dan memberikan dasar bagi kebijakan regional yang lebih terdiferensiasi sesuai karakteristik spasial setiap provinsi.

Kata Kunci: *Indonesia Blue Economy Index*; Ketimpangan spasial; Autokorelasi spasial; Kluster ekonomi biru; Keberlanjutan ekonomi biru.

Introduction

The ocean is increasingly regarded as a strategic space for economic development, food security, job creation, and environmental sustainability (Amran et al., 2025; De Luca Peña et al., 2024; Smith-Godfrey, 2016). This development has encouraged the emergence of the *Blue Economy* as a development paradigm that integrates the utilization of marine resources with ecosystem sustainability and societal well-being (Lee et al., 2020; Silver et al., 2015). Unlike the conventional marine economy, which emphasizes the scale of economic activities, the *Blue Economy* also encompasses environmental protection, social equity, and governance capacity (Bennett et al., 2019; Cisneros-Montemayor et al., 2021). Therefore, the sustainability of the *Blue Economy* cannot be assessed solely through production or the contribution of marine sectors. Assessment should also consider the capacity of regions to maintain ecosystems, meet social needs, and distribute economic benefits fairly among communities and related regions.

Increasing utilization of ocean space and marine resources creates economic opportunities while also generating sustainability challenges. Fisheries, aquaculture, tourism, shipping, offshore energy, and other marine-based activities can generate income and employment, but they can also contribute to environmental degradation, resource competition, and social inequality when governance is inadequate (Cisneros-Montemayor et al., 2019; Cohen et al., 2019). Bennett et al. (2019) emphasize that *Blue Economy* development needs to integrate economic growth, ecological protection, and societal well-being, while Cisneros-Montemayor et al. (2019) identify social equity and benefit distribution as essential elements. Accordingly, *Blue Economy* sustainability is multidimensional and varies across regions because infrastructure, institutional, economic, environmental, and social capacities are unevenly distributed (He et al., 2017; Midlen, 2021; Roy et al., 2024). These differences make regional assessment important for formulating sustainable development policies.

These multidimensional conditions have encouraged the use of composite indices to compare *Blue Economy* sustainability across regions. Ding and Tabeta (2024) developed a *Blue Economy Index* for 39 prefectures in Japan by incorporating marine resources, maritime industries, ecological sustainability, socioeconomic stability, and risk management. Their results revealed regional differences and clustering patterns in *Blue Economy* development. González-Espinosa et al. (2025) also demonstrated that relationships among *Blue Economy* components can vary across regions and over time. These findings indicate that index-based measurement needs to be complemented by a geographical perspective because economic, environmental, infrastructural, market, mobility, and institutional conditions can extend beyond administrative boundaries. Such interdependence can produce concentrations of high- or low-performing regions that are not captured by index rankings alone (Bhattacharya & Dash, 2021; De Luca

Peña et al., 2024; Sarker et al., 2018). Therefore, a spatial dimension is necessary to understand the distribution of sustainability more comprehensively.

Research on the *Blue Economy* has examined conceptual development, index construction, sectoral analysis, and factors influencing regional performance. Ding and Tabeta (2024) identified regional differences and clustering through a multidimensional index in Japan, while González-Espinosa et al. (2025) found that relationships among *Blue Economy* dimensions vary according to regional and temporal contexts. Other studies have emphasized the importance of multidimensional indicators, governance, and stakeholder engagement in *Blue Economy* development (Amran et al., 2025; Clark Howard, 2018; Hossain et al., 2024; Jouffray et al., 2020). However, these approaches do not fully explain whether regions with similar performance tend to be geographically proximate or form local clusters. Research in Indonesia has also focused more on *Blue Economy* performance levels and their determinants, while spatial dependence and *spatial outliers* among provinces remain relatively underexplored. This condition indicates a need for a more systematic spatial analysis.

This study aims to analyze the spatial distribution and dependence of *Blue Economy* sustainability across 34 provinces in Indonesia using the 2024 *Indonesia Blue Economy Index* (IBEI) and *Exploratory Spatial Data Analysis* (ESDA). *Global Moran's I* is used to identify overall patterns of spatial autocorrelation, while *Local Indicators of Spatial Association* (LISA) is used to identify clusters and *spatial outliers* at the local level (Anselin, 1995). This approach is important because IBEI rankings indicate differences in performance levels but do not explain geographical relationships among regions. By integrating the index with spatial analysis, this study identifies whether regions with similar performance are geographically concentrated or whether particular provinces differ from their surrounding areas. The findings are expected to clarify patterns of spatial inequality and provide a basis for *Blue Economy* policies that are better aligned with the characteristics and regional contexts of Indonesia.

