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CONSTRUCTION OF BLUE ECONOMY DEVELOPMENT INDEX AT THE PROVINCIAL LEVEL IN INDONESIA USING EXPLORATORY FACTOR ANALYSIS

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ABSTRACT

Indonesia, as an archipelagic country, holds marine resources of significant economic value in improving the welfare of its people. However, the community's use of marine resources does not pay attention to sustainability. The government then uses the Blue Economy concept to maximize the economic value obtained while maintaining the sustainability of the marine ecosystem through national policies and plans. In realizing blue economy development, enabler factors, such as technology and government governance, have an important role. This research aims to construct a Blue Economy Development Index (IPEB) at the provincial level in Indonesia in 2021, including enabler factors for blue economy development. The analytical method used is Exploratory Factor Analysis. The results show that the distribution of the minimum values for the indicators that make up the IPEB is found in the provinces of the Eastern Region of Indonesia. In contrast, the distribution of the maximum values of the indicators is found in the provinces of the Western Region of Indonesia. The province with the highest IPEB score is South Sulawesi, while the lowest is Central Sulawesi. The limitation of this study is the data derived from the Village Potential Survey (Potensi Desa) data collection, so several variables are not yet available in annual time. The results of this study are important in improving the ability to monitor implementation and assist in decision-making in increasing blue economic development, especially at the provincial level.

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1. INTRODUCTION

As the largest archipelagic country in the world, with 17,504 islands and a coastline of around 108,000 km, Indonesia has abundant marine resources that contribute significantly to the economy. One of the marine resources that contributes to the economy is the fisheries sector. Indonesia's fisheries sector has great potential, one of which can be indicated by the total marine catch in Indonesia, ranked second in the world in 2020 [1]. The total catch reached 6.49 million tons or eight percent of the total fish catch production in the world. In addition to the fisheries sector, Indonesia's marine economic potential is also found in the marine tourism sector. The potential of marine tourism is reflected in the 2021 data, where 11.29% of domestic tourist trips were to marine destinations. The percentage of tourist trips with marine tourism destinations is ranked third largest after culinary tourism and city and rural tourism destinations [2]. The marine tourism sector is attractive to domestic and foreign tourists, which is 29 percent of the total number of foreign tourists, with an estimated income of 3,097.5 million US dollars each year [3]. The potential of the marine economy is also evident in its biodiversity, which provides many benefits to the environment and surrounding communities, one of which is mangroves. The Indonesian mangrove area is an area with diverse biological resources, with an area of 3.31 million hectares. This area covers more than 20 percent of the total area of mangroves in the world [4]. Mangroves provide great benefits, such as being a habitat for aquatic animals that can be sold and consumed by coastal communities, absorbing carbon, and supporting people's livelihoods by being processed into products [5] [6].

With the numerous benefits obtained from the sea economically for people's lives, the use of the sea needs to pay attention to the aspect of conservation to keep its sustainability. The use of the sea in Indonesia is not balanced with its protection. One indicator of the unsustainability of marine use is the Ocean Health Index (OHI). Based on the OHI value in 2021, Indonesia is ranked 175 out of 221 countries with a score of 63. This score is far below the global average, which is 69. This shows that the sustainability of marine use activities is still low. One form of unsustainable marine use is in the marine tourism sector, namely the increase in the number of tourists in the marine tourism sector, which is not accompanied by adequate basic infrastructure and services, such as waste collection services, which ultimately pollute the sea [4]. Based on the results of the 2021 Village Potential Survey, there are 1,511 coastal villages with waste disposal sites in irrigation channels/rivers/seas and 1,087 coastal villages experiencing water pollution [7]. The unsustainability of marine utilization activities can also be reflected in the condition of marine biodiversity, namely mangroves in Indonesia. In 2019, around 1.82 million of the 3.31 million hectares of mangroves in Indonesia were degraded [4]. Mangrove degradation occurs due to the feeling of mangroves for shrimp pond areas. This felling causes the loss of mangrove benefits to protect against environmental pollution [8].

The existence of various marine environmental problems caused by unsustainable economic activities, further efforts are required in its preservation, namely through the Blue Economy. The United Nations Environment Program Finance Initiative defines the concept of a blue economy as a form of development that seeks to encourage economic growth and improve livelihoods in various sectors while ensuring the sustainable use of marine resources. Efforts to realize a sustainable marine economy through the blue economy in Indonesia are stated in national policies and plans, namely the Marine Policy in Presidential Regulation Number 16 of 2017 and the Indonesian Marine Policy Action Plan 2021-2025 [9]. However, the government's efforts to realize the development of the blue economy are stated in the policy and require benchmarks to monitor its implementation. One way that can be done to measure the development of the blue economy is to form a composite index of blue economy development. The index can simply compare each region to describe multidimensional phenomena including the blue economy [10].

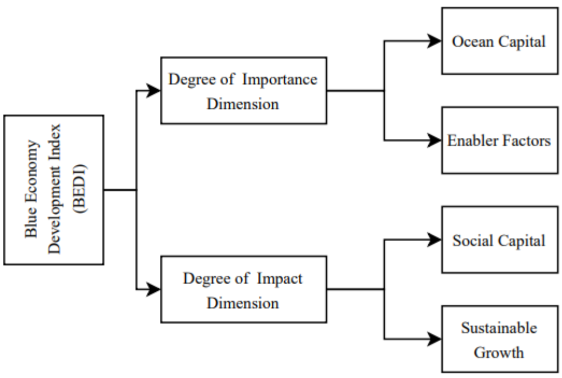

Figure 1. BEDI Conceptual Framework

The indexes that have been compiled to monitor the development of the blue economy are the Indonesia Blue Economy Index (IBEI) and the Blue Economy Development Index (BEDI). IBEI and BEDI are indexes that are compiled with the aim of being a monitoring tool for the ongoing development of the blue economy. The main difference between the two is that IBEI measures the blue economy at the provincial level using indicators in the environmental, economic, and social dimensions, while BEDI is an index that measures the blue economy at the international level and considers an enabler factor consisting of the use of technology and government governance (**Figure 1**) **[11]**.

