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Impact Assessment of Minimum Essential Force (MEF) Achievement of Indonesian Navy Using Integrated Delphi-AHP-TOPSIS

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ABSTRACT

This research aims to evaluate the progress of the Indonesian Navy's Minimum Essential Force (MEF) initiative, focusing specifically on its impact within the North Natuna Sea region. Utilizing a qualitative descriptive statistical approach, the research integrates the Delphi-Analytical Hierarchy Process (AHP) and the Technique for Order by Similarity to Ideal Solution (TOPSIS) to support its analysis. The impact of achieving the MEF is dissected into three main criteria: Deterrent Effect, Bargaining Power, and Maritime Security Threat. The research identified 4 sub-factors for both Deterrent Effect and Bargaining Power, and 6 sub-factors for Maritime Security Threat, all determined through consensus among expert panelists. In assessing the impact of MEF achievements using the 3D model, five strategies were pinpointed for their significantly high and low impacts. The strategy to increase the allocation of the state budget for the maritime sector (S1) scored the highest, whereas the strategy involving universities in defense technology research and Transfer of Technology (TOT) purchases (S4) scored the lowest.Sensitivity analysis revealed that the weights of certain factors, notably military capability and diplomatic skill sub-factors, significantly influence the ranking of strategies. These sub-factors were particularly sensitive to changes in weight. Despite this, the overall model is deemed robust, as evidenced by the minimal variation in strategy rankings under different scenarios.

1. Introduction.

Territorial disputes in the South China Sea (SCS) remain a significant security challenge within the ASEAN region due to conflicting claims. The SCS spans approximately 3 million km^2, bordered by China and Taiwan to the north, several Southeast Asian nations to the west, the Philippines to the east, and Kalimantan, Indonesia, to the south.

This maritime region is surrounded by ten countries, including Brunei Darussalam, Cambodia, China, Indonesia, Malaysia, the Philippines, Singapore, Taiwan, Thailand, and Vietnam (Schofield et al, 2016). Indonesia has been increasingly involved in the SCS disputes after China extended its claim to the northern region of the Natuna Islands in the Riau Islands Province, an area within Indonesia's Exclusive Economic Zone (EEZ). China justifies its claim by citing historical fishing rights (Dugis et al, 2018). The potential for conflict in the SCS raises concerns that the Natuna Sea and its vicinity could become a battleground for contesting nations and major powers with interests in the SCS.

Consequently, it is imperative for the Indonesian Navy to maintain a state of readiness to safeguard territorial sovereignty over the Natuna waters should disputes escalate into armed conflict (Utomo, Prihantoro dan Adriana, 2017). Marsetio (Marsetio, 2014), emphasizes the importance of consistently strengthening the Indonesian Navy in line with the national defense policy, the Minimum Essential Force (MEF), to prepare for such eventualities. If Indonesia fails to meet the objectives of the MEF, the country could face several risks, including: a) Increased threats to the sovereignty and territorial integrity of the

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Republic of Indonesia, potentially destabilizing national security; b) Obstacles in achieving the national development goals related to national defense; c) Diminished bargaining power of the Indonesian government in international diplomacy, leading to decreased influence in the international community; d) A failure to develop the primary components of the MEF could weaken national defense deterrence capabilities in the region; e) A decline in the nation's competitiveness index, affecting its standing in the international environment; f) A reduction in the Indonesian National Armed Forces' (TNI) ability to perform its primary duties.

Impact assessment has traditionally been a tool used in the public sector to evaluate both the potential positive and negative future outcomes of public policies (Scherrer, 2023). The relevance of impact assessments moving forward hinges on the capacity of researchers and practitioners to showcase clear benefits to a wide range of stakeholders (Bond dan Pope, 2012). These assessments serve various purposes and are instrumental in evaluating the environmental and social impacts of policies and projects (Penfield et al., 2014).

They offer insights into the relative impacts of products and processes throughout their life cycles, aiding in the evaluation of trade-offs (Laurin dan Dhaliwal, 2017; Octavian et al., 2020) applied the AHP-TOPSIS method to analyze the risk impact of the development of ISIS in Southeast Asia. For comparative purposes, impact assessments can utilize different Multi-Criteria Decision-Making (MCDM) techniques, such as fuzzy Promethee, fuzzy Vikor, Topsis, and others (Kaya dan Kahraman, 2011). This research aims to evaluate the progress of the Indonesian Navy's Minimum Essential Force (MEF) initiative, focusing specifically on its impact within the North Natuna Sea region. Utilizing a qualitative methodology grounded in 3D modeling, the research seeks to scrutinize the current state of MEF achievements and strategize its future development. The significance of impact assessment in this context is underscored by its ability to grant researchers the opportunity to identify and analyze factors critical to the MEF's success. This research endeavors to contribute to the field of defense management by offering insights into the handling of territorial disputes through impact assessment.

Furthermore, this research employs a qualitative descriptive statistical approach, enriched by theories on Competitive Dynamics, Deterrent Effect, and Maritime Security Threats. The research methodology integrates the Delphi technique, Analytic Hierarchy Process (AHP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), supported by a panel of 15 experts.

The North Natuna Sea is chosen as the primary focus area, and the research unfolds in several phases. Initially, it identifies the key factors influencing the achievement of MEF objectives and outlines a strategic development plan. Subsequently, it delves into modeling the weightings of impact factors and selecting strategies through a 3D model to formulate appropriate responses. Finally, the research conducts a sensitivity analysis on the impact assessment model to ensure its robustness and reliability.

This research offers several contributions. Firstly, it advances research on the Defense Force by evaluating the impact of Minimum Essential Force (MEF) development, analyzed through various lenses including Bargaining Power in diplomacy (Harry & Nugraha et al, 2017), Deterrence effect (Chadhafi et al, 2021), and the Capability to address maritime security threats (Andalus dan Djuyandi, 2022). Secondly, it establishes Confidence-Building Measures (CBMs) as both a deterrence mechanism against threats and a strategic guide for shaping defense posture policies (Santiko & Agustien et al, 2022). Thirdly, this research acts as a follow-up on the recommendations by Kaya & Kahraman (Kaya dan Kahraman, 2011), aiming to assess environmental impacts employing alternative methodologies.

2. Literature Review.

2.1. Competitive dynamics.

Dynamic competition theory, which emerged in the 1980s within the strategic management field, emphasizes the interplay of attack and counterattack actions among firms (Chen dan Miller, 2012). Chen (Chen, 2009), posits that competition forms the core of strategic considerations, encapsulating a dynamic process involving actions and reactions by companies. This interplay underscores a dependency relationship, wherein a company's competitive standing is vulnerable to its rivals' defensive or offensive strategies (Chen dan Miller, 2012). Competitive dynamics encompass the entire spectrum of competitive behaviors, meaning all actions and reactions executed by firms within a market context. Importantly, the actions and reactions of firms are deeply interdependent, with their strategic moves significantly affecting their performance (Woo et al., 2021).

As outlined in the research, the theory of competitive dynamics serves as a tool for competitors to assess the ramifications of their actions and reactions within the competitive landscape. It has a notable impact on organizational activities concerning the responses of rivals and overall organizational performance. The theory suggests that the influence on organizational activities, particularly the degree to which an organization either repetitively mirrors past actions or selectively incorporates new strategies into its strategic framework, is a critical consideration (Baskoro, 2017).

2.2. Deterrence Effect.

Deterrence theory as a concept that emerged prominently during the Cold War. This theory posits that a state seeks to enhance its military capability and strength to deter or dissuade adversaries from launching attacks, or at the very least, compel them to reconsider such actions. Deterrence is operationalized through military strategy, encompassing both tangible assets like main defense systems (alutsista) and intangible elements like military doctrine. The objective behind bolstering military capabilities. is to highlight to potential aggressors the significant risks involved in initiating an attack.

Strategically, the concept of deterrence is often juxtaposed with defense, with both paradigms heavily relying on military strength. However, the essence of deterrence, particularly as a defensive strategy, gained prominence post-World War I and was extensively applied during the Cold War era. This application is notably significant in the context of nuclear weapons deterrence and has also been relevant in addressing the challenges of the War on Terrorism (John, 2002). A deterrence strategy is deemed successful when it effectively convinces potential aggressors that the costs of attacking would vastly outweigh any potential benefits, thereby preventing conflict and maintaining peace.

2.3. Defense Diplomacy.

The establishment of defense diplomacy as a strategy to protect a country's national interests reflects a nation's recognition of the need for security against diverse and emerging threats (Saragih, 2018). This approach, particularly in times of peace, leverages various infrastructures and the armed forces as instruments that bridge security policies with foreign policy objectives. Defense diplomacy evolves through the collaboration of state actors (including intelligence agencies and politicians), non-governmental organizations, and even civil society, marking a comprehensive engagement in the diplomacy process.

Defense diplomacy differs from military diplomacy in its execution and focus. While defense diplomacy aims at fostering relations between nations through both formal and informal means, military diplomacy is concerned with the application of military capabilities to diplomatic negotiations, particularly around security matters. In the contemporary global landscape, defense diplomacy has emerged as a crucial element of a country's defense, security, and foreign policy framework. This significance is underscored by the trust and support garnered from various nations during multilateral discussions on security issues at both regional and international forums (Saragih, 2018).

Furthermore, the growth of defense forces can benefit from the strategic use of defense diplomacy tools. Defense diplomacy, therefore, presents numerous opportunities and offers a means to mitigate challenges in the context of national defense force development (Iskandar, Wibisono dan Supandi, 2019).

2.4. Impact Assessment.

Since the enactment of the National Environmental Policy Act of 1969 (NEPA) in the United States, the theory and practice of impact assessment have evolved significantly (Pope et al., 2013). Impact assessment is a systematic process designed to evaluate the effectiveness, relevance, and sustainability of an organization's current and future actions and initiatives. Its primary goal is to delineate the relationships among an organization's inputs, outputs, and outcomes, aiding organizations in making well-informed programmatic and institutional choices.