Method

This study uses Exploratory Spatial Data Analysis (ESDA) to analyze the distribution, spatial dependence, and spatial patterns of the *Blue Economy* in Indonesia (Azis et al., 2026; Santoso et al., 2019, 2025). The data consist of secondary data from the 2024 *Indonesia Blue Economy Index* (IBEI), published by the Ministry of National Development Planning/National Development Planning Agency (Kementerian PPN/Bappenas) (Kementerian PPN/Bappenas, 2025). The IBEI is used as the main variable for 34 provinces in Indonesia and is integrated with provincial administrative boundary data to construct a spatial database. The analysis is conducted using GeoDa with a spatial weight matrix based on Queen contiguity. Of the 34 provinces, 28 can be

analyzed at the local level, while six provinces are identified as spatial isolates within the spatial weight matrix used.

The ESDA analysis is conducted in two stages, namely Global Moran's I and Local Indicators of Spatial Association (LISA). Global Moran's I is used to identify the overall tendency of spatial autocorrelation, while LISA is used to identify clusters and spatial outliers at the local level (Anselin, 1995). The Global Moran's I statistic is formulated as follows (Moran, 1950)

$$I = \frac{n}{W} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2}$$

where I is Global Moran's I, n is the number of regions, x_i and x_j are the IBEI values of regions i and j , $\bar{x}$ is the mean IBEI, w_{ij} is the spatial weight between regions i and j , and W is the sum of all spatial weights. A positive value indicates a tendency for regions with similar values to be located near one another, whereas a negative value indicates a tendency for regions with different values to be located near one another.

LISA is used to identify four spatial configurations, namely High-High (HH), Low-Low (LL), High-Low (HL), and Low-High (LH) (Anselin, 1995). HH indicates a region with a high value surrounded by regions with high values, whereas LL indicates a region with a low value surrounded by regions with low values. HL indicates a region with a high value located near regions with low values, whereas LH indicates a region with a low value located near regions with high values. HH and LL are treated as spatial clusters, whereas HL and LH indicate spatial outliers. The sequential use of Global Moran's I and LISA enables the study to identify overall patterns of spatial dependence while also determining the locations and forms of clusters or spatial outliers in *Blue Economy* sustainability across Indonesian provinces.

Results and Discussion

Spatial distribution and heterogeneity of blue economy sustainability in Indonesia

The 2024 Indonesian Blue Economy Index (IBEI) calculations for 34 provinces reveal substantial heterogeneity in the level of Blue Economy sustainability across Indonesia. IBEI scores range from 11.61 to 66.51, with a mean of 37.24 and a standard deviation of 13.89. The nearly 55-point gap between the highest and lowest scores indicates that provincial capacity to support the sustainable utilization of marine resources is unevenly distributed. Accordingly, the distribution of IBEI does not exhibit a homogeneous national pattern but instead reflects considerable differences in performance across provinces. This variation provides an initial indication that Blue Economy sustainability in Indonesia needs to be understood not only in terms of the performance level of individual provinces but also in terms of how these values are geographically distributed.



Figure 1. Distribution of IBEI across Indonesian provinces, 2024

Source: Authors' analysis.

Based on Figure 1, South Sulawesi has the highest IBEI score, at 66.51, followed by East Java (60.55), West Java (54.75), Central Java (54.75), and North Sulawesi (53.99). In contrast, the lowest scores are recorded in the Special Region of Yogyakarta (11.61), Jambi (14.67), South Sumatra (19.14), Banten (24.00), and Central Kalimantan (24.28). This distribution indicates that provinces with high and low IBEI scores are not concentrated exclusively in a particular geographical region. The pattern is also evident among geographically proximate areas. On Java Island, for example, East Java, West Java, and Central Java have relatively high scores, whereas Banten and the Special Region of Yogyakarta show substantially lower scores. These differences indicate that variations in Blue Economy sustainability cannot be explained simply by dividing Indonesia into western, central, and eastern regions but instead reflect more specific diversity at the provincial level.