Based on research conducted by Sarjito in 2023, technology is a fundamental part of managing marine resources **[12]**. With the use of technology, the government can modernize maritime infrastructure, improve transportation, and port operations, which can have an impact on the country's economic growth **[12]**. In addition to technology, government governance is needed in the development of the blue economy. Every stage in realizing the development of the blue economy, starting from planning, implementation, and control, must be carried out in an integrated manner and consider various parties, starting from the government level to the community and local communities **[11]**. This shows that good governance will increase the development of the blue economy **[11]**. This has also been proven through research conducted in Seychelles in 2022. Based on the results of this study, it shows that good governance is an enabler of the blue economy which can integrate the policy framework **[30]**.

Until now, Indonesia has not had an index that can evaluate the implementation of the blue economy at the provincial level, which includes the use of technology and government governance. With the importance of both of these in supporting the blue economy, this study aims to provide an overview of the indicators that make up the Blue Economy Development Index. This research also aims to compile the Blue Economy Development Index using the BEDI conceptual framework that can be applied at the provincial level in Indonesia. This is related to the realization of the Blue Economy through the Marine Policy Action Plan 2021-2025 implemented by ministries/institutions and local governments **[9]**. With this blue economy development index for the provincial level, it is hoped that each region can evaluate and plan blue economy development better and more focused.

2. RESEARCH METHODS

In constructing the Blue Economy Development Index, Exploratory Factor Analysis is used. The use of Exploratory Factor Analysis is based on measuring how well the indicators used can describe the phenomena being measured.

2.1 Exploratory Factor Analysis

The basic concept of exploratory factor analysis is to find the interrelationship of several variables so that a group of variables can be created that is smaller than the initial number of variables, called factors or latent variables **[13]**. If there is a random vector observed $\boldsymbol{X}' = (X_1, X_2, \dots, X_p)$ with mean $\boldsymbol{\mu}$ and matrix covariance $\boldsymbol{\Sigma}$**,** linearly dependent on several unobserved variables, namely $F_1, F_2, \dots, F_m$ which are referred to as common factors with a number of p sources of variation $\varepsilon_1, \varepsilon_2, \dots, \varepsilon_p$ which are referred to as error or specific factors **[14]**. The factor analysis equation model is as follows.

$$
\begin{aligned}
X_1 - \mu_1 &= \ell_{11}F_1 + \ell_{12}F_2 + \cdots + \ell_{1m}F_m + \varepsilon_1 \\
X_2 - \mu_2 &= \ell_{21}F_1 + \ell_{22}F_2 + \cdots + \ell_{2m}F_m + \varepsilon_2 \\
&\vdots \\
X_p - \mu_p &= \ell_{p1}F_1 + \ell_{p2}F_2 + \cdots + \ell_{pm}F_m + \varepsilon_p
\end{aligned}
\tag{1}
$$

Information:

X	:	random variable matrix
μ_i	:	the mean matrix of the i −th random variable
ℓ_{ij}	:	loading for the i −th variable on the j −th factor
F_j	:	the j−th matrix common factors
$\mathcal{E}_i$	:	the i −th specific factor matrix
L	:	loading factor matrix

m : number of factors formed
p : number of variables

Stages of Exploratory Factor Analysis

a. Forming a correlation matrix

To ensure that the data has sufficient correlation in the application of exploratory factor analysis. This variable correlation check can be done in the following way.

i. Bartlett test of sphericity

The steps in the Bartlett test are as follows [15].

1. Hypothesis

H_0: $\boldsymbol{R} = \boldsymbol{I}$ (correlation matrix is an identity matrix)

H_1: $\boldsymbol{R} \neq \boldsymbol{I}$ (correlation matrix is not an identity matrix)

2. Test Statistics

$$\chi^2_{obs} = -\left[(N-1) - \frac{(2p+5)}{6}\right] \ln |\boldsymbol{R}| \quad (2)$$

Information:

N : number of observations
$|\boldsymbol{R}|$: correlation matrix determinant
p : number of variables

3. Decision-making criteria

The Bartlett test will reject H_0 if the value $\chi^2_{obs} > \chi_{\alpha,p(p-1)/2}$ or p-$value < alpha$

4. Conclusion

If H_0 is rejected, it means the correlation matrix is not an identity matrix, but if H_0 is rejected, it means the correlation matrix is an identity matrix.

ii. Kaiser Meyer Olkin Statistic (KMO)

This statistic is used to determine whether the observation data studied is worthy of further analysis with factor analysis. The requirement for conducting factor analysis is that the data must have a KMO statistical value of at least 0.5 [15] [16].

iii. Measure of Sampling Adequacy (MSA)

MSA measures the degree of intercorrelation between variables in exploratory factor analysis. The range of this index is 0 to 1. All variables must have an MSA value of more than 0.50 to continue the analysis with factor analysis [17].

iv. Communality

Communality is the sum of the squares of the loading factors that indicate the proportion of the variable value that the common factor can explain. Thus, the greater the communality value, the greater the contribution of the common factor in explaining the latent construct [17].

b. Factor Extraction

The factor extraction method is used to estimate the factor matrix. The most frequently used extraction method is Principal Component Analysis (PCA). Determining the best number of factors in this process can be done in the following manner.

i. Criteria for eigenvalue, namely factors considered significant, are factors with characteristic roots greater than 1 [18].

ii. Percentage variance criteria, namely, paying attention to the cumulative percentage of variance extracted by the selected factors. The factor variance that can be used is a factor that has a cumulative variance value of 60 percent or more because the role of factors in explaining the variance of the original data is adequate [17].

c. Factor Rotation

The factor rotation process involves rotating the factor axis to a certain position so that the original variable is highly correlated with certain factors, making it easier to interpret [17].

d. Interpretation of factors

Factor interpretation is done after obtaining the number of factors formed. Interpretation or naming of factors is subjective and depends on the indicators that compose the factors and the theory [17].

2.2 Research Variable

A total of 29 initial indicators were used in this study. The unit of analysis of this study is 33 provinces in Indonesia in 2021, excluding DI Yogyakarta due to the absence of port activities, one of the priority sectors of the blue economy in Indonesia. The data used in this study are secondary data from several agencies with the following details.

