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Priority Analysis of Regional Feeder Port Development in Nusa Tenggara Barat Province Using Entropy Weighting Method and Topsis

Ulul Albab M Khairi*, Ida Ayu Oka Suwati Sideman, Made Mahendra
Universitas Mataram, Indonesia
Email: albab123hairi@gmail.com*, suwatisideman@unram.ac.id, mahendramade@unram.ac.id

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ABSTRACT
Nusa Tenggara Barat Province, as an archipelagic region, has a high dependency on maritime transportation, making regional feeder ports play a crucial role in supporting regional connectivity. Limitations in development resources demand an objective determination of port development priorities. This research aims to identify determining aspects, determine the weight of sub-aspects using the Entropy Weighting Method, and arrange development priorities with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. The research utilized a quantitative approach with multi-criteria decision-making methods. Data consists of primary data in the form of sub-aspect assessments and secondary data from documents and field observations. The research objects include Pemenang, Carik, Sape, Waworada, and Calabai Ports. The analysis was conducted using the Entropy method for objective weighting and TOPSIS for ranking alternatives based on their proximity to the ideal solution. The results show that the Entropy–TOPSIS method is capable of producing systematic weighting and development priorities. Ports with balanced performance in technical, accessibility, economic, environmental, and spatial planning aspects have higher priority. This research can serve as a basis for port development planning in Nusa Tenggara Barat Province.

INTRODUCTION

Nusa Tenggara Barat (NTB) Province is an archipelagic region characterized by a geographical distribution of islands and activity centers scattered across several locations (Djatmiko et al., 2025; Luthfin et al., 2022; Purnama & Çoban, 2024; Rahayu, 2023; Steele et al., 2026). These conditions make the role of maritime transportation highly strategic in supporting inter-regional connectivity, both within the provincial scope and in connectivity with other regions. Ports in NTB are expected to support the smooth movement of goods and passengers, as well as strengthen the links between production and consumption areas (Ndoda et al., 2025).

In the national port system, ports are categorized into several levels based on their function and service coverage (Deng et al., 2023; Kapalidis et al., 2022; Mthembu & Chasomeris, 2023a, 2023b; N. Wang et al., 2023; Zhang et al., 2025). One level of port that plays a vital role in supporting regional connectivity is the regional feeder port. Regional feeder ports are part of the national port system that functions as a link between local service areas and higher-level ports; thus, their existence is crucial in maintaining the overall efficiency of the port network system (Minister of Transportation Decree Number KP 432 of 2017).

In NTB Province, several ports are designated as regional feeder hierarchy ports based on Minister of Transportation Decree Number KP 432 of 2017 concerning the National Port Master Plan (RIPN), including Sape, Pemenang, Waworada, Calabai, and Carik Ports. Nevertheless, each of these ports has different characteristics, conditions, and levels of readiness. These differences result in varying needs and urgency for the development of each port, necessitating the proper determination of development priorities (Almeida & Okon, 2024; Mohsendokht et al., 2026; K. Wang et al., 2024).

On the other hand, limitations in development resources, particularly from a budgetary standpoint, mean that port development cannot be carried out simultaneously (Mrak et al., 2022; Qu et al., 2023; Shirov, 2023). Therefore, a planning approach is required that can provide a rational and objective basis for consideration in determining which ports need to be prioritized for development first.

Determining the development priorities of regional feeder ports is a multi-criteria decision-making problem involving various technical, operational, economic, and regional connectivity aspects. This complexity demands the use of analytical methods that are not only capable of accommodating many criteria simultaneously but also capable of minimizing subjectivity in the assessment process. Therefore, the selection of the analytical method in this study was conducted by considering data characteristics, research objectives, and the limitations of other methods commonly used in decision-making studies.

Several Multi-Criteria Decision Making (MCDM) methods, such as the Analytical Hierarchy Process (AHP), Simple Additive Weighting (SAW), or outranking methods like PROMETHEE, can actually be used in priority analysis. However, the AHP method has a major weakness in the form of high subjectivity because weighting depends heavily on the perception of respondents or experts through pairwise comparisons. Furthermore, the more sub-aspects analyzed, the greater the computational complexity and the potential for comparison matrix inconsistency. The SAW method is known for being simple and easy to apply but has limitations in describing the proximity of alternatives to ideal conditions because it only uses the concept of weighted summation. Meanwhile, the PROMETHEE method requires the determination of relatively complex preference functions as well as additional parameters that can increase uncertainty if not supported by adequate data.