These findings also highlight the limitations of understanding Blue Economy sustainability solely through comparisons of IBEI values across provinces. The index can indicate whether a province has relatively high or low performance, but it does not explain how the province is positioned within its geographical surroundings. In other words, two provinces with relatively similar IBEI values may have different spatial contexts if one is surrounded by provinces with high values while the other is located among provinces with low values. This distinction is important in the context of the Blue Economy because fisheries, coastal ecosystems, maritime transportation, trade, and marine resource utilization can create interregional linkages that extend beyond provincial administrative boundaries. Therefore, the IBEI distribution in Figure 1 provides a basis for moving beyond the assessment of provincial performance levels toward examining spatial relationships among provinces.

The substantial variation also reinforces the view that Blue Economy sustainability is a multidimensional issue. Bennett et al. (2019) emphasize that a sustainable Blue

Economy cannot be assessed solely in terms of marine-based economic growth but must also consider ecological sustainability and the distribution of benefits to communities. Similarly, Cisneros-Montemayor et al. (2019) identify social equity and benefit distribution as important elements in the transformation of the Blue Economy. In the context of this study, differences in IBEI values across provinces may indicate variation in the overall capacity of regions to integrate economic, environmental, social, and governance objectives. This finding is also consistent with Trenggono et al. (2025), who identified variations in Blue Economy performance across Indonesian provinces based on policy, ecological, economic, and social dimensions. However, the distribution shown in Figure 1 cannot determine which specific dimensions explain the differences among provinces. Therefore, these findings are more appropriately understood as an initial depiction of regional heterogeneity that requires further analysis based on spatial relationships among regions.

Thus, Figure 1 not only shows differences in IBEI values but also demonstrates that the distribution does not follow a simple geographical pattern. This condition raises a further question as to whether provinces with relatively high or low levels of sustainability tend to be geographically proximate or are instead distributed randomly. This question provides the basis for the subsequent Global Moran's I analysis to determine whether spatial autocorrelation exists in the distribution of Blue Economy sustainability across Indonesian provinces.

Global spatial autocorrelation of the Indonesian Blue Economy Index

Further analysis was conducted using Global Moran's I to determine whether the distribution of Indonesian Blue Economy Index (IBEI) values across provinces exhibits a particular spatial pattern. The analysis produced a Moran's I value of 0.290, indicating a tendency toward positive spatial autocorrelation in the distribution of IBEI. The positive value indicates that provinces with relatively high IBEI values tend to be located within spatial environments that also have relatively high IBEI values, while provinces with relatively low IBEI values tend to be surrounded by areas with relatively low values. Thus, the variation in IBEI identified in the preceding descriptive analysis does not entirely reflect a random distribution but instead exhibits a tendency toward spatial association based on geographical position. However, the Moran's I value in this study represents spatial relationships based on the structure of the spatial weights used; therefore, its interpretation primarily indicates geographical association rather than causal relationships among provinces.

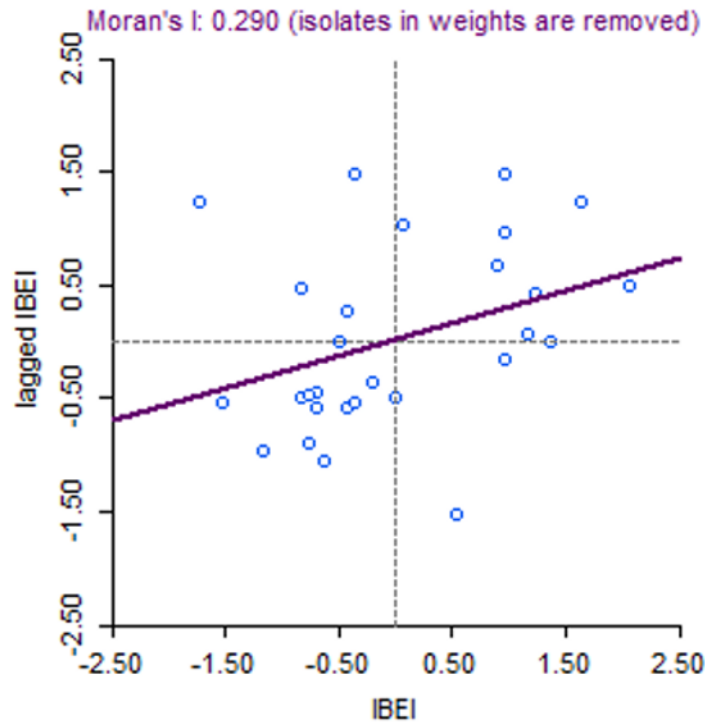


Figure 2. Moran scatter plot of IBEI across Indonesian provinces, 2024

Source: Authors' analysis.