The International Association for Impact Assessment (IAIA) outlines four key objectives of impact assessments: a) To comprehend the potential impacts of proposed actions, changes, or interventions, and to prepare for addressing both positive and negative consequences; b) To foster accountability towards a wide range of stakeholders, including shareholders, employees, donors, partners, customers, volunteers, and beneficiaries; c) To identify necessary procedures and methodologies for future policy development, planning, and project cycles; d) To facilitate decisions that are environmentally, socially, and economically sustainable, thereby supporting organizational growth and development (Bond dan Pope, 2012).

Expanding on these foundations, our paper introduces varied perspectives on the current state and future directions of impact assessment within the context of defense management strategy. We present our insights into the current advancements in impact assessment, the forthcoming challenges, and potential research directions aimed at enhancing the role of impact assessment in fostering sustainable development through informed decision-making. This research specifically addresses the impact of achieving Minimum Essential Force (MEF) based on three impact criteria: Deterrent effect (D), Bargaining power (B), and Threat to maritime security (T).

2.5. Minimum Essential Force.

Indonesia initiated the Minimum Essential Force (MEF) target as a strategic response to its defense requirements, constrained by a limited defense budget (Kennedy et al, 2023). The MEF is aligned with the government's Nawacita vision and mission, which focuses on ensuring national security and contributing to global peace. It aims to enhance Indonesia's defense capabilities to effectively address the evolving strategic environment and to deter both internal and external, as well as traditional and non-traditional threats (Santiko dan Agustien, 2022).

The MEF development was structured into three phases: Phase I from 2010 to 2014. Phase II from 2014 to 2019, and Phase III from 2019 to 2024. The completion rates of the MEF development programs and activities were recorded at 52.33% for Phase I, 59.69% for Phase II, and 68.9% for Phase III. The primary goal of the MEF initiative is not to incite an arms race or to achieve superiority for total warfare. Instead, it is meticulously designed to elevate the country's defense forces to a more optimal standard, ensuring they are capable of exerting a deterrent effect, thus contributing to national and regional stability (Ervin et al, 2022).

3. Methodology.

3.1. Delphi Method.

The Delphi method is designed to achieve consensus through a systematic process of gathering and distilling the opinions and judgments of experts and practitioners (Widiasih et al, 2015). The method aims to facilitate a convergence of opinions by narrowing down the spectrum of judgments, importantly doing so in a manner that avoids the biases and errors typically associated with direct, face-to-face interactions (Zio dan Maretti, 2015; Ahmad et al., 2021). In this study, a panel of 15 experts was engaged to oversee and participate in the rounds of Delphi questionnaires (Flostrand, Pitt dan Bridson, 2020; Ribeiro et al., 2021). The feedback process for each round of questionnaires usually requires two to three iterations to gather comprehensive feedback from the panel, with each round spanning an average of two weeks. The process is concluded once consensus among the panel members is achieved. This consensus is determined based on statistical measures such as mean, median, standard deviation, and interquartile range aligning with the predetermined objectives of the Delphi method (Widiasih, Karningsih dan Ciptomulyono, 2015). According to Karakikes & Nathanail (2020), the Delphi process comprises three primary steps:

a. The first questionnaire was sent to the expert panelists to ask for some opinions (from experience or judgment), some predictions and recommendations.
b. In the second round, a recap of the results of the first questionnaire was sent to each expert panelist to be able to re-evaluate their first assessment on the questionnaire using the set criteria.
c. In the third round, the questionnaire was sent back with information on the panelists' ratings and the consensus results. The panelists were again asked to revise their opinions or explain the reasons for disagreeing with the group consensus.

The use of the Delphi method preceded the AHP approach for the following reasons: 1) The Delphi method is based on the subjective opinions of respondents, so that it can formulate the overall objective or criteria that are revealed more flexibly; 2) The results of the Delphi approach have not been tested for consistency of answers, so the AHP method complements the proposed procedure for testing the consistency of individual and group opinions and weighting the priority of the importance of each criterion/objective. In this study, the Delphi method was used to identify factors related to the impact of MEF achievement. In the identification of factors, the Delphi method was used for up to three rounds.

3.2. Content Validation Indeks.

The Content Validity Index (CVI) stands as a pivotal method for assessing the validity of an instrument's content, widely recognized for its application in various research domains. It quantifies the degree to which experts agree on the relevance or representativeness of an instrument's items, offering insights into its content validity both at the item level (Item-level CVI or I-CVI) and across the entire instrument (Instrument-level CVI). The calculation of CVI is underpinned by expert evaluations of each item, based on its content relevance or representativeness (Almanasreh, Moles dan Chen, 2018).

In exploring factors that influence a panel's consensus on Minimum Essential Force (MEF) attainment in a given domain (during a Delphi round), both means and standard deviations are computed to gauge factor convergence. The assessment of each objective's importance by an expert panel is facilitated through a 5-point Likert scale (Stancine et al., 2019). To assess content validity, the research employs both the item-level content validity index (I-CVI) and the scale-level average content validity index (S-CVI/Ave). The S-CVI/Ave is determined by dividing the sum of I-CVI scores by the number of items. An S-CVI/Ave of ≥0.8 is considered acceptable, whereas an S-CVI/Ave of ≥0.90 denotes excellent overall content validity. The I-CVI, on the other hand, is calculated as the number of experts rating an item ≥3 divided by the total number of experts, with an I-CVI of ≥0.78 being acceptable. Literature suggests that for a new assessment instrument to be considered valid, it should achieve a total CVI of ≥0.90 or 90% and an I-CVI of ≥0.78 or 78% (Marisa, 2021).

In this particular instance, the S-CVI/Universe method was not employed due to the large size of the expert panel, which could potentially skew results towards unacceptable levels. Additionally, this approach does not account for the possibility of chance agreement among experts (Roya dan Behrooz, 2017) emphasizing the method's reliance on expert consensus without adjustments for randomness in responses.

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3.3. Analitical Hierarchy Process (AHP).

The Analytic Hierarchy Process (AHP), devised by Saaty, serves as a framework for addressing decision-making challenges. It uniquely accommodates both quantitative and qualitative factors by aligning them with the priorities of the decision-maker. In the development of MEF (Minimum Essential Force), the AHP method will be employed to assign weights to various impact factors. This technique facilitates the intuitive assignment of relative importance to different criteria through pairwise comparisons. A key strength of the AHP method lies in its provision of a structured scale for measurement and a systematic approach to establishing priorities. Furthermore, it ensures logical consistency in the evaluations utilized for priority setting (Hasanah, 2016).

The steps of the AHP method in weighting the impact factors of achieving MEF include:

a. Structuring the hierarchy of the problem at hand The problem to be solved is described based on its elements, namely objectives, factors and sub-factors and then organized into a hierarchical structure;
b. Creating a questionnaire and collecting data. Comparisons are made for each criterion and converted into quantitative numbers using linguistic terms.
c. Generating pairwise comparisons for the various criteria. As explained earlier, the comparison values are processed to determine the relative ranking of all criteria.
d. Determining the weight of each factor. Qualitative factors can be compared in accordance with predetermined judgments to obtain a factor weight value. Pairwise comparisons are processed to obtain weight or priority values with the following steps: 1) Give value to each criterion to obtain a paired matrix; 2) Divide the value of each element by the total column of each criterion to get the normalized value of the matrix; 3) Add up the value of each row of elements, then the amount is divided by the number of elements owned so that the priority value is obtained. Assessment of factors and sub-factors in pairwise comparisons using the Saaty Scale.

Table 1: Priority Scale.

Priority Scale	Definition	Remarks
1	Equally Important	Two activities contribute equally strongly to the goal
3	Slightly More Important	One activity is slightly more important than the other
5	Important	One activity is more important than the other
7	Quite Important	One activity is quite important compared to the other
9	Extremely Important	One activity is extremely important compared to the other
2.4.6,8	Mean	
Reciprocal	Describing the dominance of the second alternative compared to the first alternative	

Source: Saaty, 1990.

e. Logical Consistency For the calculation of logical consistency the steps are as follows:
1) Determine λ maks by summing the results of the multiplication between the sum of each column in the pairwise comparison matrix with the priority value column.

2) After getting λ max, the next step is to determine the Consistency Index (CI) with the following formula:

$$CI = \frac{\lambda\text{maks} - \text{n}}{n};$$

3) The Consistency Ratio (random consistency index) was measured using the following formula:

Consistency Ratio =

$$CR = \frac{\text{CI}}{RI}$$

If the CR ratio is 0.1 (i.e. 10%), the matrix is regarded consistent and the W decision is accepted. Conversely, a CR of more than that implies too many contradictions in the matrix. The anticipation for the latter situation is to review the matrix, then revise the weights loaded by the vectors.

Table 2: Randomized Consistency Index Value.

1	2	3	4	5	6	7	8	9	10
0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty, 1990.

3.4. Technique for Order by Similarity to Ideal Solution (TOPSIS).

The TOPSIS method, which stands for Technique for Order of Preference by Similarity to Ideal Solution, is a multi-criteria decision-making approach developed by Yoon and Hwang (1981). It operates on the principle that the most favorable alternative is the one that simultaneously minimizes the distance from the positive ideal solution (PIS) and maximizes the distance from the negative ideal solution (NIS), essentially from a geometric standpoint. The method quantifies the proximity of each alternative to the optimal solution by calculating the Euclidean distances to both the PIS and NIS. TOPSIS assesses these distances to determine an alternative's relative closeness to the PIS, factoring in its divergence from the NIS (Namazi dan Mohammadi, 2018).