Table 1. Data Sources for Indicators in Constructing the Blue Economy Development Index in Indonesia

Indicator	Data source
Length of coastline	Marine and Coastal Resources Statistics for 2022
Percentage of seaside villages with mangroves Marine capture fisheries production Pond aquaculture production Percentage of seaside villages with slum settlements Percentage of seaside villages with water pollution Percentage of seaside villages with waste disposal sites available	Marine and Coastal Resources Statistics for 2023
Sea Water Quality Index	Performance Report of the Directorate General of Pollution and Environmental Damage Control in 2021
Average area of marine conservation areas	Maritime Affairs and Fisheries in Figures from the Directorate General of Marine Spatial Management in 2021
Information and Communication Technology Development Index	ICT Development Index 2021
State Civil Servant Professionalism Index	State Civil Service Agency
Public Service Index	Decree of the Minister of State Apparatus Empowerment and Bureaucratic Reform of the Republic of Indonesia Number 86 of 2022 concerning Performance Evaluation Results of Public Service Delivery Units in Ministries, Institutions and Regional Governments in 2021
The ratio of fisheries instructors to fisheries actors The ratio of supervisory community groups to fisheries actors The ratio of special police monitoring coastal areas and small islands to fisheries actors	Marine and Coastal Resources Statistics for 2022
Average daily per capita protein consumption from fish Fishermen Exchange Value The ratio of marine fishing vessels to the number of marine fish catches The ratio of the number of fishing gear to the number of marine fish caught Percentage of seaside villages with cell phone towers Percentage of seaside villages with food and drink stalls Percentage of seaside villages with accommodation	Marine and Coastal Resources Statistics for 2023
GRDP at Constant Prices in the maritime transport subsector GRDP at Constant Prices in the fisheries subsector	Gross Regional Domestic Product of Provinces in Indonesia According to Business Fields 2018-2022
Percentage of domestic tourist trips by destination province with types of marine tourism activities	Statistics of Indonesian Tourists in 2021
Average flow of unloading goods at the port Average load flow of goods at the port	Maritime Transportation Statistics for 2021

Indicator	Data source
Average visits of domestic and foreign shipping vessels to ports	
Percentage of fisheries practitioners to the working population	Marine and Coastal Resources Statistics for 2023

3. RESULTS AND DISCUSSION

3.1 Descriptive Analysis

The following is a descriptive analysis of the indicators consisting of the maximum and minimum values for each indicator used in the research.

Table 2. Descriptive Indicators in Constructing the Blue Economy Development Index in Indonesia

Indicator	Minimum Value	Maximum Value
Degree of importance dimension		
Length of coastline (km)	261.80 (Jambi)	12,445.00 (Papua)
Percentage of seaside villages with mangroves (percent)	17.71 (Bengkulu)	92.50 (Central Kalimantan)
Sea Water Quality Index	70.34 (Papua)	87.55 (North Maluku)
Marine capture fisheries production (ton)	33,640.77 (North Kalimantan)	547,462.65 (Maluku)
Pond aquaculture production (ton)	127.00 (North Maluku)	1,358,764.00 (South Sulawesi)
Average area of marine conservation areas (ha/area)	976.00 (South Sumatera)	534,736.19 (Riau Islands)
Percentage of seaside villages with slum settlements (percent)	1.63 (Bengkulu)	58.82 (DKI Jakarta)
Percentage of seaside villages with water pollution (percent)	3.21 (East Nusa Tenggara)	41.18 (DKI Jakarta)
Percentage of seaside villages with waste disposal sites available (percent)	3.23 (South Sumatera)	100.00 (DKI Jakarta)
The ratio of fisheries instructors to fisheries actors (instructors per 1.000 fisheries actors)	0.26 (DKI Jakarta)	18.58 (Jambi)
The ratio of supervisory community groups to fisheries actors (supervisory community groups per 1.000 fisheries actors)	2.02 (Maluku)	17.42 (Central Kalimantan)
The ratio of special police monitoring coastal areas and small islands to fisheries actors (police per 1.000 fisheries actors)	0.02 (East Kalimantan)	0.99 (Jambi)
Public Service Index	2.81 (East Nusa Tenggara)	4.57 (West Java)
Information and Communication Technology Development Index	3.35 (Papua)	7.66 (DKI Jakarta)
State Civil Servant Professionalism Index	25.55 (Papua)	56.60 (South Sumatera)
Degree of impact dimension		
Percentage of seaside villages with cell phone towers (percent)	24.92 (Papua)	100.00 (DKI Jakarta)
Percentage of seaside villages with food and drink stalls (percent)	13.90 (Papua)	100.00 (Bali)
Percentage of seaside villages with accommodation (percent)	3.90 (Papua)	74.86 (Bali)
Average daily per capita protein consumption from fish (kkal/capita/day)	5.37 (Central Java)	19.09 (North Maluku)
Fishermen Exchange Value	92.55 (East Nusa Tenggara)	113.65 (Jambi)
The ratio of marine fishing vessels to the number of marine fish catches (marine fishing vessels per 1.000 ton of marine fish catches)	43.84 (DKI Jakarta)	348.35 (Bali)

Indicator	Minimum Value	Maximum Value
The ratio of the number of fishing gear to the number of marine fish caught (fishing gear per 1.000 ton of marine fish catches)	44.24 (DKI Jakarta)	370.29 (Central Sulawesi)
GRDP at Constant Prices in the maritime transport subsector (percent)	0.01 (West Java)	1.82 (South Kalimantan)
Percentage of domestic tourist trips by destination province with types of marine tourism activities (percent)	3.21 (Central Kalimantan)	45.01 (Bangka Belitung Islands)
Average flow of unloading goods at the port (ton/ port)	66,872.50 (West Sulawesi)	19,090,058.25 (Banten)
Average load flow of goods at the port (ton/port)	45,474.92 (West Sulawesi)	27,657,963.50 (South Kalimantan)
Average visits of domestic and foreign shipping vessels to port (visits of domestic and foreign shipping vessels/ports)	101.70 (Southeast Sulawesi)	14,369.25 (South Kalimantan)
GRDP at Constant Prices in the fisheries subsector (percent)	0.04 (DKI Jakarta)	12.90 (Maluku)
Percentage of fisheries practitioners to working population (percent)	0.32 (West Java)	25.00 (Maluku)

***Data source**: Processed data results*

Table 2 shows that minimum indicator values on the degree of importance dimension are mostly found in the Eastern Region of Indonesia, namely North Kalimantan, East Kalimantan, East Nusa Tenggara, Maluku, North Maluku, and Papua. The distribution of the maximum value of the indicator on the blue economy importance dimension is found in several provinces in the Western Region of Indonesia, namely Jambi, Riau Islands, and DKI Jakarta, and provinces in the Eastern Region of Indonesia, namely Maluku, North Maluku, Papua, South Sulawesi, and East Nusa Tenggara.