Figure 2 illustrates the relationship between standardized IBEI values on the horizontal axis and the spatial lag of IBEI on the vertical axis. The mean IBEI value of 37.2353 is used as the center point of the distribution, while the standard deviation of 13.8893 indicates the degree of variation in IBEI values across provinces. The regression line in the Moran scatter plot has a positive slope, which is consistent with the Moran's I value of 0.290. This pattern indicates that relative changes in the IBEI value of a province tend to be accompanied by changes in the same direction in its spatial environment. In other words, the IBEI value of a province does not exist entirely in isolation, as its relative position is associated with the values of neighboring areas defined by the spatial weights matrix. At the same time, the distribution of observations across the four quadrants indicates that this association is not uniform across all provinces. Some observations fall within high-high and low-low combinations, while others exhibit high-low or low-high combinations. These local patterns provide the basis for identifying spatial clusters and spatial outliers through the subsequent LISA analysis.

These findings are relevant to the characteristics of the Blue Economy, which involves activities and resources that can extend beyond administrative boundaries. Lee et al. (2020) explain that the Blue Economy connects marine-based economic activities with environmental sustainability and social development objectives. In this context, fisheries, coastal ecosystems, maritime transportation, trade, and marine resource utilization can generate interregional linkages. Jouffray et al. (2020) likewise

demonstrate that increasing human activity in marine spaces has produced economic and ecological interconnectedness across increasingly broad spatial scales. Therefore, the tendency toward positive spatial autocorrelation in IBEI can be understood as an indication that the distribution of Blue Economy sustainability has a geographical dimension that requires consideration. However, the Moran's I result does not, by itself, indicate that specific activities such as trade, fisheries, or transportation cause the observed pattern. The finding only indicates that IBEI values tend to be spatially associated based on the configuration of regions used in the analysis.

These findings are related to the study by Ding and Tabeta (2024), which identified multipolarity and clustering patterns in Blue Economy sustainability across 39 prefectures in Japan. This similarity indicates that Blue Economy sustainability is not necessarily distributed homogeneously across administrative regions but may form particular spatial configurations. The present study extends this perspective to the Indonesian context by demonstrating a tendency toward positive spatial autocorrelation in IBEI across provinces. Meanwhile, Trenggono et al. (2025) focused on measuring Blue Economy performance across Indonesian provinces based on several policy, ecological, economic, and social dimensions. The present study complements this approach by demonstrating that differences in IBEI values also have a geographical dimension. Accordingly, measuring the sustainability level of a province needs to be complemented by an analysis of the province's position within its spatial environment.

Although Global Moran's I indicates an overall tendency toward positive spatial association, the global statistic does not identify which provinces specifically form concentrations of high or low values or which provinces deviate from the characteristics of their surrounding areas. This is important because Moran's I is an aggregate measure that describes spatial patterns across the study area as a whole. Therefore, the subsequent analysis employs Local Indicators of Spatial Association (LISA) to identify the specific locations of High-High (HH), Low-Low (LL), High-Low (HL), and Low-High (LH) patterns and to distinguish between spatial clusters and spatial outliers.

Local spatial clustering of the Indonesian Blue Economy Index

The Local Indicators of Spatial Association (LISA) results show that, of the 34 provinces in Indonesia, 28 provinces can be analyzed based on the spatial neighborhood structure, while six provinces are categorized as neighborless based on the spatial weights matrix used. Among the 28 provinces, 23 are classified as insignificant, one province forms a High-High (HH) cluster, two provinces form Low-Low (LL) clusters, one province is categorized as Low-High (LH), and one province as High-Low (HL). Thus, significant local spatial patterns are identified in only five provinces, while most provinces do not exhibit statistically significant local spatial

associations. This condition indicates that the tendency toward positive spatial autocorrelation identified through Global Moran's I does not occur uniformly across Indonesia but is concentrated in specific locations. Within the LISA framework, HH and LL represent spatial clusters, whereas HL and LH represent spatial outliers that reflect a mismatch between the value of a region and its spatial environment (Anselin, 1995).