The PIS is characterized by the aggregation of the optimal values achievable across all criteria, while the NIS is the compilation of the least desirable values for each criterion. The TOPSIS method is favored in practical decision-making processes due to its straightforward concept, computational efficiency, and its capability to evaluate the relative performance of various decision alternatives comprehensively (Yang et al., 2018). The essential steps of the TOPSIS method, as applied in this study, are outlined as follows:

a. Creating a matrix for each decision criterion, with the following matrix equation.
b. Creating a normalized decision matrix
The matrix $X = [X_{ij}]$ is normalized with the following equation:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

where, $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, n$.
c. Creating a normalized weighted decision matrix. Multiplying the impact matrix by the weight of each AHP criterion. With weights $w_{ij} = w_1, w_2, \ldots, w_m$ is the weight of the j criterion, the normalized weight matrix X is:

$$X_{ij} = [w_1, w_2, \ldots, w_m] \begin{bmatrix} r_1 & r_{12} & \ldots & r_{1n} \\ r_{21} & r_{22} & \ldots & r_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ r_{m1} & r_{m2} & \ldots & r_{mn} \end{bmatrix}$$

$$= \begin{bmatrix} w_{1x}r_{11} & w_{1x}r_{12} & \ldots & w_{1x}r_{1n} \\ w_{2x}r_{21} & w_{2x}r_{22} & \ldots & w_{2x}r_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ w_{mx}r_{m1} & w_{mx}r_{m2} & \ldots & w_{mx}r_{mn} \end{bmatrix}$$

w_j = criterion weight j-number
r_{ij} = normalized decision matrix r-element

d. Creating a matrix of positive ideal solutions and negative ideal solutions. $\boldsymbol{A^+}$ is the symbol for positive ideal solution and $\boldsymbol{A^-}$ symbol for negative ideal solution, with the following equation:

$$A^+ = \left\{\left(\max v_{ij} \mid j\varepsilon J\right), \left(\min v_{ij} \mid j\varepsilon J'\right) | i = 1,2,\ldots, m\right\}$$

$$= \left\{v_1^+, v_2^+, \ldots, v_j^+, \ldots, v_n^+\right\}$$

$$A^- = \left\{\left(\min v_{ij} \mid j\varepsilon J\right), \left(\max v_{ij} \mid j\varepsilon J'\right) | i = 1,2,\ldots, m\right\}$$

$$= \left\{\boldsymbol{v_1^-, v_2^-, \ldots, v_j^-, \ldots, v_n^-}\right\}$$

$J = \{j = 1, 2, \ldots, n|j\}$ associated with benefit criteria
$J' = \{j = 1, 2, \ldots, n|j\}$ associated with cost criteria

e. Calculating the separation distance. The distance between each alternative can be measured by the n-dimensional Euclidean distance.The gap between alternative $\boldsymbol{A_i}$ and positive ideal solution $\boldsymbol{A^+}$

$$\boldsymbol{D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}, i = 1, 2, \ldots, m}$$

The gap between alternative $\boldsymbol{A_i}$ and ideal negative solution $\boldsymbol{A^-}$

$$\boldsymbol{D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, i = 1, 2, \ldots, m}$$

where:
$\boldsymbol{v_{ij}}$ = elements of normalized matrix
$\boldsymbol{v_j^+}$ = solusi ideal positif untuk kriteria j^{th}
$\boldsymbol{v_j^-}$ = solusi ideal negatif untuk kriteria j^{th}

f. Calculating the closeness to the positive ideal solution Calculating the relative closeness of each alternative to the positive ideal solution can be calculated by the following equation:

The relative closeness of A_i to $A^{+/-}$is defined as:

$$\boldsymbol{C_i = \frac{D_i^-}{(D_i^+ + D_i^-)}}, 0 < C_i < 1 \text{ and } i = 1, 2, \ldots, m$$

Where,
$\boldsymbol{C_i^+}$ is the relative closeness of the i-th alternative to the positive ideal solution.
If $A_i = A^+$ thereby $C_i = 1$
If $A_i = A^-$ thereby $C_i = 0$

g. Calculating the impact preference value of each alternative Ranking alternatives that have been sorted from alternatives that have the largest $\boldsymbol{C_i^+}$ to the smallest. Where alternatives have $\boldsymbol{C_i^+}$ and $\boldsymbol{C_i^-}$ is the result of the assessment of the position of the MEF competitive impact level.

Based on the closeness of each alternative to positive ideal impact, preference level value of each alternative choice can be determined.

3.5. Conceptual Framework

This research was conducted in the Indonesian Sea, specifically at the outer boundary of the North Natuna Sea. It aimed to evaluate the Indonesian Navy's MEF achievements and its impact within the North Natuna Sea area, focusing on it as a case research and for the development of strategic initiatives. This research utilized a qualitative descriptive statistical approach, employing a three-stage decision-making process augmented by the integration of the Delphi method, the Analytical Hierarchy Process (AHP), and the Technique for Order by Similarity to Ideal Solution (TOPSIS).

The analysis commenced with the application of the AHP method to assess impact factors and establish priorities for achieving MEF objectives. This was followed by the use of TOPSIS to classify impact levels and to visualize them within a 3D impact matrix, as demonstrated by Putra et al., (2023), along with a sensitivity analysis to evaluate the reliability of the results based on the criteria weights (Axelsson, Giove dan Soriani, 2021).

Delphi method was employed to achieve consensus through iterative rounds of information collection regarding impact factors. This required soliciting opinions and judgments from experts and practitioners (Widiasih et al, 2015). A panel of 15 experts was selected in alignment with the methodology described by Ribeiro et al.,(2021).

The Delphi survey was meticulously designed to gather data on objectives or criteria, employing a 1-9 scale for each survey round and framing impact assessment questions on a five-point Likert scale. Following the approach of Tamasila et al. (2020), eight experts were engaged to collect MEF data through email and Google Forms, as suggested by Akter et al. (2022). The experts involved were predominantly senior officials in the maritime sector.

Criteria for expert selection were established as follows:

a. Possession of specialized knowledge and experience related to their role or involvement in military strategy and agenda formulation, akin to that of a Chief Navy Officer (Fletcher dan Griffiths, 2020);
b. Expertise in Minimum Essential Force (MEF) matters (Nasa et al., 2021);
c. Relevant expertise to the research question (Nguyen et al., 2022);
d. A minimum of 10 years of professional experience (Khalilzadeh, Katoueizadeh dan Zavadskas, 2020)
e. An academic background at least at the Master's level (Guimarães et al., 2016). The input and insights from these experts were crucial in constructing and refining the MEF impact analysis model.

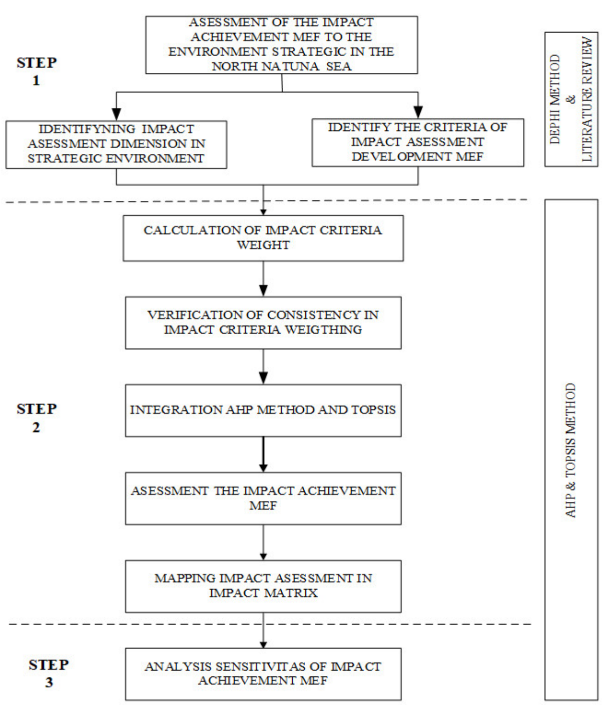
The proposed conceptual framework of this reseachis shown in Figure 1. The research object consists of three parts, including:

- Identifying MEF development criteria and strategy;
- Analyzing, measuring, mapping the impact level of MEF achievement and its sensitivity analysis using AHP-TOPSIS approach;

This research further develops a model capable of assessing and quantifying the impact levels of MEF achievements. The adoption of the Delphi-AHP-TOPSIS integration technique for this model is attributed to its numerous advantages, as highlighted by Zytoon (2020) and (Tuzemen, 2020).The operational mechanism of this model is delineated in a flowchart, illustrated in Figure 2. designed to address research questions 1, 2 and 3.

Step 1: Assessment of MEF Impact. The initial phase involves assessing the impact of achieving MEF. The Delphi method plays a pivotal role here, facilitating consensus-building through a structured process of gathering and refining impact factor information. The culmination of this phase involves the integration of all collected data, serving as foundational input for the Analytical Hierarchy Process (AHP). This input, along with comprehensive literature reviews and expert consultations, aids in creating a detailed mapping of all pertinent factors and strategies essential for informed decision-making.

Figure 1: The Conceptual Framework of Impact Assessment.



Source: Modified from Singh & Sarkar, (2019), Octavian et al., (2020), and Nengah Putra, (2023).

Step 2: Hierarchical Structure and Impact Evaluation. In this stage, participants are presented with a questionnaire aimed at eliciting responses to identify impact factors, which leads to the establishment of a hierarchical structure. This is followed by the application of AHP to calculate the relative importance or weight of these identified factors. Subsequently, the Technique for Order by Similarity to Ideal Solution (TOPSIS) is employed to ascertain rankings and measure the value of impact levels, culminating in the construction of an impact level matrix.

Table 3: Value of Impact Assessment Level of Each Criteria.

AHP Scale	Likert Score	Impact Assessment Level		
		Deterrence Effect	Bargaining Power	Threat Maritime Security
9	5	Very High	Very High	Very High
7-8	4	High	High	High
5-6	3	Medium	Medium	Medium
3-4	2	Low	Low	Low
1-2	1	Very Low	Very Low	Very Low

Source: Modified From: Sudarsana (2021), Liu et al. (Liu et al., 2012) and Nengah Putra et al., (2023).

Table 4: Value of Rating Level Impact Assessment Level of Each Criteria.