Based on these considerations, this study chose the Entropy Weighting Method as the approach for determining sub-aspect weights. The Entropy method has advantages because it is objective and based on the variation of information contained in the data. Sub-aspects that have a higher level of value variation are considered to have a larger information contribution to the decision-making process. Thus, the use of Entropy is able to reduce the subjective bias that often arises in expert assessment-based methods and provides a stronger quantitative basis for weighting.

Furthermore, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method is used in the alternative port ranking process. TOPSIS was chosen because it can evaluate alternatives based on the concepts of positive ideal solutions and negative ideal solutions, so that each alternative is assessed not only by its criterion values but also by its distance from the best and worst conditions simultaneously. This approach is considered relevant for the context of port development because priority is not determined solely by high performance in one aspect, but rather by overall performance balance.

The use of a combination of the Entropy Weighting Method and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) has been widely applied in multi-criteria decision-making research because it is capable of producing objective weighting as well as systematic alternative ranking. The entropy method is known as an objective approach that determines weights based on the level of data variation to minimize assessment subjectivity, while TOPSIS is used to determine the best alternative based on the proximity to the positive ideal solution and the distance from the negative ideal solution.

Several previous studies show that the combination of these two methods is effective for use in various fields of planning and evaluation. Pangesti, Ardianto, and Pungkasanti (2024) used the Entropy and TOPSIS methods to determine regional development priorities in Central Java and produced systematic regional priority recommendations based on socio-economic indicators. The results of that study showed that the entropy method is capable of producing objective weights so that the TOPSIS ranking process becomes more rational and data-driven. Another study by Zhang (2023) on urban logistics systems also showed that the entropy method can capture the dispersion level of indicator data more accurately than subjective weighting, while TOPSIS is capable of producing clear priority orders through the ideal solution approach. The combination of these two methods is considered effective in handling multi-criteria decision problems involving many indicators. In the field of sustainable development, Zhao et al. (2022) also applied entropy and TOPSIS to evaluate the development of archipelagic regions and found that this hybrid approach is capable of combining quantitative indicator analysis with a transparent ranking process. This indicates that the entropy–TOPSIS method has high flexibility for application in various contexts of infrastructure and regional planning.

Despite the growing application of Entropy–TOPSIS in various planning contexts, there remains a notable research gap in its application to regional feeder port development prioritization, particularly in the Indonesian archipelagic context. Previous studies have predominantly focused on seaport competitiveness evaluation (Wang, Mo, & Ma, 2023) or urban logistics systems (Zhang, 2023), while limited attention has been given to regional feeder ports that play a critical role in connecting local service areas to higher-level ports. Furthermore, most prior research on port development prioritization in Indonesia has relied on subjective weighting methods such as AHP (Martono, 2024), which are susceptible to expert bias and inconsistency, without incorporating objective data-driven approaches. Additionally, studies that comprehensively integrate spatial planning aspects, accessibility, economic potential, environmental conditions, and technical readiness in a single decision-making framework for regional feeder ports are still scarce. This gap is particularly relevant for archipelagic regions like Nusa Tenggara Barat, where limited development resources demand objective and transparent priority-setting mechanisms.

The novelty of this research lies in the integration of the Entropy Weighting Method and TOPSIS for objective port development prioritization in the context of Indonesian regional feeder ports. Unlike previous studies that relied on subjective expert judgments, this research employs an entirely data-driven weighting approach based on the variation of information contained in the assessment data, thereby minimizing subjectivity and enhancing the objectivity of the decision-making process. The study also contributes by incorporating five comprehensive assessment aspects spatial and regional policy, accessibility, economy and regional potential, environment, and technical and facility conditions into a unified analytical framework, providing a holistic evaluation of port readiness and development urgency. Furthermore, this research offers a practical and replicable methodology for port planners and policymakers in other archipelagic regions facing similar resource allocation challenges.