Table 2 shows that minimum indicator values on the degree of impact dimension are mostly found in the Eastern Region of Indonesia, namely East Nusa Tenggara, Papua, Central Sulawesi, West Sulawesi, Southeast Sulawesi, and North Kalimantan. The distribution of the maximum value of the blue economy impact dimension is found in several provinces on the island of Sumatra, namely Jambi and the Bangka Belitung Islands; South Kalimantan, Maluku, and Bali.

Based on the description above, the distribution of the minimum value of the indicator that constructs the Blue Economy Development Index is generally found in provinces in the Eastern Region of Indonesia. Conversely, the distribution of the maximum value of the indicator is found in provinces in the Western Region of Indonesia.

3.2 Preparation and Analysis of the Blue Economy Development Index at the Provincial Level in Indonesia

3.2.1 Normalization and Exploratory Factor Analysis

Min-max normalization is performed on the indicators, and then exploratory factor analysis is performed using the PCA method on each subdimension. In exploratory factor analysis, assumptions are checked on the indicators using the Bartlett test, KMO value, MSA, and communality. At this stage, indicators that do not meet the assumptions will be reduced. The indicators must meet the assumptions, namely, the Bartlett test results show that the correlation matrix is not an identity matrix, the KMO value must be at least 0.50, the MSA value must be more than 0.50, and the communality value must meet the minimum value limit, which is 0.5.

Table 3. Results of Exploratory Factor Analysis for Indicators on the Degree of Importance Dimension that Have Met the Assumptions

Sub-dimension	Indicator	Loading factor	MSA	Commu-nality	KMO	Bartlet Test	Eigen-values	Variance
Ocean Capital	Percentage of seaside villages with water pollution	0.910	0.511	0.849	0.515	0.000	1.822	45.553

Sub-dimension	Indicator	Loading factor	MSA	Commu-nality	KMO	Bartlet Test	Eigen-values	Variance
	Percentage of seaside villages with slum settlements	0.915	0.508	0.837				
	Marine capture fisheries production	0.766	0.547	0.644			1.217	75.984
	Pond aquaculture production	0.837	0.514	0.710				
Enabler Factor	The ratio of fisheries instructors to fisheries actors	0.933	0.570	0.871	0.597	0.000	2.291	45.812
	The ratio of supervisory community groups to fisheries actors	0.835	0.622	0.698				
	The ratio of special police monitoring coastal areas and small islands to fisheries actors	0.792	0.648	0.659				
	Information and Communication Technology Development Index	0.845	0.509	0.718			1.353	72.872
	State Civil Servant Professionalism Index	0.817	0.578	0.698				

***Data source**: Processed data results*

The exploratory factor analysis conducted on the ocean capital subdimension (Table 3) was conducted to produce indicators that met the assumptions. The results of the Bartlett test show four indicators that have met the Bartlett test with a p-value (0.000), which means with a significance level of 5 percent, it can be proven that there is a correlation between variables. The indicators also meet the KMO value of more than 0.5. This means that data are sufficient for exploratory factor analysis. In addition, the four indicators have met the MSA value and communality of more than 0.5, which means that the indicators have sufficient intercorrelation and have more than 50 percent of the indicator variance that can be explained by the general factor formed. The four indicators in the ocean capital subdimension form two sub-indicators (two factors) with eigenvalues greater than 1 and have a total variance of 75.984 percent. This means the factors' role in explaining the original data's total variance is sufficient.

The exploratory factor analysis was also conducted on the enabler factor subdimension (Table 3). In this subdimension, five indicators were produced that met the assumptions of the Bartlett test with a p-value (0.000), had a KMO value of 0.597, and MSA and communality in the five indicators were more than 0.5. The five indicators in the enabler factor subdimension form two sub-indicators (two factors) with eigenvalues greater than 1 and have a total variance that can be explained as 72.872 percent. This means the factors' role in defining the original data's total variance is sufficient.

Table 4. Results of Exploratory Factor Analysis for Indicators on the Degree of Impact Dimension that Have Met the Assumptions

Sub-dimension	Indicator	Loading factor	MSA	Commu-nality	KMO	Bartlett Test	Eigen-values	Variance
Social Capital	Percentage of seaside villages with cell phone towers	0.937	0.577	0.877	0.581	0.000	2.597	51.945
	Percentage of seaside villages with food and drink stalls	0.828	0.662	0.686				
	Percentage of seaside villages with accommodation	0.807	0.692	0.747				

Sub-dimension	Indicator	Loading factor	MSA	Commu-nality	KMO	Bartlett Test	Eigen-values	Variance
	The ratio of marine fishing vessels to the number of marine fish catches	0.991	0.527	0.989			1.688	85.708
	The ratio of the number of fishing gear to the number of marine fish caught	0.987	0.524	0.795				
Sustainable Growth	GRDP at Constant Prices in the maritime transport subsector	0.756	0.569	0.795	0.635	0.000	2.791	46.523
	Average flow of unloading goods at the port	0.660	0.628	0.631				
	Average load flow of goods at the port	0.891	0.674	0.820				
	Average visits of domestic and foreign shipping vessels to port	0.891	0.715	0.811				
	GRDP at Constant Prices in the fisheries subsector	0.881	0.586	0.795			1.790	76.352
	Percentage of fisheries practitioners to working population	0.881	0.579	0.777				

***Data source**: Processed data results*

The exploratory factor analysis on the social capital subdimension (**Table 4**) was conducted to produce indicators that met the assumptions. The results of the Bartlett test show five indicators that have met the Bartlett test with a p-value (0.000), which means with a significance level of 5 percent, it can be proven that there is a correlation between variables. The indicators also meet the KMO value of more than 0.5. This means that data are sufficient for exploratory factor analysis. In addition, the five indicators have met the MSA value and communality of more than 0.5, which means that the indicators have sufficient intercorrelation and have more than 50 percent of the indicator variance that can be explained by the general factor formed. The five indicators in the social capital subdimension form two sub-indicators (two factors) with eigenvalues greater than 1 and have a total variance that can be explained as 85.708 percent. This means the factors' role in explaining the original data's total variance is sufficient.

The exploratory factor analysis was also conducted on the sustainable subdimension (**Table 4**). In this subdimension, six indicators were produced that met the assumptions of the Bartlett test with a p-value (0.000), had a KMO value of 0.635, and MSA and communality in the six indicators were more than 0.5. The six indicators in the enabler factor subdimension form two sub-indicators (two factors) with eigenvalues greater than 1 and have a total variance that can be explained as 76.352 percent. This means that the role of factors in explaining the total variance of the original data is sufficient.