Likert Score	Description of Impact Assessment MEF		
	Deterrence Effect	**Bargaining Power**	**Threat Maritime Security**
5	One or more major weaknesses have been identified that make the asset extremely susceptible to an aggressor.	The Organization excellent capability of bargaining the occurrence of the negotiation	The likelihood of a threat, weapon, and tactic being used against the site or building is imminent. Internal decision-makers and/or external law enforcement and intelligence agencies determine the threat is credible. The threat causes a total system loss. An extremely serious consequence that affects national stability
4	One or more major weaknesses have been identified that make the asset Highly susceptible to an aggressor	The Organization has good capability of bargaining the occurrence of the negotiation	The likelihood of a threat, weapon, and tactic being used against the site or building is expected. Internal decision- makers and/or external law enforcement and intelligence agencies determine the threat is credible. The threat causes major system damage. High degree of national stability interruption occurs
3	A weakness has been identified that makes the asset moderately susceptible to an aggressor	The Organization has moderate capability of bargaining the occurrence of a negotiation	The likelihood of a threat, weapon, and tactic being used against the site or building is possible. Internal decision-makers and/or external law enforcement and intelligence agencies determine the threat is known, but is not verified. The threat causes moderate system damage. The threat causes a major degree of national stability interruption occurs
2	A minor weakness has been identified that slightly increases the susceptibility of the asset to an aggressor	The Organization has moderate capability of bargaining the occurrence of a negotiation.	The likelihood of a threat, weapon, and tactic being used in the region is possible. Internal decision-makers and/or external law enforcement and intelligence agencies determine the threat exists, but is not likely. The threat causes marginal system damage.The threat causes a minor degree of national stability interruption occurs
1	Very low susceptibility of the asset to an aggressor.	The Organization has no capability of bargaining the occurrence of a negotiation	The likelihood of a threat, weapon, and tactic being used in the region or against the site or building is very negligible. Internal decision-makers and/or external law enforcement and intelligence agencies determine the threat is non-existent or extremely unlikely. The consequence of the threat is limited.

Source: Modified From: Sudarsana (2021), Liu et al. (Liu et al., 2012) and Nengah Putra et al., (2023).

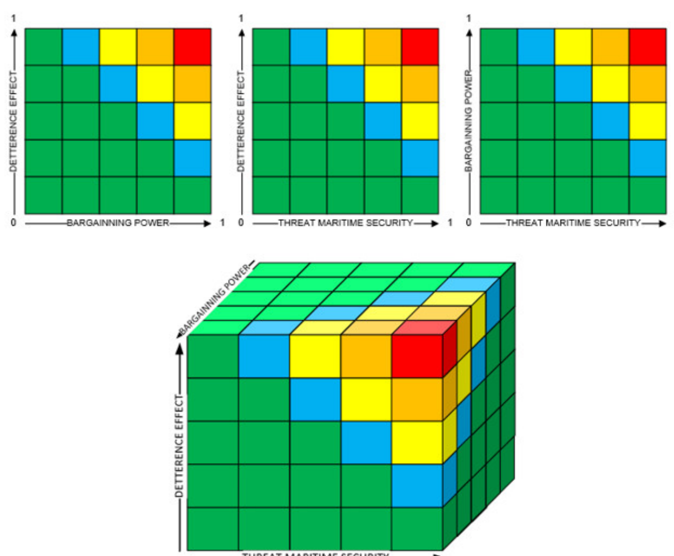
Step 3: Sensitivity Analysis. The final stage involves conducting a sensitivity analysis, which assesses the robustness of the impact factors and strategies. This analysis serves as a critical response mechanism, ensuring the model's adaptability and reliability in reflecting the nuances of real-world scenarios and strategic implications. In this study, we developed and evaluated a hierarchical model through the application of multicriteria decision-making techniques, specifically the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

Table 5: Value Level of Impact Assessment.

Level	Score	Description	Level	Colour
5	0.8-1	No weaknesses exist. The building capability of the stability national interest and an a significant impact on economic and political well-being of the nation.	Very High	
4	0.6-0.799	A minor weakness has been identified that slightly increases the susceptibility of the asset to an aggressor or attack. The building has good capability of resisting the occurrence of a threat security. minor degree of national instability interruption occurs and a minor impact stability on economic and political well-being of the nation	High	
3	0.4-0.599	A weakness has been identified that makes the asset moderately susceptible to an aggressor or attack. The building has moderate capability of resisting the occurrence of a threat. The system operations are interrupted and moderate impact stability on economic and political well-being of the nation.	Medium	
2	0.2-0.399	The impact causes marginal system damage and a minor impact on economic and political well -being of the nation.	Low	
1	0.1-0.199	-One or more major weaknesses have been identified that make the asset extremely susceptible to an aggressor or hazard. The building has no capability of resisting the occurrence of a threat or conflict -Consequence the impact causes a total system loss. An extremely serious consequence that affects national instability operations occurs and a catastrophic impact on economic and political well-being of the nation	Very Low	

Source: Modified From: Sudarsana (2021), Liu et al. (Liu et al., 2012) and Nengah Putra et al., (2023).

Figure 2: 3D of Impact Assessment model.



Source: Modified Form: Nengah Putra et al., (2023) and (Octavian et al., 2020).

To gauge the robustness of the results generated by the AHP-TOPSIS analysis, it is crucial to undertake sensitivity analysis. This is particularly important given the inherent uncertainties in making subjective assessments. Sensitivity analysis, as described by Axelsson et al.,(2021), assesses the dependability of the outcomes by adjusting the weights assigned to the criteria. Specifically, this analysis involved modifying the significance attributed to the most heavily weighted sustainable practices, following the approach by Ali et al.,(2023). In summary, the sensitivity analysis substantiates the reliability and validity of the evaluation results produced by the proposed model.

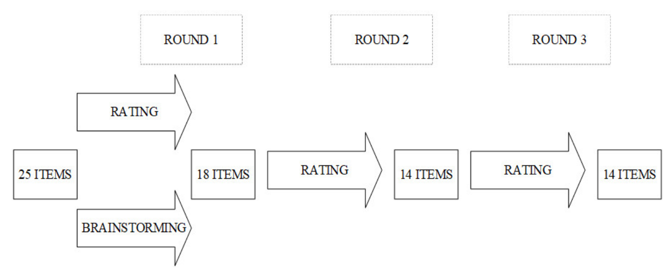
4. Results.

In this segment, we employ the Delphi-AHP-Topsis Methodology to evaluate the ramifications of attaining MEF, categorizing the levels of impact and plotting them within a three-dimensional impact matrix. Initially, the process involves pinpointing the factors influencing impact and formulating developmental strategies. Subsequently, we measure, evaluate, and chart the impacts resulting from achieving MEF. Finally, the assessment's sensitivity is scrutinized.

4.1. Identification of impact factors and development strategies.

This section elaborates on the systematic approach undertaken to finalize the impact factors from three principal aspects: Deterrence Effect, Bargaining Power, and Maritime Security Threat . Given the stringent criteria, this research engaged a panel of 15 maritime field experts to partake in a Delphi survey. The design of the Delphi survey questionnaire was critical to garner insights about the objectives or criteria in each survey round. All panelists, comprising 12 practitioners at the maritime manager level and 3 academics specializing in maritime defense, completed three survey rounds.

Figure 3: Review of various rounds and number of indicators.



Source: Authors.

Round 1: The initial round involved distributing a Google Form questionnaire to the 15 expert panelists. This questionnaire outlined the research and its objectives and included three variable dimensions: 8 items on the deterrence effect, 8 on bargaining power, and 9 on maritime security threats. Utilizing a Likert scale of 1-5 for assessments, the estimated completion time was between 10-15 minutes. The analysis revealed that all dimensions were crucial for constructing the assessment tool, as evidenced by the average importance rating of each dimension being above 3 (mean). Item-CVI scores ranged from 0.40 to 1. validating all items. The set achieved an S-CVI of 85% (≥0.8 is acceptable) and an I-CVI of 87% (I-CVI ≥0.78 is acceptable), with no suggestions for theme or indicator modifications (Lakmini et al., 2023). The first round led to the elimination of 3 deterrence effect items, 2 bargaining power items, and 3 maritime security threat items, narrowing down from 25 to 18 items.

Round 2: Two weeks later, the second round asked experts to assess the CVI of the remaining 18 items across the three dimensions. Item-CVI ranged from 0.67 to 1. again validating all items with a 1-5 Likert scale and maintaining the 10-15 minute completion estimate. This round achieved an S-CVI of 85% and an I-CVI of 81%, reaffirming the fundamental nature of all dimensions, as the average importance rating of each remained above 3. This round resulted in the removal of 4 items related to sub-factors (Economic Resources, Population Size and Market Potential, Wealth of Natural Resources, Geopolitical Dynamics), reducing the item count to 14.

Round 3: After reformulating, the instrument underwent a third evaluation round to assess final validity. The consensus was nearly unanimous, with the I-CVI value at 1 for almost all items, indicating 100% agreement among experts. This resulted in an impressive S-CVI of 98%. Given the very good I-CVI values, this round effectively completed the instrument's overall validity phase, negating the need for further evaluation. All items fell into valid or very valid categories, achieving consensus in the Delphi process.

Table 6: Summarizes the progression and outcomes of expert opinions across rounds 1. 2 and 3 detailing the methodical refinement and validation of the instrument items through expert consensus.