Based on the background, this study aims to identify the determining aspects and sub-aspects in the priority analysis of regional feeder port development in Nusa Tenggara Barat Province, determine the objective weights of each sub-aspect using the Entropy Weighting Method, and arrange the development priority order of regional feeder ports using the TOPSIS method, with the research objects including five regional feeder ports in NTB Province: Sape, Waworada, Calabai, Pemenang, and Carik Ports. The benefits of this research are both theoretical and practical; theoretically, this study contributes to the literature on multi-criteria decision-making in infrastructure planning, particularly in the context of port development in archipelagic regions, by demonstrating the application of an objective weighting method combined with a systematic ranking approach, while the findings also enrich the understanding of how various assessment aspects spatial planning, accessibility, economy, environment, and technical readiness interact in determining port development priorities; practically, the results of this study are expected to provide an evidence-based reference for the Government of Nusa Tenggara Barat Province and the Ministry of Transportation in allocating development resources more effectively and transparently, with the priority map generated from this research serving as a strategic guide for phased port development planning to ensure that limited budgets are directed to ports with the highest readiness and development potential, and the methodology employed can be replicated by other regions facing similar challenges in prioritizing infrastructure development under resource constraints.

METHOD

This research employed a quantitative approach with a multi-criteria decision-making (MCDM) framework. The quantitative approach was chosen because this study aims to measure, analyze, and prioritize port development alternatives based on numerical data and objective calculations, rather than exploring subjective perceptions or experiences. The research design is evaluative and prescriptive, as it seeks to evaluate the current conditions of regional feeder ports and prescribe development priorities based on systematic and data-driven analysis. This research utilizes two types of data, primary and secondary, to obtain a comprehensive overview of the existing port conditions and to support the priority analysis for regional feeder port development in Nusa Tenggara Barat Province. Primary data were obtained through direct assessment of research sub-aspects based on technical parameters, supporting data, policies, and field observation results, using a standardized numerical scale which was subsequently processed using the Entropy Weighting and TOPSIS methods. Meanwhile, secondary data were used as supporting information sourced from policy and regulatory documents, related agency data, official statistical publications, technical reports, and scientific literature. Data collection was carried out through documentation studies, literature studies, and field observations to obtain accurate and relevant information. Additionally, the acquired secondary data were processed through adjustment, standardization, and conversion into an assessment scale to be used optimally in the analysis.

RESULTS AND DISCUSSION

Preparation and Compilation of Research Data

The initial stage in this research is the compilation of research data to be used in the analysis process. The research objects consist of regional feeder ports in Nusa Tenggara Barat Province, which include Sape, Waworada, Calabai, Pemenang, and Carik Ports. Each port was assessed based on a number of aspects and sub-aspects established in Table 3.1.

The data used were collected from various sources, including secondary data, planning documents, and field observation results. All data were then converted into assessment scores for each sub-aspect based on assessment parameters, resulting in an initial decision matrix that represents the relative condition of each port against all the criteria used.

Tabel 1. Decision Matrix for Regional Feeder Port Development Priority Assessment in NTB Province

No.	Aspect	Sub-Aspect	Port Alternatives				
			Sape	Waworada	Calabai	Pemenang	Carik
1	Spatial and Regional Policy Analysis	Alignment with Provincial Spatial Structure (RTRW)	80	80	80	80	80
		Alignment with Provincial Marine Spatial Patterns (RTRW)	100	100	100	100	100
		Suitability of Marine Space Utilization based on Provincial RTRW	100	100	100	100	100
2	Accessibility	Accessibility to and from the port	60	60	100	100	60
		Availability of Public Transportation	60	60	60	100	60
		Port Activities	60	40	100	100	20
3	Economy & Regional Potential	Regional Economic Index	60	40	60	80	60
		Population Density (People/Km2)	20	20	20	40	40
		Distance to leading regional economic centers	80	60	40	100	60
4	Environment	Water sedimentation level based on dredging frequency	100	60	100	100	100
		Disaster Vulnerability	25	50	50	25	25
		Marine space utilization conflicts	100	100	100	100	100
5	Technical, Navigation Safety, and Port Facility Conditions	Berth Length	100	50	100	100	50
		Water area for vessel maneuvering	100	50	100	100	100
		Navigation Channel	25	50	50	75	75
		Condition of Port Facilities	100	50	100	75	25

Source: Author, 2026

Determination of Criterion Weights using Entropy Weighting Method

The determination of criterion weights in this research was conducted using the Entropy Weighting Method. This method was chosen because it is capable of producing criterion weights objectively based on data variation, without involving subjective assessments from the researcher.

Konversi skala penilaian

Before the analysis process using the Entropy Weighting Method and TOPSIS was conducted, the assessment data were first standardized into the same scale. This scale standardization is necessary because the initial assessment values were expressed on a 0–100 scale but within different ranges, while multi-criteria decision-making methods require data to be on a comparable scale to be processed consistently.