3.2.2 Weighting

The weighting of the indicators is done using unequal weighting, and the weighting of the dimensions uses equal weighting, which refers to the research **[11]**. The unequal weighting for indicators uses two types of weighting, namely as follows.

a. Unequal weighting 1: weight for each indicator in one dimension **[19] [20]**.

$$Weight_i = \frac{LF_i}{\sum LF} \; x \; \% \; variance_i \tag{3}$$

b. Unequal weighting 2: weight for each indicator in one dimension **[21]**.

$$Weight_i = \frac{(LF_i)^2}{variance_i} \tag{4}$$

Each indicator weight is then standardized using the formula:

$$Standard\ weight_i = \frac{Weight_i}{\sum Weight} \tag{5}$$

Information:

$Weight_i$: Weight value of each indicator $\sum Weight$: Total of dimension weight

% of variance: percent of variance LF: loading factor

3.2.3 Uncertainty Analysis

Uncertainty analysis is used to test the robustness and stability of the index by determining the best scenario (stable and reliable) from several scenarios. In this study, the scenarios are compiled using several indicator weighting and dimension aggregation methods. The uncertainty analysis is based on the Spearman correlation of the ranking results between scenarios and the average absolute change in rankings between scenarios in each province [22] [23]. This study uses four scenarios listed in Table 5.

Table 5. Scenarios used in the Uncertainty Analysis Process

Scenario	Indicator normalization	Indicator Weighing Method	Indicator Aggregation Method	Dimensional Weighing Method	Dimension Aggregation Method
1	Min-Max	unequal 1	linear	equal	linear
2	Min-Max	unequal 1	linear	equal	geometric
3	Min-Max	unequal 2	linear	equal	linear
4	Min-Max	unequal 2	linear	equal	geometric

The scenario that maximizes the value of the rank correlation coefficient is the most stable and reliable scenario [22] [23]. Based on Table 6, it shows that the fourth scenario has the highest Spearman correlation.

Table 6. Spearman Correlation Values Between Scenarios in the Uncertainty Analysis Process

Scenario	1	2	3	4	Average
1	1.000	0.977	0.972	0.976	0.981
2	0.977	1.000	0.942	0.966	0.971
3	0.972	0.942	1.000	0.991	0.976
4	0.976	0.966	0.991	1.000	0.983

The scenario that can minimize the absolute difference from other scenarios is the most stable scenario [22] [23]. Based on Table 7, the scenario with the smallest average absolute difference is scenario 4. Based on the Spearman correlation value and the average absolute difference, it can be concluded that the best scenario for the uncertainty analysis is scenario 4.

Table 7. Average Value of Absolute Change in Ranking Between Scenarios

Scenario	1	2	3	4	Average
1	0.000	1.091	1.515	1.455	1.015
2	1.091	0.000	1.697	1.636	1.106
3	1.515	1.697	0.000	0.848	1.015
4	1.455	1.636	0.848	0.000	0.985

3.2.4 Relationship of the Blue Economy Development Index with Other Indicators

In constructing a composite index, index validation is needed to evaluate the index's feasibility using other indicators that also explain similar phenomena. The Blue Economy Development Index is correlated with the Inclusive Economic Development Index (IPEI) using Pearson correlation.

Based on the data processing results, the correlation value between IPEB and IPEI is 0.3015 with a positive direction. This indicates that an increase will follow an increase in the Blue Economy Development Index in the Inclusive Economy Development Index. Indirectly, this correlation analysis proves the validity of the Blue Economy Development Index in explaining the phenomenon to be measured.

3.2.5 Decomposition of the Blue Economy Development Index

Based on **Figure 2**, it can be seen that the highest value of the degree of importance dimension is in South Sulawesi, which is 0.285. The high value of the degree of importance dimension in South Sulawesi is due to the high production of pond cultivation and marine fish catches. In 2021, pond cultivation production in South Sulawesi was the highest in Indonesia. This also causes the value of the ocean capital subdimension of South Sulawesi to be the highest at 0.369.

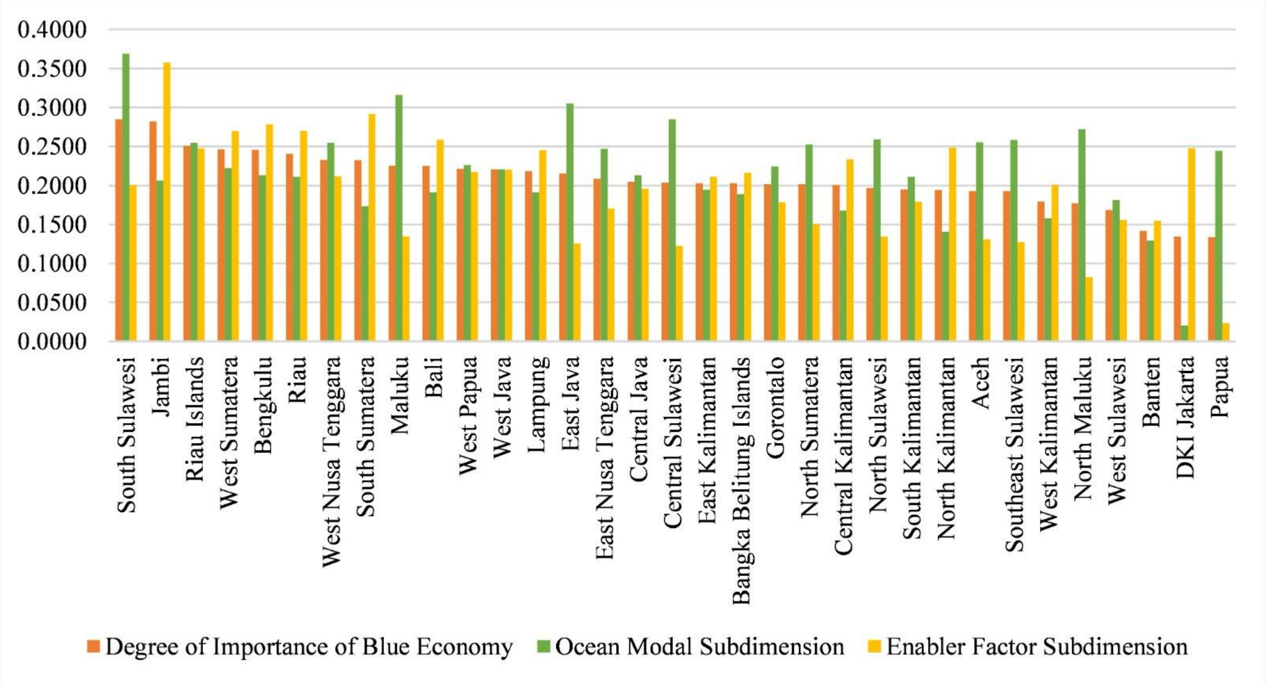

Figure 2. The Value of the Degree of Importance Dimension and Its Constituent Subdimensions by Province