No	Dimension	Item	Round 1			Round 2			Round 3		
			Mean	CVI	Result	Mean	CVI	Result	Mean	CVI	Result
1	Deterrence Effect	Military Capability	4.40	0.93	Accepted	4.40	0.93	Acceptep	4.47	1.00	Accepted
2		Nuclear Deterrence	3.80	0.80	Accepted	3.80	0.80	Accepted	4.00	1.00	Accepted
3		Effective Communication	3.60	0.60	Rejected						
4		Credible Leadership	4.33	0.93	Accepted	4.33	0.93	Accepted	4.33	1.00	Accepted
5		Alliances and Coalitions	4.67	0.93	Accepted	4.67	0.93	Accepted	4.73	0.93	Accepted
6		Negotiation	3.73	0.73	Rejected						
7		Enemy Perceptions and Calculations	3.93	0.67	Rejected						
8		Economic Resources	3.80	0.80	Accepted						
9	Bargaining Power	Economic power	3.80	0.80	Accepted	3.73	0.73	Rejected			
10		Political Influence	4.20	0.93	Accepted	3.80	0.80	Accepted	0.40	1.00	Accepted
11		Aliances International	4.47	0.93	Accepted	4.20	0.93	Accepted	0.54	1.00	Accepted
12		Diplomatic Skills	4.40	0.93	Accepted	4.47	0.93	Accepted	0.50	0.93	Accepted
13		International Laws and Norms	3.20	0.47	Rejected						
14		Population Size and Market Potential	3.80	0.80	Accepted	4.40	0.93	Accepted	0.61	0.93	Accepted
15		Geopolitical Significance	3.60	0.60	Rejected	3.73	0.73	Rejected			
16		Wealth Natural Resources	4.13	0.80	Acceptep	4.00	0.73	Rejected			
17	Maritime Security Threat	Territorial Disputes	4.27	1.00	Accepted	4.27	1.00	Accepted	4.27	1.00	Accepted
18		Piracy	4.33	1.00	Accepted	4.33	1.00	Accepted	4.33	1.00	Accepted
19		Terrorism	4.27	1.00	Accepted	4.27	1.00	Accepted	4.27	1.00	Accepted
20		Illegal Fishing	4.13	1.00	Accepted	4.13	1.00	Accepted	4.13	1.00	Accepted
21		Smuggling	4.40	1.00	Accepted	4.40	1.00	Accepted	4.40	1.00	Accepted
22		Geopolitical dynamics	4.20	0.80	Accepted	4.00	0.67	Rejected			
23		Cybersecurity Risks	3.80	0.73	Rejected						
24		Competition for maritime resources	4.07	0.80	Accepted	4.07	0.80	Accepted	4.33	0.93	Accepted
25		Environmental Damage	3.53	0.60	Rejected						

Source: Authors.

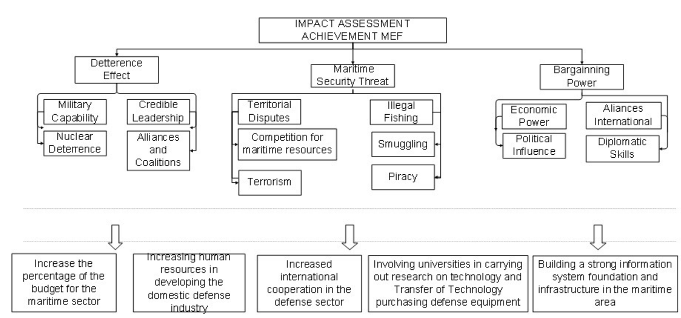
Utilizing information from the final phase, the AHP approach incorporates this data as foundational input for the creation of elements within the pairwise comparison matrix. Strategies for alternative approaches, as gleaned from various literature reviews, primarily emphasize the augmentation of the state budget percentage dedicated to the maritime sector. This entails bolstering the Indonesian Navy and relevant entities' capabilities for conducting maritime crime enforcement operations, with a budgetary provision of 22.587%. Additionally, there's a focus on enhancing maritime infrastructure and connectivity in coastal and border regions to facilitate logistics routes (Kukuh et al., 2019). The government is urged to prioritize human resource development within the domestic industry as a critical aspect of implementing the MEF policy (Andalus dan Djuyandi, 2022).

Moreover, expanding international cooperation in defense and participating in global peace missions under the guidance of the United Nations and other global bodies is vital for contributing to the maintenance of international order and peace (Ardi, Siahaan dan Jandhana, 2022). The involvement of universities in researching technology and ensuring Technology Transfer in every foreign Alutsista purchase are steps towards the independent development of Alutsista (Wardhana dan Soediantono, 2022).

4.2. *Impact Assessment.*

The following step involves organizing a hierarchy that encompasses goals, criteria, and alternatives/strategies. This structure was developed based on the impact assessment factors and subfactors, derived from the Delphi consensus method's outcomes. Additionally, five alternative strategies were identified through literature reviews (Kukuh et al., 2019; Andalus dan Djuyandi, 2022; Ardi, Siahaan dan Jandhana, 2022; Wardhana dan Soediantono, 2022), which include: a) Increasing the allocation of the state budget for the maritime sector (S1), b) Enhancing human resources for the domestic defense industry's development (S2), c) Boosting international cooperation in the defense sector (S3), d) Engaging universities in research on technology and Transfer of Technology (TOT) for defense equipment (S4), and e) Establishing a robust information system and infrastructure in maritime areas (S5).

Figure 4: Impact Assessment Achievement MEF Hierarchy.



Source: Authors.

The identification of impact factors or criteria is essential for conducting the impact assessment analysis in achieving the MEF. To this end, constructing a hierarchical structure serves a critical function in identifying and building correlation relationships among these factors. Specifically, the deterrent effect factor encompasses four subfactors, while the bargaining power factor also includes four subfactors. The maritime security threat factor is comprised of six subfactors. Moreover, the development of an Alternative Strategy for MEF involves five dimensions. All these hierarchical factors are depicted in Figure 4.

Upon establishing the significance of key factors for a valid questionnaire, a Consistency Index (C.I.) of 0.0 and a Consistency Ratio (C.R.) of 0.0 were achieved across 3 main criteria and 14 assessment sub-criteria. This indicates that the questionnaire adheres to the standard consistency criteria, confirming its validity. The relative importance of these key factors, crucial

Table 7: Overall priority weight and ranking of factors and sub-factors.

Impact Factor	Evaluation of Sub Factor	Weight (Prioritized)	Overall Weight (Prioritized)	Rank
Deterrence Effect			1st (Criteria)	
0.400	Military Capability	0.387	0.154	1
	Nuclear Deterrence	0.139	0.055	8
	Credible Leadership	0.198	0.079	5
	Alliances and Coalitions	0.274	0.109	4
Bargaining power			2nd (Criteria)	
0.400	Economic Power	0.278	0.111	3
	Political Influence	0.168	0.067	7
	International Alliance	0.233	0.093	5
	Diplomatic Skills	0.320	0.128	2
Threat Maritime Security			3rd (Criteria)	
0.200	Territorial Disputes	0.246	0.049	9
	Competition for maritime resources	0.216	0.043	10
	Terrorism	0.099	0.019	14
	Illegal Fishing	0.195	0.039	11
	Smuggling	0.115	0.023	13
	Piracy	0.125	0.025	12

Source: Authors.

for the impact assessment analysis towards achieving the MEF, is detailed in Table 7. The application of the Analytic Hierarchy Process (AHP) methodology in this research underscores the significance of deterrence effect and bargaining power criteria, which collectively account for 40% of the importance, while the aspect of maritime security threat is valued at 20%.

Among the 14 assessment sub-criteria, the five most critical are military capability (15.4%), diplomatic skills (12.8%), economic power (11.1%), alliances and coalitions (10.9%), and credible leadership (7.9%). The dominance of military capability and diplomatic skills as sub-criteria highlights the challenges faced by Indonesian defense sector policymakers in ensuring national stability.

Following the determination of the weights for the impact assessment criteria, a scheme for questionnaire selection was developed. This scheme assesses the impact of the five dimensions of alternative strategies on the aspects of deterrence effect, bargaining power, and maritime security threat. The goal is to identify the ideal positive solution that is most distanced from the negative ideal solution. Priority is given to the most suitable strategies using a 5-step index scale, ensuring all variables achieve their maximum value.

Table 8: Impact assessment value of deterrence effect.

Alternative	D+	D-	Result	Rank	Level
S1	0.000	0.006	1.000	1	Very High
S2	0.001	0.006	0.896	3	Very High
S3	0.001	0.006	0.927	2	Very High
S4	0.006	0.003	0.299	5	Low
S5	0.002	0.006	0.706	4	High

Source: Authors.

Table 8 reveals how the different strategies rank in terms of their contribution to the deterrence effect aspect. Among the five strategies evaluated, three are identified as having a very high impact level. These include: 1) increasing the allocation of the state budget for the maritime sector (S1), 2) enhancing international cooperation in the defense sector (S3), and 3) bolstering human resources for the development of the domestic defense industry (S2), with proximity coefficients of 1.00. 0.927, and 0.896, respectively. Additionally, the strategy of establishing a robust information system and infrastructure in the maritime area (S5) is recognized at a high level, with a closeness coefficient of 0.706. Conversely, the strategy involving universities in technology research and Transfer of Technology (TOT) for purchasing defense equipment (S4) is categorized at a low level with a coefficient of 0.299.

Table 9: Impact assessment value of bargaining power.

Alternative	D+	D-	Result	Rank	Level
S1	0.000	0.006	1.000	1	Very High
S2	0.001	0.006	0.871	3	Very High
S3	0.001	0.006	0.900	2	Very High
S4	0.005	0.002	0.300	5	Low
S5	0.002	0.005	0.718	4	High

Source: Authors.

Referring to Table 9, within the context of the deterrence effect, an analysis of the five strategic dimensions reveals three that are classified at a very high level of impact. These are: 1) the increase in the state budget allocation for the maritime sector (S1), 2) the enhancement of international cooperation in the defense sector (S3), and 3) the strengthening of human resources in the development of the domestic defense industry (S2), with respective proximity coefficients of 1.00. 0.900. and 0.871. Additionally, the strategy aimed at developing a strong information system and infrastructure in the maritime area (S5) is ranked at a high level, with a closeness coefficient of 0.718. On the other hand, the strategy that involves universities in technology research and the Transfer of Technology (TOT) for purchasing defense equipment (S4) is placed in the low category, indicated by a coefficient of 0.300.

Table 10: Impact assessment value of threat maritime security.

Alternative	D+	D-	Result	Rank	Level
S1	0.001	0.010	0.933	1	Very High
S2	0.002	0.010	0.823	3	Very High
S3	0.001	0.010	0.878	2	Very High
S4	0.010	0.001	0.074	5	Very Low
S5	0.002	0.009	0.821	4	Very High

Source: Authors.