The scale conversion was performed to transform the initial assessment values into a linear 0–5 scale. This process was not intended to change the meaning or weight of the assessment, but rather served as a mathematical transformation so that all sub-aspects have the same value range before the normalization stage and further calculations are carried out.

Tabel 2. Conversion of Assessment Scales

No	Aspects	Sub Aspects	Port Alternatives				
			Sape	Waworada	Calabai	Pemenang	Carik
1	Spatial and Regional Policy Analysis	Alignment with Provincial Spatial Structure (RTRW)	**4**	**4**	**4**	**4**	**4**
		Alignment with Provincial Marine Spatial Patterns (RTRW)	5	5	5	5	5
		Suitability of Marine Space Utilization based on Provincial RTRW	5	5	5	5	5
2	Accessibility	Accessibility to and from the port	3	3	5	5	3
		Availability of Public Transportation	3	3	3	5	3
		Port Activities	3	2	5	5	1
3	Economy & Regional Potential	Regional Economic Index	3	2	3	4	3
		Population Density (People/Km2)	1	1	1	2	2
		Distance to leading regional economic centers	4	3	2	5	3
4	Environment	Water sedimentation level based on dredging frequency	5	3	5	5	5
		Disaster Vulnerability	1,25	2,5	2,5	1,25	1,25
		Marine space utilization conflicts	5	5	5	5	5
5	Technical, Navigation Safety, and Port Facility Conditions	Berth Length	5	2,5	5	5	2,5
		Water area for vessel maneuvering	5	2,5	5	5	5
		Navigation Channel	1,25	2,5	2,5	3,75	3,75
		Condition of Port Facilities	5	2,5	5	3,75	1,25

Source: Author's analysis, 2026

Data Normalization

After the assessment data were converted into the 0–5 scale, the next step was to perform data normalization. Data normalization aims to eliminate the influence of differences in value magnitudes between sub-aspects, ensuring that each sub-aspect has a comparable contribution in the weight calculation process using the Entropy Weighting Method.

In the Entropy Weighting Method, normalization is carried out by comparing the value of an alternative to the total value of the same sub-aspect. Thus, the normalized value represents the relative proportion of each alternative against all alternatives in each sub-aspect. These normalization results are subsequently used in the entropy value calculation to determine the relative importance level of each sub-aspect.

Tabel 3. Normalisasi data hasil penilaian

No	Aspect	Sub Aspect	Port Alternatives				
			Sape	Waworada	Calabai	Pemenang	Carik
1	Spatial and Regional Policy Analysis	Alignment with Provincial Spatial Structure (RTRW)	0,2000	0,2000	0,2000	0,2000	0,2000
		Alignment with Provincial Marine Spatial Patterns (RTRW)	0,2000	0,2000	0,2000	0,2000	0,2000
		Suitability of Marine Space Utilization based on Provincial RTRW	0,2000	0,2000	0,2000	0,2000	0,2000
2	Accessibility	Accessibility to and from the port	0,1579	0,1579	0,2632	0,2632	0,1579
		Availability of Public Transportation	0,1765	0,1765	0,1765	0,2941	0,1765
		Port Activities	0,1875	0,1250	0,3125	0,3125	0,0625
3	Economy & Regional Potential	Regional Economic Index	0,2000	0,1333	0,2000	0,2667	0,2000
		Population Density (People/Km2)	0,1429	0,1429	0,1429	0,2857	0,2857
		Distance to leading regional economic centers	0,2353	0,1765	0,1176	0,2941	0,1765
4	Environment	Water sedimentation level based on dredging frequency	0,2174	0,1304	0,2174	0,2174	0,2174
		Disaster Vulnerability	0,1429	0,2857	0,2857	0,1429	0,1429
		Marine space utilization conflicts	0,2000	0,2000	0,2000	0,2000	0,2000
5	Technical, Navigation Safety, and Port Facility Conditions	Berth Length	0,2500	0,1250	0,2500	0,2500	0,1250
		Water area for vessel maneuvering	0,2222	0,1111	0,2222	0,2222	0,2222
		Navigation Channel	0,0909	0,1818	0,1818	0,2727	0,2727
		Condition of Port Facilities	0,2857	0,1429	0,2857	0,2143	0,0714

Source: Author's analysis, 2026

Calculation of Entropy Value, Diversification, and Entropy Weight

After obtaining the normalized data matrix, the next step is to calculate the entropy value for each sub-aspect. The entropy calculation aims to measure the level of diversity (diversification) of the data among alternatives in each sub-aspect. The greater the variation in the values of a sub-aspect, the more information that sub-aspect contains in differentiating between alternatives.