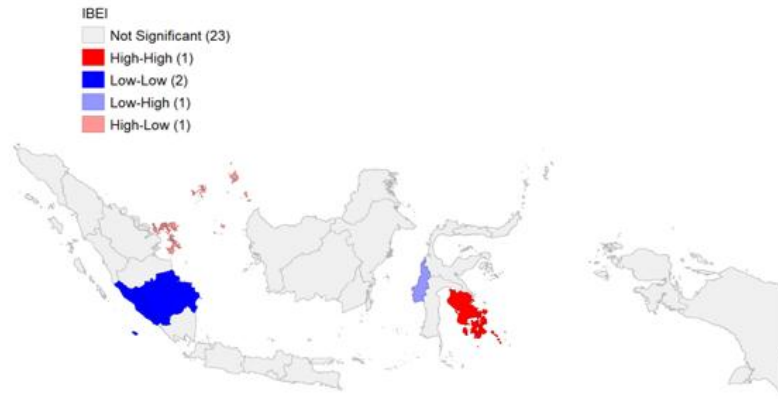


Figure 3. LISA significance map of IBEI across Indonesian provinces, 2024

Source: Authors' analysis.

The map in Figure 3 shows the dominance of the insignificant category, represented by most areas in grey. This finding indicates that the presence of positive spatial autocorrelation at the global level does not mean that all provinces have significant local spatial relationships. In other words, the pattern identified through Global Moran's I should be understood as an overall tendency, whereas LISA demonstrates that this relationship occurs significantly only in specific locations. This distinction is important when interpreting the distribution of Blue Economy sustainability because differences in IBEI values across provinces do not necessarily form geographical concentrations. This approach is consistent with developments in Blue Economy measurement that emphasize the importance of the geographical dimension in understanding differences in sustainability across regions. Ding and Tabeta (2024), for example, identified multipolarity and spatial clustering in Blue Economy development at the regional level in Japan. In the Indonesian context, the LISA results indicate that similar patterns do not occur homogeneously but only within specific regional configurations.

The only High-High (HH) cluster is found in South Sulawesi, with an IBEI value of 66.51, the highest among the 34 provinces and substantially above the national mean of 37.24. The HH category indicates that the relatively high IBEI value of South Sulawesi is situated within a spatial environment that also has relatively high IBEI values. Thus, the position of South Sulawesi reflects not only strong individual performance but also consistency with the spatial context considered in the analysis. Within its regional environment, West Sulawesi has an IBEI value of 31.72, Central

Sulawesi 49.44, and Southeast Sulawesi 50.72, indicating that the surrounding environment is not entirely homogeneous but nevertheless produces an HH configuration based on the spatial relationships used in the LISA analysis. This finding is consistent with Trenggono et al. (2025), who identified South Sulawesi as one of the provinces with relatively strong Blue Economy performance. The present findings add a spatial perspective by showing that this performance is reflected not only in the individual index value but also in a local spatial configuration.

In contrast, South Sumatra and Lampung form two Low-Low (LL) clusters, with IBEI values of 19.14 and 25.28, respectively, both of which are below the national mean. The LL category indicates that relatively low IBEI values in these two provinces occur within spatial environments that also have relatively low values. This pattern is particularly evident in South Sumatra, which is situated within a regional context characterized by relatively low IBEI values, including Jambi at 14.67, Bengkulu at 27.77, and Lampung at 25.28. Thus, the relatively low IBEI values in these areas do not appear solely as individual provincial characteristics but indicate a spatial concentration of relatively low values. This finding is relevant to Bennett et al. (2019), who argue that Blue Economy sustainability cannot be separated from the balance between economic growth, ecological sustainability, and the distribution of benefits to communities. Cisneros-Montemayor et al. (2019) likewise identify social equity and benefit distribution as important elements of Blue Economy development. Therefore, the LL pattern can be understood not merely as a concentration of low index values but as an indication that regional sustainability conditions need to be interpreted together with their broader regional context.