Table 10 illustrates the assessment of the deterrence effect aspect among five strategic dimensions, where four are rated at a very high level of impact. These strategies include: 1) increasing the state budget allocation for the maritime sector (S1), 2) enhancing international cooperation in the defense sector (S3), 3) strengthening human resources for the development of the domestic defense industry (S2), and 4) developing a strong information system and infrastructure in the maritime area (S5), with proximity coefficients of 0.933; 0.878; 0.823; and 0.821 respectively. Conversely, the strategy involving universities in research on technology and Transfer of Technology (TOT) for defense equipment purchasing (S4) is identified at a very low level, with a closeness coefficient of 0.074.

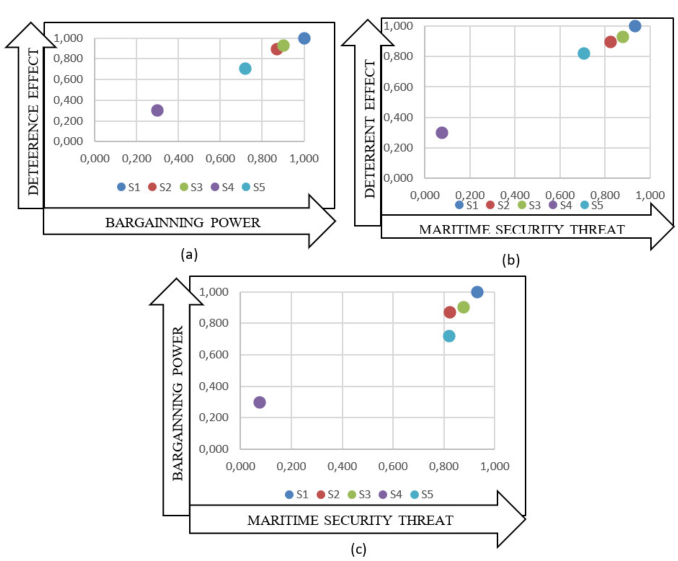
Table 11: Impact assessment evaluation value level of strategy MEF.

Dimension	D	B	T	Impact Score	Impact Level	Color
S1	1.00	1.00	0.93	0.933	Very High	
S2	0.89	0.87	0.82	0.642	High	
S3	0.92	0.90	0.87	0.733	High	
S4	0.29	0.30	0.07	0.007	Very Low	
S5	0.70	0.71	0.82	0.416	Medium	

Source: Authors.

The concluding phase of the impact assessment analysis involves establishing a reference value to ascertain the definitive level of impact achievement. This determination hinges on three pivotal variables: The Deterrence effect (D), Bargaining power (B), and Maritime security threat (T). Given the multidimensional nature of these factors, adopting a 3D model offers the most appropriate means to visualize and understand the impact levels comprehensively. This 3D approach facilitates a spatial representation of how each variable interacts with the others, thereby providing a clearer depiction of their collective influence on the overall assessment.

Figure 5: Results of the 3D Matrix for MEF impact assessment.



Source: Authors.

In Table 11 and Figure 5. which present the results of the impact calculations for the five MEF competitive strategies, it is observed that these strategies vary significantly in their impact levels, ranging from very high to very low. Specifically, two strategies are identified as having a high impact: the first involves enhancing human resources for the development of the domestic defense industry (Strategy 2), which has impact values of 0.642 and 0.733. In stark contrast, two strategies are noted for their very low impact: increasing the allocation of the state budget for the maritime sector (Strategy 1) and fostering university involvement in research and technology transfer (TOT) for defense equipment purchases (Strategy 4), with respective impact values of 0.933 and 0.007. The strategy aimed at establishing a robust information system and infrastructure foundation in maritime areas (Strategy 5) is assessed to have a medium impact. In summary, the overall impact of implementing these MEF competitive strategies in the North Natuna Sea region of Indonesia is categorized as Medium.

4.3. Sensitivity Analysis.

Table 12: Weights of different scenarios on factors affecting the deterrence.

DETERRENCE EFFECT	Derived	Scen 1	Scen 2	Scen 3	Scen 4
Military Capability	0.387	**0.387**	0.287	0.267	0.242
Nuclear Deterrence	0.140	0.204	**0.140**	0.267	0.242
Credible Leadership	0.198	0.204	0.287	**0.198**	0.242
Alliances and Coalitions	0.275	0.204	0.287	0.267	**0.275**

Source: Authors.

Table 13: Relative closeness values with different scenarios on deterrence factor.

Relative closeness value	Derived	Scen 1	Scen 2	Scen 3	Scen 4
Territorial Disputes	1.000	1.000	1.000	1.000	1.000
Piracy	0.896	0.886	0.844	0.876	0.853
Terrorism	0.927	0.891	0.924	0.846	0.862
Illegal Fishing	0.299	0.327	0.417	0.361	0.408
Smuggling	0.706	0.684	0.587	0.660	0.606

Source: Authors.

Table 12 explores variations in the deterrence dimension by altering the weight distributions across different scenarios, deviating from the baseline results. This examination includes four distinct scenarios. In the first scenario, the weight assigned to the military capability criterion remains unchanged, with the subsequent four criteria receiving equal weighting. This process is methodically applied from the second scenario through to the fourth, adjusting the weight for each subsequent sub criterion. The relative closeness values derived under these varying scenarios are presented in Table 13.

Table 14: Weights given in different scenarios on bargaining factors.

BARGAINING POWER	Derived	Scen 1	Scen 2	Scen 3	Scen 4
Economic Power	0.278	**0.278**	0.277	0.256	0.227
Political Influence	0.169	0.241	**0.169**	0.256	0.227
International Alliance	0.233	0.241	0.277	**0.233**	0.227
Diplomatic Skills	0.320	0.241	0.277	0.256	**0.320**

Source: Authors.

Table 15: Relative closeness values with different scenarios on deterrence factor.

Relative closeness value	Derived	Scen 1	Scen 2	Scen 3	Scen 4
Territorial Disputes	1.000	1.000	1.000	1.000	1.000
Piracy	0.871	0.863	0.841	0.867	0.873
Terrorism	0.900	0.854	0.894	0.846	0.866
Illegal Fishing	0.300	0.405	0.323	0.423	0.376
Smuggling	0.718	0.609	0.703	0.590	0.637

Source: Authors.

Table 14 presents the impact of modifying the weights within the deterrence aspect to identify deviations from the initial findings. This analysis comprises four scenarios. In the first scenario, the economic power criterion retains its original weight, and the remaining four criteria are assigned equal weights. This approach is sequentially applied from the second through to the fourth scenario, adjusting the focus to each subsequent sub-criterion. The relative closeness values derived from these varied scenarios are documented in Table 15.

Table 16: Weights given in different scenarios on threat factors.

MARITIME SECURITY THREAT	Derived	Scen 1	Scen 2	Scen 3	Scen 4	Scen 5	Scen 6
Territorial Disputes	0.247	**0.247**	0.157	0.180	0.161	0.177	0.175
Piracy	0.217	0.151	**0.217**	0.180	0.161	0.177	0.175
Terrorism	0.100	0.151	0.157	**0.100**	0.161	0.177	0.175
Illegal Fishing	0.196	0.151	0.157	0.180	**0.196**	0.177	0.175
Smuggling	0.115	0.151	0.157	0.180	0.161	**0.115**	0.175
Competition for maritime resources	0.126	0.151	0.157	0.180	0.161	0.177	**0.126**

Source: Authors.

Table 17: Relative closeness values with different scenarios on threat factor.

Relative closeness value	Derived	Scen 1	Scen 2	Scen 3	Scen 4	Scene 5	Scene 6
Territorial Disputes	0.933	0.912	0.916	0.899	0.909	0.933	0.906
Piracy	0.823	0.789	0.799	0.760	0.782	0.771	0.822
Terrorism	0.878	0.851	0.858	0.829	0.846	0.845	0.868
Illegal Fishing	0.074	0.088	0.084	0.100	0.091	0.102	0.068
Smuggling	0.821	0.876	0.837	0.858	0.872	0.855	0.868

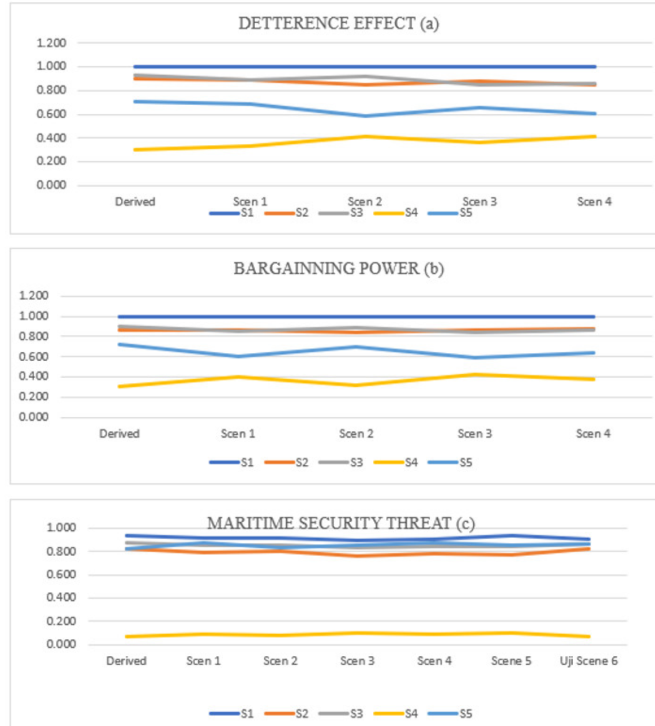
Source: Authors.

Table 16 presents an analysis of how altering the weights within the deterrence aspect influences deviations from the baseline outcomes. This section encompasses six scenarios. In the initial scenario, the territorial dispute criterion retains its original weight, and the other six criteria are allocated equal weights. This methodology is systematically applied from the second scenario, focusing on the second sub-criterion, through to the sixth scenario, each time adjusting the weight for one of the sub-criteria. The relative closeness values derived from these various scenarios are compiled in Table 17.

The outcomes of the sensitivity analysis, as depicted in Figure 6, indicate minimal variations in the ranking order across different scenarios, affirming that increasing the (state budget) allocation for the maritime sector (Scenario 1) consistently emerges as a viable strategy in all tested scenarios. This consistency underscores the robustness of the proposed model.