The lowest dimension value of the degree of importance is DKI Jakarta and Papua, which is 0.134. The low value of this dimension in DKI Jakarta is due to the low quality of the coastal environment. The low value of this dimension in DKI Jakarta is due to the low quality of the coastal environment. DKI Jakarta has coastal villages with the highest percentage of water pollution and the presence of slums compared to other provinces. This is due to high population density and growth, and people living on the coast of DKI Jakarta generally have low economic conditions **[24]**. Meanwhile, Papua has a low value of the degree of importance dimension due to the low enabler factor subdimension (0.023). One of the indicators of the low enabler factor subdimension is the ICT Development Index in Papua Province, which is 3.35.

Based on **Figure 3**, the highest value of the degree of impact dimension was obtained by DKI Jakarta at 0.265. DKI Jakarta has the highest social capital subdimension value (0.432). This is due to the existence of good fisheries infrastructure. DKI Jakarta fishermen have a high capacity of ships and marine fishing equipment in DKI Jakarta, which is 44 ships per 1,000 tons of marine fish catch. The large ship capacity is caused by the large number of fishermen in DKI Jakarta being large-scale fishermen (characterized by the large number of ship sizes over 30 gross tonnage). Large-scale fishermen have operating areas in more expansive waters and far from the coast equipped with large ships and modern equipment to catch fish in large quantities **[25]**. In addition, DKI Jakarta has basic infrastructure in coastal villages to increase tourist attraction, such as the percentage of coastal villages with telephone towers and lodgings of 100 percent and 41.176 percent, respectively.

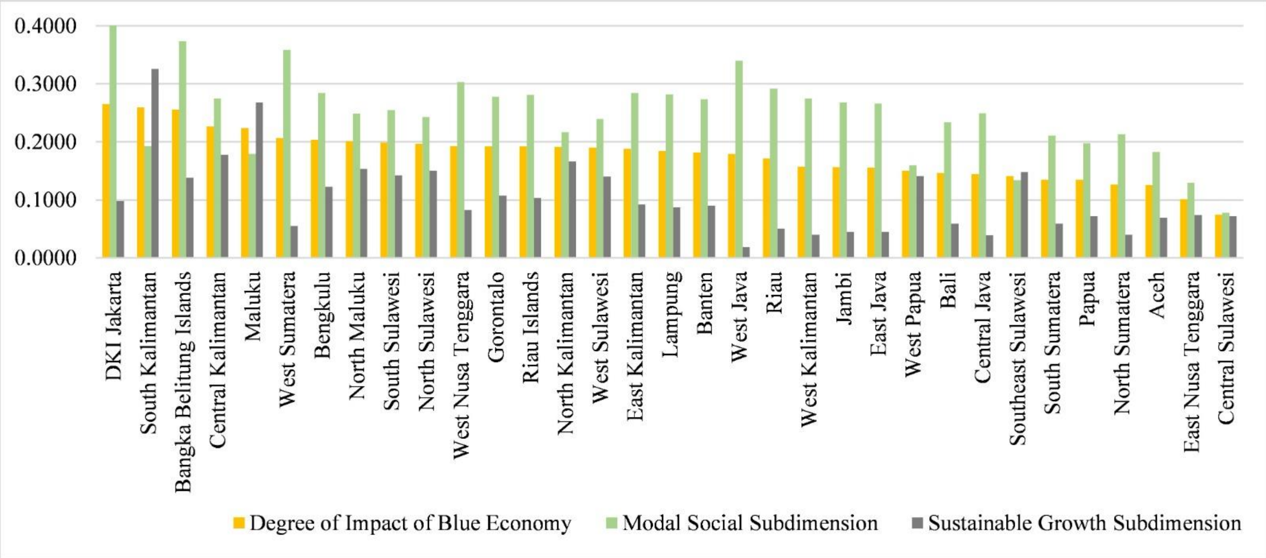

Figure 3. The Value of The Degree of Impact Degree Dimension and Its Constituent Subdimensions by Province

The lowest value of the blue economy impact dimension is in Central Sulawesi, which has a value of 0.071. This is due to the low supporting facilities for marine fishing (part of the social capital subdimension), as evidenced by the low capacity of Central Sulawesi's marine fishing gear, which is 348 gears per 1,000 tons of marine fish catch. Central Sulawesi fishermen are dominated by small-scale fishermen with more traditional boats and fishing gear. Small-scale fishermen generally go to sea to catch fish for consumption [26]. In addition, the contribution of the GRDP at Constant Price to the sea transportation sector of Central Sulawesi is only 0.10 percent.

3.2.6 Blue Economy Development Index at the Provincial level in Indonesia

The Blue Economy Development Index ranges from 0 to 1. A higher index value or one closer to 1 indicates a higher level of blue economy development in the region, and vice versa.