Unlike the LL pattern, West Sulawesi is categorized as a Low-High (LH) spatial outlier, with an IBEI value of 31.72. This value is below the national mean, while the province is situated within a relatively higher spatial context. The LH position indicates a difference between the IBEI level of a province and the characteristics of its spatial environment. Regionally, West Sulawesi is located near areas with higher values, including South Sulawesi at 66.51 and Central Sulawesi at 49.44. Therefore, the LH pattern differs from the LL cluster. In the LL configuration, both the province and its spatial environment have relatively low values, whereas in the LH configuration, the province has a relatively low value but is situated within a relatively higher spatial environment. This distinction is relevant to the findings of Cisneros-Montemayor et al. (2021), who argue that the Blue Economy capacity of a region is influenced not only by resource potential but also by supporting conditions such as institutional stability, infrastructure, governance, and social conditions. However, these factors are not tested as causes of the LH position in this study. Therefore, the finding for West Sulawesi is more appropriately understood as an indication of a spatial mismatch between provincial performance and its regional context, which may provide a basis for considering stronger interregional relationships and learning.

The opposite pattern is found in the Riau Islands, which are categorized as a High-Low (HL) spatial outlier, with an IBEI value of 44.60, above the national mean. The HL position indicates that the Riau Islands have a relatively high IBEI value but are situated within a spatial environment characterized by relatively lower values. This finding demonstrates that a high IBEI value does not necessarily form an HH cluster. The comparison between South Sulawesi and the Riau Islands is therefore relevant: both have IBEI values above the national mean, but South Sulawesi is classified as HH, whereas the Riau Islands are classified as HL. Thus, the LISA classification provides information that cannot be obtained solely by comparing IBEI rankings. This finding is consistent with González-Espinosa et al. (2025), who show that relationships among Blue Economy indicators may vary across regions and over time, meaning that understanding Blue Economy sustainability is influenced by the scale and geographical characteristics of the analysis. In the case of the Riau Islands, their archipelagic characteristics should also be considered when interpreting the spatial relationships generated from the geographical weighting matrix used in this study.

Overall, the LISA results demonstrate that the Blue Economy performance of a province cannot be fully separated from its spatial context. South Sulawesi shows a combination of high performance and a relatively high spatial environment (HH), while South Sumatra and Lampung exhibit relatively low values within spatial environments that are also relatively low (LL). In contrast, West Sulawesi has a relatively low value within a relatively higher spatial environment (LH), while the Riau Islands have a relatively high value within a relatively lower spatial environment (HL). Thus, two provinces with similarly high or low IBEI values may have different spatial configurations. This finding reinforces the argument in the literature that Blue Economy measurement needs to consider the geographical dimension because differences in regional performance may form spatial concentrations or mismatches that are not visible through index rankings alone (Ding & Tabeta, 2024; González-Espinosa et al., 2025). In the Indonesian context, these findings complement the Blue Economy performance measurement conducted by Trenggono et al. (2025) by demonstrating that variations in IBEI across provinces also exhibit different spatial configurations.

Spatial inequality and policy implications for Blue Economy sustainability

Blue Economy sustainability inequality in Indonesia cannot be understood solely as differences in scores across provinces because the more important issue concerns how these differences are spatially structured and what implications they have for development policy. A Moran's I value of 0.290 indicates a tendency toward positive spatial association, while LISA identifies four local configurations: HH, LL, LH, and HL. Accordingly, the performance of a province needs to be understood together with the conditions of geographically adjacent areas. Garland and Heidkamp (2019)

demonstrate that discussions of the Blue Economy need to consider the concepts of space, place, and scale because marine-based economic activities always occur within specific geographical contexts. This perspective reinforces the finding that Blue Economy inequality in Indonesia reflects not only differences in provincial capacity but also the relative position of each region within its regional environment. Therefore, policies based solely on IBEI rankings may overlook spatial relationships that constitute an important part of sustainability challenges.

Table 1. Spatial configurations and policy implications for Blue Economy sustainability

Spatial Configuration	Province	Main Issue	Policy Implication
HH	South Sulawesi	High sustainability performance within a relatively strong regional environment	Strengthening the province as a center for learning, innovation, connectivity, and regional capacity diffusion
LL	South Sumatra and Lampung	Low sustainability performance within a relatively weak regional environment	Developing integrated regional interventions in infrastructure, human resources, environmental quality, and institutional capacity
LH	West Sulawesi	Relatively low internal performance within a stronger regional environment	Strengthening interregional learning, knowledge transfer, innovation, and institutional cooperation
HL	Riau Islands	Relatively high internal performance within a weaker regional environment	Expanding economic, institutional, and knowledge linkages so that internal advantages generate wider regional benefits

Source: Authors' synthesis based on ESDA and LISA results.