The entropy value is calculated based on the normalized values using information theory concepts. Sub-aspects with a lower entropy value indicate a higher level of data variation, and thus are considered to have a greater level of importance in the decision-making process. Conversely, sub-aspects with a high entropy value indicate relatively uniform data across alternatives.

Next, the diversification value is calculated as the inverse of the entropy value to show the magnitude of the information contribution from each sub-aspect. This diversification value is then used to determine the entropy weight, which is the objective weight reflecting the relative importance of each sub-aspect based on the data characteristics.

Tabel 4. Entropy Weight Calculation Results

No	Aspect	Sub Aspect	*Entropy* Calculation (EWM)		
			Entropy	Diversification	Bobot *Entropy*
1	Spatial and Regional Policy Analysis	Alignment with Provincial Spatial Structure (RTRW)	1,000	0,000	0,000
		Alignment with Provincial Marine Spatial Patterns (RTRW)	1,000	0,000	0,000
		Suitability of Marine Space Utilization based on Provincial RTRW	1,000	0,000	0,000
2	Accessibility	Accessibility to and from the port	0,980	0,020	0,051
		Availability of Public Transportation	0,984	0,016	0,040
		Port Activities	0,916	0,084	0,213
3	Economy & Regional Potential	Regional Economic Index	0,986	0,014	0,036
		Population Density (People/Km2)	0,963	0,037	0,094
		Distance to leading regional economic centers	0,972	0,028	0,071
4	Environment	Water sedimentation level based on dredging frequency	0,990	0,010	0,026
		Disaster Vulnerability	0,963	0,037	0,094
		Marine space utilization conflicts	1,000	0,000	0,000
5		Berth Length	0,969	0,031	0,079

No	Aspect	Sub Aspect	*Entropy* Calculation (EWM)		
			Entropy	Diversification	Bobot *Entropy*
	Technical, Navigation Safety, and Port Facility Conditions	Water area for vessel maneuvering	0,982	0,018	0,045
		Navigation Channel	0,961	0,039	0,099
		Condition of Port Facilities	0,940	0,060	0,153

Source: Author's analysis, 2026

The weighting results using the Entropy Weighting Method in Table 4.4 show that not all sub-aspects have the same level of importance in determining port development priorities. Sub-aspects with uniform values across ports produce entropy values close to one and very small or zero weights, thus having no significant effect on the decision-making process. Conversely, sub-aspects that show higher value variations between ports have lower entropy values and larger weights, indicating a more dominant contribution in differentiating the priorities of port alternatives.

Determination of Priority Order Using the TOPSIS Method

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method is used to determine port development priorities based on the proximity of each alternative to the ideal solution. The basic concept of TOPSIS is that the best alternative is the one that has the shortest distance to the positive ideal solution and the farthest distance from the negative ideal solution. In this study, the TOPSIS method is applied using sub-aspect weights obtained from the Entropy Weighting Method, so that the assessment process considers the objective importance of each sub-aspect.

The stages of TOPSIS analysis in this study include normalizing the decision matrix, forming the weighted decision matrix, determining the positive and negative ideal solutions, calculating the distance of each alternative to the ideal solutions, and determining the preference values and ranking of port alternatives.

Vector Normalization

The first stage in the TOPSIS method is to normalize the decision matrix. Normalization is performed to eliminate scale differences between sub-aspects so that all performance values of the port alternatives can be compared proportionally. This study uses the vector normalization method as it aligns with the principle of Euclidean distance calculation used in TOPSIS.

Vector normalization is performed by dividing each performance value of an alternative in a sub-aspect by the square root of the sum of squares of the values in the same sub-aspect for all port alternatives.