The methodology for evaluating the impact of MEF achievements on the strategic environment in the North Natuna Sea

Figure 6: The Results of 3D Sensitivity Analysis.



Source: Authors.

region was crafted around 3D models and a comprehensive hybrid decision support system. This approach was tailored for application across various maritime defense activities, incorporating adjustments to impact factors and exploring alternative MEF development strategies. A key innovation of this method is the development of a 3D impact assessment model that integrates the three critical elements of deterrence effect, bargaining power, and maritime security threat. This model stands out as a significant advancement in maritime defense research due to its novelty. Furthermore, the application of both the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) in the case research demonstrates compatibility between these methods.

5. Implication.

Theoretical Implications: This research sheds light on the qualitative aspects of managing defense strategies within the maritime sphere of Indonesia, an area witnessing annual technological advancements and shifts in the stability of its strategic environment, alongside evolving threats to maritime security. It offers a foundational step for stakeholders aiming to evaluate and develop a 3D model-based framework for impact assessment. This tool is pivotal for policy strategy formulation, leveraging the solutions identified through this research. The proposed framework facilitates a self-assessment of capabilities by state actors, enabling them to benchmark against competitors and strategize for enhancing their regional defense competitiveness.

Practical and Managerial Contributions: This research stands to benefit practitioners and decision-makers by acquainting them with novel methodologies. It introduces a conceptual model for assessing the minimum base force, aimed at aiding policymakers in defense capability development. The anticipated outcome is to guide stakeholders in shaping future policies for Minimum Essential Force (MEF) enhancement. Furthermore, from a governmental standpoint, the proposed model is expected to play a significant role in managing territorial disputes, thus aiding in the preservation of national and regional stability. It positions itself as a strategic tool for negotiation, offering leverage in the context of the South China Sea disputes.

Conclusions.

This research employs a 3D impact assessment analysis, developed specifically to evaluate the dimensions and impacts of interventions in the North Natuna sea area of Indonesia. Utilizing a 3D matrix approach that integrates Delphi, AHP (Analytic Hierarchy Process), and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), this method proves to be an effective and efficient means of identifying key factors, and assessing and analyzing the impacts toward achieving MEF objectives. This framework facilitates the balancing and comparison of impacts stemming from different elements of maritime defense capabilities, while also building a database enriched with factual data. It supports the identification and comparative analysis of 14 subfactors.

Adopting new models within impact assessment is highlighted as a notable advantage of this analytical approach. When applied to the maritime domain of Indonesia, the framework reveals advancements in maritime defense analysis models compared to other methodologies. In terms of impact factors, the research identifies three primary subfactors: Military Capability (37.8%), Diplomatic Skills (32%), and Economic Power (27.8%), with Military Capability and Diplomatic Skills emerging as the most significant sub-criteria in the impact assessment.

From the 3D impact assessment analysis, five Strategy Dimensions were pinpointed as exhibiting either a Very High or a Very Low impact level. The strategies with the highest impact scores involve increasing the (state budget) allocation for the maritime sector (S1) and promoting university involvement in technological research and Transfer of Technology (TOT) for defense equipment (S4), scoring 0.933 and 0.007, respectively.

The sensitivity analysis indicates minimal variation in the ranking order across different scenarios, affirming the robustness of the proposed model. This analysis suggests that adjusting the weights and scores used in evaluating competitive strategies can enhance decision-making processes, as it demonstrates the significant role these factors play in strategy ranking.

This research acknowledges several limitations that pave the way for future research avenues. Firstly, while the research successfully identifies key factors influencing maritime security threats, there is a pressing need to develop a comprehensive framework that encompasses both tangible and intangible threat factors. This is identified as a critical direction for subsequent research. Secondly, future studies should aim to incorporate additional selection criteria and explore diverse impact assessment models, including the involvement of individual, organizational, and policy-level actors, to ensure a more exhaustive evaluation. Lastly, given the dynamic nature of impact assessments in the evolving strategic landscape of MEF competitive, this research does not delve into sustainability assessments in strategic dimensions. Future research could significantly benefit from offering simulation-based analyses focused on sustainability, recognized as linking variables, and two were classified as dependent, illustrating a complex network of interactions. Notably, the absence of factors in the autonomous category emphasizes the significance of each factor within the coastal defense framework.

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References.

Ahmad, O.F. et al. (2021) "Establishing key research questions for the implementation of artificial intelligence in colonoscopy: A modified Delphi method," Endoscopy, 53(9), hal. 893–901. Tersedia pada: https://doi.org/10.1055/a-1306-7590.

Akter, S., Debnath, B. dan Bari, A.B.M.M. (2022) "A grey decision-making trial and evaluation laboratory approach for evaluating the disruption risk factors in the Emergency Life-Saving Drugs supply chains Healthcare Analytics A grey decision-making trial and evaluation laboratory approach for evaluating," Healthcare Analytics, 2(October), hal. 100120. Tersedia pada: https://doi.org/10.1016/j.health.2022.100120.

Ali, S.S., Kaur, R. dan Khan, S. (2023) "Evaluating sustainability initiatives in warehouse for measuring sustainability performance: an emerging economy perspective," Annals of Operations Research, 324(1–2), hal. 461–500. Tersedia pada: https://doi.org/10.1007/s10479-021-04454-w.

Almanasreh, E., Moles, R. dan Chen, T.F. (2018) "Research in Social and Administrative Pharmacy Evaluation of methods used for estimating content validity," Research in Social and Administrative Pharmacy, (xxxx), hal. 0–1. Tersedia pada: https://doi.org/10.1016/j.sapharm.2018.03.066.

Andalus, M.K. dan Djuyandi, Y. (2022) "Analisis Implementasi Kebijakan Pengadaan Alutsista Ri Dalam Kerangka Kebijakan Minimum Essential Force (Mef) Pada Tahun 2020 . . . ," Aliansi: Jurnal Politik, Keamanan Dan . . . , 1(3), hal. 175–188. Tersedia pada: https://doi.org/10.24198/aliansi.v1i3.44009.

Ardi, A.A.Z.H., Siahaan, T. dan Jandhana, I.P. (2022) "KEBIJAKAN PUBLIK PERTAHANAN NEGARA INDONESIA," Citizen : Jurnal Ilmiah Multidisiplin Indonesia, 2 (1), hal. 81–87. Tersedia pada: https://doi.org/10.53866/jimi.v2i1.40.

Axelsson, C., Giove, S. dan Soriani, S. (2021) "Urban pluvial flood management part 1: Implementing an ahp-topsis multicriteria decision analysis method for stakeholder integration in urban climate and stormwater adaptation," Water (Switzerland), 13(17). Tersedia pada: https://doi.org/10.3390/w13172422.

Baskoro, H. (2017) "The Role of Awareness , Motivation and Capability on the Competitive Reaction of Middle and Lower Managers of Private Higher Education," hal. 8178–8189.

Bond, A. dan Pope, J. (2012) "The state of the art of impact assessment in 2012," Impact Assessment and Project Appraisal, 30 (1), hal. 1–4. Tersedia pada: https://doi.org/10.1080/14615-517.2012.669140.

Chadhafi, M.I. (2021) Peningkatan Kualitas Industri Pertahanan Strategis Guna Membangun Kekuatan Pertahanan Maritim dalam rangka Mewujudkan Visi Poros Maritim Dunia.

Chen, M. (2009) "Competitive dynamics research : An insider ' s odyssey," hal. 5–25. Tersedia pada: https://doi.org/10-.1007/s10490-008-9110-7.

Chen, M. dan Miller, D. (2012) "Competitive Dynamics : Themes , Trends , and a Prospective Research Platform," 6 (1), hal. 135–210.Dugis, V. (2018) Teori Hubungan Internasional ; Perspektif-Perspektif Klasik.

Ervin, A.F.M. (2022) "Dampak Kerjasama Pertahanan Indonesia dan Amerika Serikat terhadap Pencapaian Minimum Essential Force (MEF) Tahap II," Global and Policy Journal of International, 10 (2), hal. 26–40. Tersedia pada: http://ejournal.-upnjatim.ac.id/index.php/jgp/article/view/3746%0Ahttp://ejournal.upnjatim.ac.id/index.php/jgp/article/viewFile/3746/2121.

Fletcher, G. dan Griffiths, M. (2020) "Digital transformation during a lockdown," International Journal of Information Management, 55(June), hal. 10–12. Tersedia pada: https://doi.-org/10.1016/j.ijinfomgt.2020.102185.

Flostrand, A., Pitt, L. dan Bridson, S. (2020) "The Delphi technique in forecasting– A 42-year bibliographic analysis (1975–2017)," Technological Forecasting and Social Change, 150(January 2018), hal. 119773. Tersedia pada: https://doi.org/-10.1016/j.techfore.2019.119773.

Harry, M. dan Nugraha, R. (2017) "Muhammad Harry Riana Nugraha / Indonesian Future Strategic Defense Planning /207-220 Indonesian Future Strategic Defense Planning."

Hasanah, R. (2016) "Decision Support System Validation Recipient Program Keluarga Harapan (PKH) in Wonosari District using AHP- TOPSIS Method," 5 (2), hal. 111–121.

Hwang, C.L. dan Yoon, K. (1981) Multiple attribute decision making: Methods and applications. New York: Springer-Verlag. Tersedia pada: https://doi.org/10.1007/978-3-642-483-18-9.I.N.

Putra, Amarulla Octavian, A.K.S. (2023) "A hybrid AHP-TOPSIS for risk analysis in maritime cybersecurity based on 3D models I," Decision Science Letters, 12(2023), hal. 759–772. Tersedia pada: https://doi.org/10.5267/dsl.2023.6.005.

Iskandar, I.F.R., Wibisono, M. dan Supandi (2019) "Diplomasi Pertahanan Indonesia terhadap Kebijakan Minimum Essential Force di Kementerian Pertahanan," Jurnal Diplomasi Pertahanan, 5 (2), hal. 51–83. Tersedia pada: https://www.ukessays.com/essays/business/the-.

John, B. (2002) "Strategy in the Contemporary World: An Introduction to Strategic Studies," Scientia Militaria - South African Journal of Military Studies, 31 (1). Tersedia pada: https://doi.org/10.5787/31-1-149.