Table 1 is not intended to reproduce the LISA statistics but to translate the spatial configurations into policy implications. The four configurations indicate that regions with different spatial positions require different forms of intervention. Gerhardinger et al. (2020), through their study of Blue Economy sustainability transition experiments in Brazil, demonstrate the importance of policy experimentation, stakeholder engagement, and knowledge integration in building sustainability transitions. This perspective is relevant because spatial configurations not only indicate where problems are located but also help identify interregional relationships that may need to be strengthened. Within this framework, HH does not simply represent a region that should be maintained, LL does not merely identify a region whose score should be improved, and LH and HL are not simply categories of outliers. Rather, the four configurations represent different policy positions within a regional system. Therefore, Table 1 serves as a bridge between the ESDA findings and policy formulation that is more sensitive to spatial characteristics.

The HH configuration in South Sulawesi indicates that Blue Economy strength can occur alongside a relatively strong regional environment. South Sulawesi has an IBEI of 66.51 and is adjacent to Central Sulawesi, with a value of 49.44, and Southeast Sulawesi, with a value of 50.72. This position gives the strength of South Sulawesi a regional dimension that would not be visible if the analysis were limited to provincial rankings. Fu et al. (2022), through their study of 11 coastal provinces and cities in China from 2009 to 2019, identified positive spatial correlation as well as HH and LL concentration patterns in green innovation capacity in the marine fisheries sector. Their study also demonstrated the importance of innovation, capital, environmental regulation, and industrial structure in shaping sustainability capacity. These findings provide a relevant perspective for the HH configuration in Indonesia because a concentration of strong performance within a relatively strong environment can provide a basis for developing regional capacity. The policy implication is therefore not merely to maintain the position of South Sulawesi but also to strengthen its function as a center for learning, innovation, connectivity, and capacity diffusion to surrounding areas.

In contrast, the LL configuration in South Sumatra and Lampung demonstrates that Blue Economy weaknesses can also be spatially concentrated. South Sumatra has an IBEI of 19.14 and Lampung 25.28, while Jambi, at 14.67, and Bengkulu, at 27.77, also contribute to a regional environment characterized by relatively low performance. This pattern indicates that the challenges in LL areas are not entirely individual because the provinces are situated within a regional context that also faces limitations. Sarker et al. (2018), through their study of the Blue Economy in Bangladesh, show that marine resource utilization faces various pressures, including climate change, overexploitation, pollution, and weak law enforcement. They emphasize the importance of strategic planning, research, and marine governance in linking economic growth with environmental sustainability. This perspective reinforces the policy direction for LL areas, where increasing marine-based economic activity alone is insufficient. Interventions need to be implemented in an integrated manner through improvements in infrastructure, environmental quality, community capacity, research, and marine resource governance so that spatially concentrated weaknesses are not continuously reproduced.

The LH configuration in West Sulawesi reflects a different situation because relatively low internal performance occurs within a stronger regional environment. West Sulawesi has an IBEI of 31.72, substantially below South Sulawesi at 66.51 and Central Sulawesi at 49.44. This condition does not demonstrate that the performance of neighboring provinces causes the lower performance of West Sulawesi, but it indicates a spatial disparity that is relevant to policy formulation. Kontovas et al. (2022), through their study of Blue Economy innovation in the United Kingdom from a stakeholder perspective, demonstrate that innovation requires interaction among actors,

knowledge, technology, and collaborative mechanisms. These findings provide a basis for interpreting the LH configuration as a condition in which there may be scope for strengthening learning and capacity transfer from a relatively stronger regional environment. Midlen (2021) also emphasizes that the Blue Economy needs to be understood through relationships among place, space, and governance because Blue Economy management practices are influenced by the material and spatial characteristics of individual regions. Accordingly, policy in West Sulawesi could focus on connectivity, knowledge exchange, innovation, and institutional cooperation so that spatial proximity to stronger regions can be translated into development capacity without assuming a direct causal effect.