Tabel 5. Vector Normalization

No	Aspect	Sub Aspect	Port Alternatives				
			Sape	Waworada	Calabai	Pemenang	Carik
1	Spatial and Regional	Alignment with Provincial Spatial Structure (RTRW)	0,4472	0,4472	0,4472	0,4472	0,4472

No	Aspect	Sub Aspect	Port Alternatives				
			Sape	Waworada	Calabai	Pemenang	Carik
	Policy Analysis	Alignment with Provincial Marine Spatial Patterns (RTRW)	0,4472	0,4472	0,4472	0,4472	0,4472
		Suitability of Marine Space Utilization based on Provincial RTRW	0,4472	0,4472	0,4472	0,4472	0,4472
2	Accessibility	Accessibility to and from the port	0,3419	0,3419	0,5698	0,5698	0,3419
		Availability of Public Transportation	0,3841	0,3841	0,3841	0,6402	0,3841
		Port Activities	0,3750	0,2500	0,6250	0,6250	0,1250
3	Economy & Regional Potential	Regional Economic Index	0,4376	0,2917	0,4376	0,5835	0,4376
		Population Density (People/Km2)	0,3015	0,3015	0,3015	0,6030	0,6030
		Distance to leading regional economic centers	0,5040	0,3780	0,2520	0,6299	0,3780
4	Environment	Water sedimentation level based on dredging frequency	0,4789	0,2873	0,4789	0,4789	0,4789
		Disaster Vulnerability	0,3015	0,6030	0,6030	0,3015	0,3015
		Marine space utilization conflicts	0,4472	0,4472	0,4472	0,4472	0,4472
5	Technical, Navigation Safety, and Port Facility Conditions	Berth Length	0,5345	0,2673	0,5345	0,5345	0,2673
		Water area for vessel maneuvering	0,4851	0,2425	0,4851	0,4851	0,4851
		Navigation Channel	0,1925	0,3849	0,3849	0,5774	0,5774
		Condition of Port Facilities	0,5898	0,2949	0,5898	0,4423	0,1474

Source: Author's analysis, 2026

Formation of the Weighted Decision Matrix

The next stage in the TOPSIS method is the formation of the weighted decision matrix. This matrix is obtained by multiplying each value in the normalized decision matrix by the sub-aspect weights previously calculated using the Entropy Weighting Method. The purpose of this stage is to incorporate the relative importance level of each sub-aspect into the assessment process, so that sub-aspects with greater influence will contribute more significantly to the final value of the port alternatives.

Tabel 6. Weighted Decision Matrix

No	ASpect	Sub Aspect	Port Alternatives				
			Sape	Waworada	Calabai	Pemenang	Carik
1	Spatial and Regional Policy Analysis	Alignment with Provincial Spatial Structure (RTRW)	0,0000	0,0000	0,0000	0,0000	0,0000
		Alignment with Provincial Marine Spatial Patterns (RTRW)	0,0000	0,0000	0,0000	0,0000	0,0000
		Suitability of Marine Space Utilization based on Provincial RTRW	0,0000	0,0000	0,0000	0,0000	0,0000

No	ASpect	Sub Aspect	Port Alternatives				
			Sape	Waworada	Calabai	Pemenang	Carik
2	Accessibility	Accessibility to and from the port	0,0175	0,0175	0,0291	0,0291	0,0175
		Availability of Public Transportation	0,0152	0,0152	0,0152	0,0253	0,0152
		Port Activities	0,0800	0,0533	0,1333	0,1333	0,0267
3	Economy & Regional Potential	Regional Economic Index	0,0156	0,0104	0,0156	0,0208	0,0156
		Population Density (People/Km2)	0,0283	0,0283	0,0283	0,0566	0,0566
		Distance to leading regional economic centers	0,0358	0,0268	0,0179	0,0447	0,0268
4	Environment	Water sedimentation level based on dredging frequency	0,0126	0,0076	0,0126	0,0126	0,0126
		Disaster Vulnerability	0,0283	0,0566	0,0566	0,0283	0,0283
		Marine space utilization conflicts	0,0000	0,0000	0,0000	0,0000	0,0000
5	Technical, Navigation Safety, and Port Facility Conditions	Berth Length	0,0420	0,0210	0,0420	0,0420	0,0210
		Water area for vessel maneuvering	0,0217	0,0108	0,0217	0,0217	0,0217
		Navigation Channel	0,0191	0,0381	0,0381	0,0572	0,0572
		Condition of Port Facilities	0,0901	0,0451	0,0901	0,0676	0,0225

Source: Author's analysis, 2026

Determination of Positive Ideal Solution and Negative Ideal Solution

The next stage in the TOPSIS method is the determination of the positive ideal solution and the negative ideal solution. The positive ideal solution represents the best condition achievable by an alternative across all assessment sub-aspects, while the negative ideal solution represents the worst possible condition. The basic principle of TOPSIS is that the best alternative is the one with the shortest distance to the positive ideal solution and the farthest distance from the negative ideal solution.