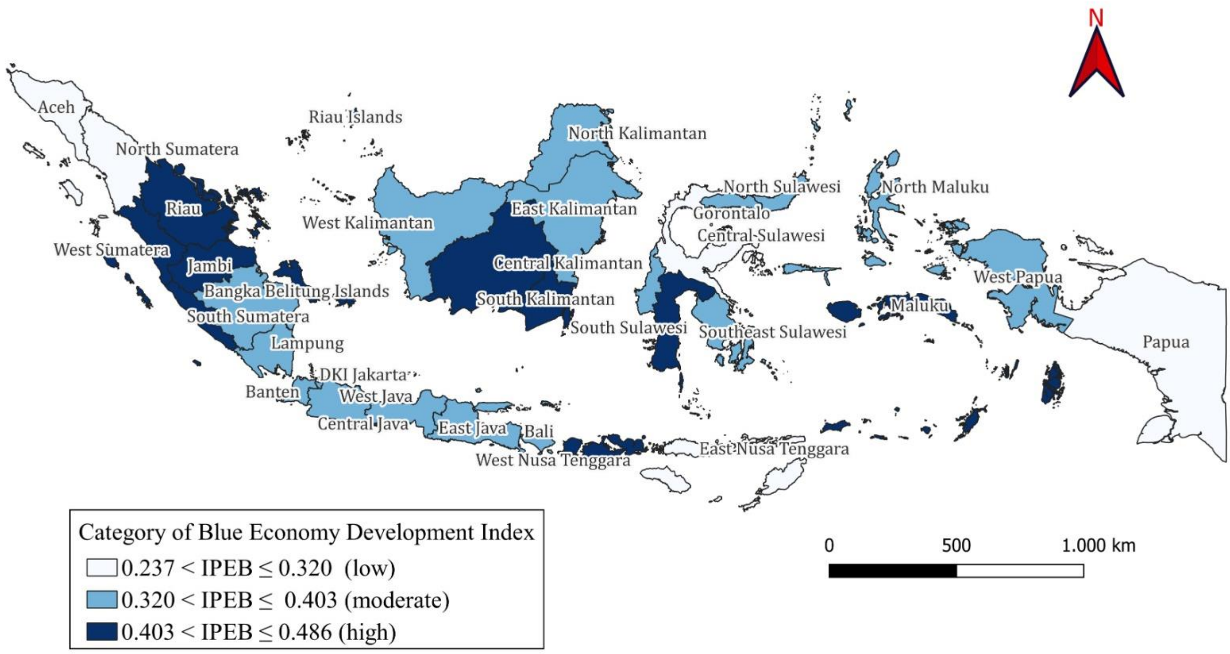

Figure 4. Blue Economy Development Index 2021 Results Map

Based on **Figure 4**, it can be seen that the Blue Economy Development Index is in the range of 0.2 to 0.4. The method used in grouping provinces is an equal interval. Based on the grouping results, there are 6 provinces with a low category, 15 with a medium category, and 12 with a high category. **Figure 4**, shows that provinces with a medium and high IPEB category are generally located in some provinces of Kalimantan and Java.

The province with the highest Blue Economy Development Index value is South Sulawesi, which is 0.476, while the lowest value is Central Sulawesi, with a value of 0.247. South Sulawesi has a high index, one of which is due to high pond aquaculture production. In 2021, the total pond aquaculture production was 1,350,764 tons. This total production is the highest pond aquaculture production in Indonesia. In addition, marine fish catch production in South Sulawesi is also relatively high, at 376,122.89 tons. The high pond aquaculture and marine catch production contribute to the large GRDP of the fisheries sector and the employment rate in the fisheries sector. South Sulawesi's fisheries GRDP in 2021 was 7.99 percent, with an employment rate in the fisheries sector of 10.24 percent.

Central Sulawesi has the lowest Blue Economy Development Index compared to other provinces. Based on the value of each dimension, the dimension of the degree of impact is only 0.075 but has a fairly high value of the dimension of the degree of importance, which is 0.204. This means Central Sulawesi has large marine resources and supporters of blue economy development, but they have not been maximized, so they have less social and economic impact. This is related to the production of Central Sulawesi aquaculture, which is ranked second highest after South Sulawesi (605,035 tons) in 2021. However, high aquaculture production does not play a significant role in the economy of Central Sulawesi. This can be seen from the GRDP contribution to Central Sulawesi's fisheries sector, which is 3.90 percent. The low contribution of aquaculture to GRDP is due to low productivity [27]. The pond production process is not yet efficient because it uses traditional technology [27]. This is proven by the low ICT Development Index of 3.41. Technology is important in economic development to increase the efficiency of activities [11], [28]. In addition, the efficiency of fisheries extension activities in Central Sulawesi is still low, with only 1 to 2 fisheries instructors for 1,000 fisheries actors. Extension activities can help Central Sulawesi fisheries actors increase the latest pond production knowledge [29]. Another cause of the low Blue Economy Development Index in Central Sulawesi is the still low contribution of the sea transportation sector to the economy, where the percentage of GRDP in the sea transportation sub-sector is only 0.11 percent.

4. CONCLUSIONS

Based on the results and discussion in this study, it can be concluded:

a. The distribution of IPEB indicator values shows that minimum values are generally found in the Eastern Region of Indonesia, such as East Nusa Tenggara (Public Service Index and Fishermen's Exchange Rate), Papua (Sea Water Quality Index, ICT Development Index, State Civil Apparatus Professionalism Index, coastal villages with the presence of food and beverage stalls and lodging), and West Sulawesi (average flow of loading and unloading goods at the port). The distribution of the maximum indicator values is found in provinces in the Western Region of Indonesia, such as DKI Jakarta (ICT Development Index and the percentage of coastal villages with garbage dumps), Jambi (ratio of fisheries extension workers to fisheries actors, ratio of special police for coastal and small island surveillance to fisheries actors, and fishermen's exchange rate), and South Kalimantan (GRDP of the sea transportation sub-sector, average flow of goods loading at the port, and average visits by domestic and foreign shipping vessels at the port).

b. The Blue Economy Development Index is composed of two dimensions with a total of 20 indicators, namely the dimension of the degree of blue economy importance and the dimension of the degree of blue economy impact. The results of the uncertainty test show that scenario 4 with the min-max normalization method, unequal weighting 2 on indicators, linear indicator aggregation, equal weighting on dimensions, and geometric dimension aggregation. The Blue Economy Development Index in level provinces in Indonesia using equal intervals is mainly in the moderate category. South Sulawesi Province obtained Indonesia's highest Blue Economy Development Index in 2021; the lowest was in Central Sulawesi Province.

c. Lastly, this blue economy development index, structured into detailed subdimensions and available at the provincial level, is expected to help local governments carry out targeted and focused economic development planning. However, this study has limitations, namely data derived from the Village Potential Survey (Potensi Desa), so several variables are not available annually. The identified limitations can guide researchers on what has been explored or needs to be explored in the future.