The HL configuration in the Riau Islands presents the opposite condition to LH. The Riau Islands have an IBEI of 44.60, above the national mean, but their spatial environment is relatively weaker, resulting in a spatial outlier classification. This condition indicates that strong internal performance does not necessarily form a regional cluster of strong performance. Ni et al. (2024), through an analysis using complex networks and spatial econometrics, show that differences in Blue Economy product structures can be associated with Blue Economy status and produce heterogeneous spatial relationships across regions. This finding is important because the strength of a province cannot be separated from the structure of activities and economic relationships surrounding it. Mogiła et al. (2024), through an analysis of 16 regions in Poland, also demonstrate that maritime economic activities generate intersectoral and interregional linkages extending beyond coastal areas, including through spillover effects to regions supplying goods and services. Accordingly, policy for the Riau Islands should not focus solely on maintaining internal performance but also on expanding economic, institutional, and knowledge linkages so that provincial strengths can generate broader benefits for the surrounding regional environment.

The differences among the four configurations indicate that Blue Economy policy needs to consider the relationship between internal capacity and the spatial environment simultaneously. Marwa et al. (2024), through their study of Blue Economy growth in Indonesia, show that factors associated with Blue Economy development do not operate uniformly. Their analysis of the 2012–2021 period found positive associations between ICT, capture fisheries, and aquaculture and Blue Economy growth, while trade openness and electricity consumption showed negative associations, and investment was not statistically significant in their model. These findings indicate that Blue Economy development cannot be achieved through a single policy instrument applied uniformly across all regions. Sarker et al. (2018) likewise emphasize the importance of linking marine economic potential with strategic planning and governance. When these perspectives are considered together with the ESDA results, policy needs to move beyond a uniform approach toward one that considers regional configurations. HH requires capacity diffusion, LL requires

integrated strengthening, LH requires interregional learning, while HL requires broader regional connectivity.

Ultimately, the main issue identified by the ESDA is not merely that Blue Economy sustainability levels differ across provinces, but that these differences have spatial configurations that generate different policy needs. Midlen (2021) positions place and space as important aspects of understanding Blue Economy governance, while Mogila et al. (2024) demonstrate that maritime economic activities can generate economic relationships extending beyond coastal boundaries. These perspectives help situate the findings of this study within a broader framework. HH and LL configurations indicate concentrations of strength and vulnerability that require regional strategies, whereas LH and HL indicate that the internal performance of a province may differ from the conditions of its spatial environment. Therefore, Blue Economy policy in Indonesia should not focus solely on improving IBEI rankings but also on strengthening interregional relationships, equalizing capacity, transferring knowledge, protecting the environment, and integrating governance. The contribution of ESDA in this study lies in its ability to transform information on inequality into a basis for differentiating policy directions according to the spatial context of each region.

Conclusion

This study demonstrates that Blue Economy sustainability in Indonesia is characterized by interprovincial disparities as well as non-uniform spatial associations. The 2024 IBEI values range from 11.61 to 66.51, indicating substantial heterogeneity in provincial performance, while the Global Moran's I value of 0.290 indicates a tendency toward positive spatial autocorrelation. The LISA analysis further shows that this pattern is not distributed uniformly across Indonesia but occurs in specific local configurations, consisting of one High-High cluster in South Sulawesi, two Low-Low clusters in South Sumatra and Lampung, and spatial outliers classified as Low-High in West Sulawesi and High-Low in the Riau Islands. These configurations demonstrate that provinces with relatively high or low performance may have different spatial contexts. Therefore, Blue Economy sustainability cannot be adequately understood through comparisons of IBEI values alone but needs to consider the relationship between the internal conditions of a region and the characteristics of its surrounding areas.

This study contributes to the multidimensional assessment of the Blue Economy by applying an ESDA approach capable of identifying spatial concentrations and spatial outliers that are not captured through provincial rankings alone. The findings provide a basis for differentiating policies according to spatial characteristics, particularly by strengthening low-performing clusters, leveraging concentrations of strong performance, and enhancing interregional connectivity and learning. Nevertheless,

this study is limited by the use of Queen contiguity as the representation of spatial relationships and by the use of 2024 IBEI data, which does not allow changes in spatial patterns to be observed over a longer period. In addition, ESDA identifies spatial associations but does not explain the causal factors underlying these configurations. Future research should extend the analysis using panel data, alternative spatial weight matrices that incorporate maritime connectivity, and spatial econometric approaches to examine the factors underlying spatial clusters and the mechanisms of spatial spillover.

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