In this study, all sub-aspects are treated as benefit-type criteria, so the positive ideal solution is determined based on the maximum value of each sub-aspect, while the negative ideal solution is determined based on the minimum value of each sub-aspect in the weighted decision matrix.

Tabel 7. Determination of Positive Ideal Solution and Negative Ideal Solution

No	Aspect	Sub Aspect	Port Alternatives					A +	A-
			Sape	Waworada	Calabai	Pemenang	Carik		
1	Spatial and Regional Policy Analysis	Alignment with Provincial Spatial Structure (RTRW)	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
		Alignment with Provincial Marine Spatial Patterns (RTRW)	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
		Suitability of Marine Space Utilization	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

No	Aspect	Sub Aspect	Port Alternatives					A +	A-
			Sape	Taworada	Calabai	Pemenang	Carik		
		based on Provincial RTRW							
2	Accessibility	Accessibility to and from the port	0,0175	0,0175	0,0291	0,0291	0,0175	0,0291	0,0175
		Availability of Public Transportation	0,0152	0,0152	0,0152	0,0253	0,0152	0,0253	0,0152
		Port Activities	0,0800	0,0533	0,1333	0,1333	0,0267	0,1333	0,0267
3	Economy & Regional Potential	Regional Economic Index	0,0156	0,0104	0,0156	0,0208	0,0156	0,0208	0,0104
		Population Density (People/Km2)	0,0283	0,0283	0,0283	0,0566	0,0566	0,0566	0,0283
		Distance to leading regional economic centers	0,0358	0,0268	0,0179	0,0447	0,0268	0,0447	0,0179
4	Environment	Water sedimentation level based on dredging frequency	0,0126	0,0076	0,0126	0,0126	0,0126	0,0126	0,0076
		Disaster Vulnerability	0,0283	0,0566	0,0566	0,0283	0,0283	0,0566	0,0283
		Marine space utilization conflicts	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
5	Technical, Navigation Safety, and Port Facility Conditions	Berth Length	0,0420	0,0210	0,0420	0,0420	0,0210	0,0420	0,0210
		Water area for vessel maneuvering	0,0217	0,0108	0,0217	0,0217	0,0217	0,0217	0,0108
		Navigation Channel	0,0191	0,0381	0,0381	0,0572	0,0572	0,0572	0,0191
		Condition of Port Facilities	0,0901	0,0451	0,0901	0,0676	0,0225	0,0901	0,0225

Source: Author's analysis, 2026

Calculation of Alternative Distance to the Ideal Solution

After the positive and negative ideal solutions are determined, the next step in the TOPSIS method is to calculate the distance of each alternative to both ideal solutions. This distance indicates how close an alternative is to the best ideal condition and how far it is from the worst condition.

In this study, distance is calculated using the Euclidean distance, as this method can represent value differences proportionally in each sub-aspect. The smaller the alternative's distance to the positive ideal solution and the larger the distance to the negative ideal solution, the better the alternative.

Tabel 8. Calculation Results of Alternative Distance to the Ideal Solution

No	Port Alternatives	D^+ ke A^+	D^- ke A^-
1	Sape	0,0790	0,0913
2	Taworada	0,1041	0,0496
3	Calabai	0,0449	0,1336
4	Pemenang	0,0362	0,1316
5	Carik	0,1333	0,0500

Source: Author's analysis, 2026

Based on the calculation results using the TOPSIS method, the distance values of each port alternative to the positive ideal solution (D to A^+) and the negative ideal solution (D^- to A^-) were obtained, as presented in Table 4.8. The value of D^+ to A^+ indicates the proximity of the alternative to the best ideal condition, while the value of $D^-$to A^- indicates the distance of the alternative from the worst ideal condition.

The calculation results show that Pemenang Port has the smallest D^+ to A^+ value of 0.0362, indicating that this port is the alternative closest to the positive ideal solution. Additionally, Pemenang Port also has the largest D^- to A^- value of 0.1316, meaning this alternative is the farthest from the negative ideal solution compared to other alternatives. This condition indicates that Pemenang Port overall has performance that most closely resembles the ideal condition based on all assessment sub-aspects.