REFERENCES

[1] FAO, *The State of World Fisheries and Aquaculture 2022*, Rome: FAO, 2022.
[2] BPS, *Domestic Tourism Statistics 2021*. Jakarta: Badan Pusat Statistik, 2021.
[3] M. Spalding, L. Burke, S. A.Wood, J. Ashpole, J. Hutchison, and P. zu Ermgassen, “Mapping the global value and distribution of coral reef tourism,” *Marine Policy*, vol. 82, pp.104–113, 2017.
[4] Bank Dunia, *Laut untuk Kesejahteraan: Reformasi untuk Ekonomi Biru di Indonesia*. Washington D.C.: Bank Dunia, 2021.
[5] BPS, *Statistik Sumber Daya Laut dan Pesisir 2022*, Jakarta: Badan Pusat Statistik, 2022
[6] D. S. Alnursa, “Manfaat Hutan Mangrove dalam Kehidupan Masyarakat di Kelurahan Guraping Kecamatan Oba Kabupaten Tidore Kepulauan Darling Surya Alnursa STKIP Kie Raha Ternate”, *Jurnal Ilmiah Wahana Pendidikan*, vol. 9,no. 5, pp.116–124, March 2023.
[7] BPS, *Statistik Sumber Daya Laut dan Pesisir 2023*, Jakarta: Badan Pusat Statistik, 2023
[8] D. Evitasar and Sukendah, “Dampak Degradasi dan Strategi Hutan Mangrove dalam Menjaga Ekosistem,” *Jurnal Ilmu Pertanian Dan Perhutanan*, vol. 5, no. 1,pp. 39–46, January 2023.
[9] Bappenas, *Indonesia Blue Economy Roadmap*, Jakarta: Bappenas, 2022.
[10] R. Faradis and U. N. Afifah, “Infrastructure Development Composite Index of Provinces in Indonesia,” *Jurnal Ekonomi Dan Pembangunan Indonesia*, vol. 20, pp. 33–55. October 2020.
[11] L. Adrianto, B. O. Nababan, and N. Eishner, *Blue Economy Development Indext (BEDI): A Preliminary Study with the Case Studies of 10 Archipelagic Island States*, Bogor: UNDP, 2020.
[12] A. Sarjito, "The Role of Technology in Indonesia's Maritime Development," *Jurnal Lemhannas RI*, vol. 11, no. 4, pp. 219–236, 2023.
[13] A. Asra, A. P. Utomo, M. Asikin, and N. H. Pusponegoro, *Analisis Multivariabel Suatu Pengantar*, Bogor: In Media, 2022.
[14] R. A. Johnson and W. Dean, *Applied Multivariate Statistical Analysis: Fifth Edition*, New Jersey: Prentice Hall International Inc, 2002.
[15] S. Nugroho, *Statistika Mutivariat Terapan*, Bengkulu: UNIB Press, 2008.
[16] R. Candrawati, J. Raja, and H. Sitorus, "Construction of Maternal Wellbeing Index in Indonesia: Analysis of Susenas Data in 2021", *Seminar Nasional Official Statistics 2023*, pp. 879–888, 2023.
[17] J. F. Hair, Jr, W. C. Black, B. J. Babin, and R. E. Anderson, "Multivariate Data Analysis, Eighth Edition," Andover: Pearson Education, Inc., 2019.
[18] S. Pangestu, and J. R. H. Sitorus, "The Construction of Sanitation Index of Provinces in Indonesia: Analysis of Susenas MKP Data in 2019 ", *Seminar Nasional Official Statistics 2021*, pp. 363–372, 2021.
[19] S. Pertiwi and H. Usman, "Human Relationship Index Arrangement in 2018 Based on Concept of Tri Hita Karana", *Seminar Nasional Official Statistics 2019*, pp.902–911, 2019.
[20] S. D. Lestari and A. Mun’im, "Measuring Indonesian Creative Economy Performance," *Kajian*, vol. 27, no. 2, pp. 209–221, December 2022.
[21] M. Dharmaratne and M. Attygalle, "Improving the Statistical Capacity Index: A Statistical Approach," *American Journal of Applied Mathematics and Statistics*, vol. 6, no. 3, pp. 80–95, 2018.
[22] L. Salvati and M. Carlucci, "A composite index of sustainable development at the local scale: Italy as a case study," *Ecological Indicators*, vol. 43, pp. 162–171, 2014.
[23] S. Asnuri and R. Yuliana, "Constructing Sustainability Index of Rice Availability System in Indonesia at 2021", *Seminar Nasional Official Statistics 2023*, pp.675–686, 2023.
[24] H. Maharani and N. Nurlaili, "Fisherman Settlement Management in Urban Region of Northern-Coast of Jakarta," *Buletin Ilmiah Marina Sosial Ekonomi Kelautan Dan Perikanan*, vol. 4, no. 1, pp. 7-13, June 2018.
[25] U. Haris, "Ironi Kondisi Nelayan di Kota Makassar (Analisis Tipologi Nelayan Berdasarkan UU Nomor 45 Tahun 2009," *Jurnal Administrasi Karya Dharma*, vol. 2, no. 45, pp. 1–8, March 2023.
[26] A. Halim, B. Wiryawan, N. R. Loneragan, A. Hordyk, M. F. A. Sondita, A. T. White, S. Koeshendrajana, T. Ruchimat, R. S. Pomeroy, and C. Yuni, "Merumuskan Definisi Perikanan Skala-Kecil untuk Mendukung Pengelolaan Perikanan Tangkap di Indonesia," *Journal of Fisheries and Marine Research*, vol. 4, no. 2, pp. 239–262, 2020.
[27] M. Yasin, F. Baslum, and S. Lahati, " Economic Analysis Of Income And Feasibility Of Shrimp Cultivation Business In Parigi Moutong Regency, Central Sulawesi Province," *Jurnal TROFISH*, vol. 1, no. 1, pp. 36–43, February 2022.
[28] D. Libraningrum and D. B. Santoso, "Analisis Dampak Pembangunan Teknologi Informasi Dan Komunikasi Terhadap Pertumbuhan Ekonomi Indonesia," *Journal of Development Economic and Social Studies*, vol. 2, no. 3, pp. 600–607, July 2023.
[29] Safrida, T. Makmur, and H. Fachri, "Peran Penyuluh Perikanan dalam Pengembangan Sektor Perikanan di Kabupaten Aceh Utara," *Jurnal Agrisep Unsyiah*, vol. 16, no. 2, pp. 17–27, 2015.
[30] Benzaken, D., Voyer, M., Pouponneau, A., and Hanich, Q. "Good governance for sustainable blue economy in small islands: Lessons learned from the Seychelles experience". *Frontiers in Political Science*, vol. 4, pp.01–23, 2022.