Karakikes, I. dan Nathanail, E. (2020) "Using the delphi method to evaluate the appropriateness of urban freight transport solutions," Smart Cities, 3(4), hal. 1428–1447. Tersedia pada: https://doi.org/10.3390/smartcities3040068.

Kaya, T. dan Kahraman, C. (2011) "An integrated fuzzy AHP-ELECTRE methodology for environmental impact assessment," Expert Systems with Applications, 38(7), hal. 8553–8562. Tersedia pada: https://doi.org/10.1016/j.eswa.2011.01.0-57.

Kennedy, P.S.J. (2023) "Indonesian Defense Industry and Minimum Essential Force," International Research Journal of Economics and Management Studies IRJEMS, 2 (2), hal. 138–142. Tersedia pada: https://doi.org/10.56472/25835238/IRJE-MS-V2I2P116.

Khalilzadeh, M., Katoueizadeh, L. dan Zavadskas, E.K. (20-20) "Risk identification and prioritization in banking projects of payment service provider companies: an empirical study," Frontiers of Business Research in China, 14 (1). Tersedia pada: https://doi.org/10.1186/s11782-020-00083-5.

Kukuh, A. et al. (2019) Analysis of National Maritime Security Strategy as an Effect of Regional Development using SWOT, Fuzzy Multi Criteria Decision Making (FMCDM) and Borda.

Lakmini, N. et al. (2023) "International Journal of Disaster Risk Reduction Developing a hospital disaster preparedness evaluation tool for Sri Lanka - A modified Delphi study," International Journal of Disaster Risk Reduction, 95(July), hal. 103866. Tersedia pada: https://doi.org/10.1016/j.ijdrr.2023.10-3866.

Laurin, L. dan Dhaliwal, H. (2017) Life Cycle Environmental Impact Assessment, Encyclopedia of Sustainable Technologies. Elsevier. Tersedia pada: https://doi.org/10.1016/B978-0-12-409548-9.10060-0.

Liu, C. et al. (2012) "The security risk assessment methodology," Procedia Engineering, 43(65), hal. 600–609. Tersedia pada: https://doi.org/10.1016/j.proeng.2012.08.106.

Marisa, R. da silva; R. de C. (2021) "Contributions of the Delphi technique to the validation of an occupational therapy assessment in the visual impairment field 1," Brazillian Journal of Occupational Theraphy, hal. 1–15.

Marsetio (2014) "Manajemen strategis negara maritim dalam perspektif ekonomi dan pertahanan," (November).

Namazi, M. dan Mohammadi, E. (2018) "Natural resource dependence and economic growth: A TOPSIS/DEA analysis of innovation efficiency," Resources Policy, 59(August), hal. 544–552. Tersedia pada: https://doi.org/10.1016/j.resourpol.2018.-09.015.

Nengah Putra, I.A. (2023) "Decision Science Letters," Decision Science Letters, 8(2023), hal. 429–440. Tersedia pada: https://doi.org/10.5267/dsl.2023.6.005.

Nguyen, H.N. et al. (2022) "Datasets of skills-rating questionnaires for advanced service design through expert knowledge elicitation," Scientific Data, 9 (1), hal. 1–7. Tersedia pada: https://doi.org/10.1038/s41597-022-01421-3.

Octavian, A. et al. (2020) "Risk analysis of islamic state (Is) network development in southeast asia based on 3d matrix," International Journal of Operations and Quantitative Management, 26 (2), hal. 195–223. Tersedia pada: https://doi.org/10.-46970/2020.26.3.3.

Penfield, T. et al. (2014) “Assessment, evaluations, and definitions of research impact: A review,” Research Evaluation, 23 (1), hal. 21–32. Tersedia pada: https://doi.org/10.1093/reseval/-rvt021.

Pope, J. et al. (2013) “Advancing the theory and practice of impact assessment: Setting the research agenda,” Environmental Impact Assessment Review, 41, hal. 1–9. Tersedia pada: https://doi.org/10.1016/j.eiar.2013.01.008.

Quatrini Carvalho Passos Guimarães, H.C. et al. (2016) “Experts for Validation Studies in Nursing: New Proposal and Selection Criteria,” International Journal of Nursing Knowledge, 27 (3), hal. 130–135. Tersedia pada: https://doi.org/10.1-111/2047-3095.12089.

Ribeiro, A.S. et al. (2021) “A Delphi method to classify wave energy resource for the 21st century: Application to the NW Iberian Peninsula,” Energy, 235, hal. 121396. Tersedia pada: https://doi.org/10.1016/j.energy.2021.121396.

Roya, F. dan Behrooz, F. (2017) “Item Selection and Content Validity of the Risk Factors of Post-Intubation Tracheal Stenosis Observation Questionnaire for ICU-Admitted Patients Study design,” 16 (1), hal. 22–33.

Saaty, T.L. (1990) “How to make a decision: The analytic hierarchy process,” European Journal of Operational Research, 48 (1), hal. 9–26. Tersedia pada: https://doi.org/10.1016/0377-2217(90)90057-I.

Santiko, U. dan Agustien, M.D. (2022) “Kerja Sama Industri Pertahanan Indonesia-Perancis Dalam Memenuhi Minimum Essential Force Tentara Nasional Indonesia Tahun 2015-2019,” Mjir) Moestopo Journal International Relations, 2 (1), hal. 77–90.

Saragih, H.M. (2018) “Diplomasi Pertahanan Indonesia Dalam Konflik Laut China Selatan,” Jurnal Ilmu Politik dan Komunikasi, 8 (1). Tersedia pada: https://doi.org/10.34010/jipsi.-v8i1.880.

Scherrer, V. (2023) “Geneva Centre for the Democratic Control of Armed Forces Chapter Title: Impact Assessment: Approaches and Methodologies Book Title: Measuring the Impact of Peacebuilding Interventions on Rule of Law and Security Institutions,” hal. 9–30. https://about.jstor.org/terms.

Schofield, C. (2016) “Untangling a Complex Web: Understanding Competing Maritime Claims in the South China Sea.” ISEAS–Yusof Ishak Institute, hal. 21–46. Tersedia pada: https-://www.cambridge.org/core/product/5CAA47D4B7C8AA97FD-35CF9B2D2E73AA (Diakses: 1 Agustus 2023).

Singh, P.K. dan Sarkar, P. (2019) “A framework based on fuzzy AHP-TOPSIS for prioritizing solutions to overcome the barriers in the implementation of ecodesign practices in SMEs,” International Journal of Sustainable Development and World Ecology, 26(6), hal. 506–521. Tersedia pada: https://doi.org/10-.1080/13504509.2019.1605547.

Stancine, K. et al. (2019) “Development and content validation of an instrument to support pharmaceutical counselling for dispensing of prescribed medicines,” (September 2018), hal. 1–8. Tersedia pada: https://doi.org/10.1111/jep.13102.

Sudarsana, D.K. (2021) “A concept model to scale the impact of safety risk in a construction project using a semi quantitative method,” Civil Engineering and Architecture, 9 (1), hal. 263–269. Tersedia pada: https://doi.org/10.13189/cea.2021.0-90122.

Tamasila, M. et al. (2020) “Evaluating and prioritizing municipal solid waste management-related factors in Romania using fuzzy AHP and TOPSIS,” Journal of Intelligent and Fuzzy Systems, 38 (5), hal. 6111–6127. Tersedia pada: https://doi.org-/10.3233/JIFS-179695.

Tuzemen, A. (2020) “WHICH YOUTUBER SHOULD BE FOLLOWED ? A COMPARISON BASED DELPHI-AHP-TOPSIS 2 . YouTube Platform and YouTuber,” International Journal of Contemporary Economics and Administrative Sciences, hal. 451–467.

Utomo, H., Prihantoro, M. dan Adriana, L. (2017) “Peran Pemerintah Indonesia Dalam Mengelola Konflik Laut China Selatan,” Prodi Damai dan Resolusi Konflik, 3 nomor 3, hal. 63–88.

Wardhana, M.A. dan Soediantono, D. (2022) “Analisis Strategi Pemberdayaan Industri Pertahanan Nasional Dalam Mendukung Terwujudnya Minimum Essential Force,” Journal of Industrial Engineering & Management Research, 3 (5), hal. 32–38.

Widiasih et al (2015) “Prosiding Seminar Nasional Manajemen Teknologi XXIII Program Studi MMT- ITS, Surabaya 1 Agustus 2015 Identifikasi Risiko Pada Saat Implementasi Lean Manufacturing Dengan Metode Delp...,” (January 2016).

Widiasih, W., Karningsih, P.D. dan Ciptomulyono, U. (2015) “Development of Integrated Model for Managing Risk in Lean Manufacturing Implementation: A Case Study in an Indonesian Manufacturing Company,” Procedia Manufacturing, 4(Lm), hal. 282–290. Tersedia pada: https://doi.org/10.1016/j.promfg.2015-.11.042.

Woo, A. et al. (2021) “An Analysis of the Competitive Actions of Boeing and Airbus in the Aerospace Industry Based on the Competitive Dynamics Model,” Journal of Open Innovation: Technology, Market, and Complexity, 7 (3), hal. 192. Tersedia pada: https://doi.org/10.3390/joitmc7030192.

Yang, W. et al. (2018) “Integrated flood vulnerability assessment approach based on TOPSIS and Shannon entropy methods,” Ecological Indicators, 89(December 2017), hal. 269–280. Tersedia pada: https://doi.org/10.1016/j.ecolind.2018.02.015.

Zio, S. Di dan Maretti, M. (2015) Acceptability of energy sources using an integration of the Delphi method and the analytic hierarchy process. Tersedia pada: https://doi.org/10.1007/-s11135-013-9935-0.

Zytoon, M.A. (2020) “A Decision Support Model for Prioritization of Regulated Safety Inspections Using Integrated Delphi , AHP and Double-Hierarchical TOPSIS Approach,” 8. Tersedia pada: https://doi.org/10.1109/ACCESS.2020.2991179.