Conversely, Carik Port has the largest D^+ to A^+ value of 0.1333 and the smallest D^- to A^- value of 0.0500, showing that this alternative is relatively the farthest from the positive ideal condition and the closest to the negative ideal condition. This indicates that Carik Port has a lower development priority level compared to other alternatives.

Meanwhile, Calabai Port has a D^+ to A^+ value of 0.0449 and a D^- to A^- of 0.1336, while Sape Port has a D^+ to A^+ value of 0.0790 and a D^- to A^- of 0.0913, and Waworada Port has a D^+ to A^+ value of 0.1041 and a D^- to A^- of 0.0496. These conditions show that these three ports are at a medium priority level in the context of regional feeder port development.

Calculation of Preference Values and Ranking

The final stage in the TOPSIS method is to calculate the preference value (Ci) for each port alternative. The preference value indicates the relative proximity of an alternative to the positive ideal solution while simultaneously moving away from the negative ideal solution. The larger the preference value, the more prioritized the alternative.

Tabel 9. Calculation Results of Preference Values and Ranking

No.	Port Alternatives	D^+	D^-	Nilai Preferensi (Ci)	Peringkat
1	Sape	0,0790	0,0913	0,5361	3
2	Waworada	0,1041	0,0496	0,3228	4
3	Calabai	0,0449	0,1336	0,7485	2
4	Pemenang	0,0362	0,1316	0,7843	1
5	Carik	0,1333	0,0500	0,2729	5

Source: Author's analysis, 2026

The calculation results show that Pemenang Port has the highest preference value of 0.7843, making it the primary priority in regional feeder port development in Nusa Tenggara Barat Province. This is because Pemenang Port has the shortest distance to the positive ideal solution and simultaneously the farthest distance from the negative ideal solution compared to other alternatives.

Furthermore, Calabai Port and Sape Port rank second and third with preference values of 0.7485 and 0.5361, respectively. Both ports show fairly good development potential but remain below Pemenang Port.

Meanwhile, Waworada Port and Carik Port rank fourth and fifth. Waworada Port has a preference value of 0.3228, while Carik Port has the lowest preference value of 0.2729, indicating that this alternative has the lowest level of proximity to the ideal condition compared to other alternatives.

CONCLUSION

Based on the research results, it can be concluded that the determination of aspects and sub-aspects in the priority analysis for regional feeder port development in Nusa Tenggara Barat Province has comprehensively represented the links between spatial planning policies, accessibility, regional economic potential, environmental conditions, and the technical readiness of the ports. The weighting results using the Entropy Weighting Method show that the sub-aspects with the greatest influence in differentiating development priorities are port activities (0.213), followed by the condition of port facilities (0.153), shipping lanes (0.099), and population density (0.094), while normative sub-aspects such as alignment with the Regional Spatial Plan (RTRW) have very small weights (approaching zero) due to uniform values across ports. Furthermore, the TOPSIS analysis results indicate that the priority order for port development is Pemenang Port (0.7843) as the primary priority, followed by Calabai Port (0.7485), Sape Port (0.5361), Waworada Port (0.3228), and Carik Port (0.2729), confirming that development priority is determined not solely by a lack of facilities but by the level of readiness, activity, and development potential that most closely approaches the ideal condition. A priority map was also generated as a spatial representation of the ranking results, serving as a strategic reference for the provincial government and the Ministry of Transportation in allocating development resources. Theoretically, this study contributes to the literature on multi-criteria decision-making in infrastructure planning by demonstrating the application of an objective weighting method combined with a systematic ranking approach, while practically, the results provide an evidence-based reference for allocating development resources more effectively and transparently. Based on these findings, it is recommended that Pemenang Port be prioritized for immediate development, followed by Calabai and Sape Ports, while Waworada and Carik Ports may require further feasibility studies. For future researchers, it is recommended to expand the research object to other archipelagic regions, include additional assessment aspects such as social impact or disaster resilience, and incorporate sensitivity analysis to test the robustness of the priority rankings. This study has several limitations, including the limited number of ports analyzed (five ports in NTB Province), the cross-sectional nature of the data, and the absence of stakeholder preferences in the weighting process. Despite these limitations, the Entropy–TOPSIS method has proven to be a systematic, objective, and replicable approach for port development prioritization, providing a valuable tool for evidence-based infrastructure planning in archipelagic regions.

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