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# A System Dynamics Model for the Sustainability of Naval Capabilities Toward Indonesia Maritime Security

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*ABSTRACT*

Sustainability in the development of naval capabilities plays a crucial role to ensure national maritime security in future wars. This study seeks to provide an analysis of the sustainability framework for the enhancement of naval capabilities in the context of national maritime security. This study uses descriptive statistics, supported by the system dynamics (SD) model. Eight personnel, including academicians and practitioners, participated in the research, which was conducted between January 2022 and February 2023. Based on the study findings, it is projected that the value of naval capabilities will range from 3.77 to 3.78 between 2022 and 2027, indicating a highly capable status (level 4). However, there will be a slight decline in naval capabilities from 2022 to 2024, and naval capabilities will dynamically experience a slight decline. Subsequently, between 2024 and 2027, the naval capability is predicted to slowly increase, remaining within the range of 3.78 (highly capable). The development and establishment of naval capabilities are influenced by various factors, including dynamic and uncertain external and internal threats. Nonetheless, through the strengthening of capabilities, the addition of main equipment and weapon systems, and strategic operational patterns, there will be a gradual enhancement of defense capabilities. This, in turn, will facilitate the promotion and preservation of territorial claims and national interests, ultimately upholding national maritime security..



## 1. Introduction.

Indonesia is an archipelagic country located in Southeast Asia and Oceania. It occupies a strategic position between Asia and Australia, with the Pacific Ocean and the Indian Ocean surrounding its shores. Covering a vast land area of 1.9 million square kilometers, Indonesia ranks as the 14th largest country in the world in terms of landmass (Teniwut et al., 2019). One notable feature of Indonesia is its extensive coastline, stretching over 54,000 kilometers. Additionally, the country boasts an exclusive economic zone (EEZ) spanning approximately 6.1 million square kilometers. Its geographical location has made it a vital sea lane connecting the Pacific Ocean and the Indian Ocean. With around 40% of global maritime traffic passing through Indonesian waters, it serves as a vital pathway for international trade and commerce (Rochwulaningsih et al., 2019). The Indonesian Sea is the world's largest sea and plays an important role in international trade, national defense, and natural resource management (Kipgen, 2021).

This vast maritime territory is crucial for Indonesia's economic growth and national security. However, Indonesia faces significant challenges in ensuring its maritime security (Rismana et al., 2021). One of the primary challenges is illegal, unreported, and unregulated (IUU) fishing. Additionally, piracy and armed robbery at sea present a formidable challenge. The waters around Indonesia are among the most dangerous in the world in terms of piracy and armed robbery. Moreover, Indonesia must confront non-traditional security threats, including the degradation of marine environments and the impact of climate change. These threats have the potential to negatively affect the country's maritime resources and ecosystems. Furthermore,

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terrorism also poses a threat to Indonesia's maritime security (Maulana, 2022).

Indonesia has taken steps to improve its counterterrorism capabilities by implementing various measures, including strengthening its coast guard and strengthening intelligence sharing with international partners. In response, Indonesia has stepped up its maritime security efforts by deploying more naval assets, conducting joint patrols with neighboring countries, and enhancing information sharing (Gartzke & Lindsay, 2020). The Indonesian Navy (TNI AL), as a state element, bears a fundamental duty to maintain the defense and security of the country's maritime territory (Susilo et al., 2019b).

Collin (2015) suggests the need for an analysis of the common challenges faced by the Navy in the current landscape, including competing defense budget requirements, geopolitical uncertainties, and mounting strategic pressures. Susilo et al. (2019b) proffer that it is imperative to increase the allocation of the state budget towards the maritime sector, thereby enhancing the capabilities of the Indonesian Navy. Noraini et al. (2020), Furthermore, an analysis of the modernization of the TNI-AL is crucial to augment the capabilities of the Green Water Navy, enabling it to effectively respond to dynamic threats. A comprehensive approach to threat-based and capability-based planning and projections is necessary to develop the strength of the TNI-AL for the future (Laksmana 2014). Additionally, capability-based planning analysis is vital in preparing for future wars, as emphasized by Putra (2021). Therefore, research focusing on the analysis of the Indonesian naval capability development in addressing maritime security threats is essential to ensure its readiness and effectiveness.

The objective of this research is to analyze the sustainability framework of the naval capabilities required for national maritime security. This research holds significant importance for several reasons. Firstly, it aids in assessing the preparedness of the navy to effectively address various types of threats. A comprehensive analysis encompasses factors such as the navy's size, composition, and capacity to operate in diverse environments, including coastal zones and the high seas. Such information is vital for policymakers when making decisions regarding defense expenditures and resource allocation. Secondly, an analysis of naval capabilities assists in identifying potential vulnerabilities. By understanding the areas where the Navy may be susceptible, appropriate measures can be taken to address and mitigate those vulnerabilities. Lastly, analyzing naval capabilities contributes to enhancing stability and deterrence. A strong naval presence by countries within a region serves as a deterrent to potential aggressors, effectively preventing conflict escalation and fostering increased stability.

To accomplish our research objectives, we begin by establishing a sustainability framework for the development of naval capabilities. This framework consists of three subsystems: strength, capability, and pattern of operation. The study employs a qualitative descriptive statistical method approach, complemented by the system dynamics (SD) model built by STELLA 9. This combination allows us to identify key factors, interactions, and feedback mechanisms within the urban subsystems. Through simulations of various response policy scenarios, we can assess the impacts of these policies and discuss their implications. This analysis aims to provide valuable insights for the advancement of robust naval capabilities in ensuring national maritime security. The study is supported by an expert panel of academicians and practitioners from January 2022 to February 2023. with a focus on Indonesia's maritime security and naval capabilities as examples.

This research offers several contributions. First, focusing on the sustainability of naval capability by examining the dynamics of capability across various subsystems, bridging the gap between conceptual attributes and measurable variables the integrated model proposed in this study addresses challenges related to static variables encountered in naval capability modeling systems, and thereby introducing new solutions for sustainability assessment. Third, this paper contributes to the development of an operational approach to sustainability assessment. It combines system dynamics (SD) modeling with a participatory approach, building upon the research conducted by Susilo et al. (2019b).

## 2. Literature Review.

### 2.1. Maritime Security.

The definition and understanding of maritime security have undergone significant changes and lack a universally precise depiction; it depends on the specific context, viewpoint, and utilization (Desiana & Prisma, 2022). From a military perspective, maritime security has traditionally focused on national security issues to protect state sovereignty from armed attacks or other use of force and to protect state interests elsewhere. However, the scope of maritime security defense has broadened to cover a wider range of threats (Bueger, 2015).

Maritime security refers to the measures taken to safeguard ships, ports, and other maritime infrastructure from various threats, including piracy, terrorism, and smuggling (Chapsos & Malcolm, 2017; Susilo et al., 2020). Maritime security is shaped by the actions and patterns of interaction between the actors involved. The concept of maritime security lies between two perspectives (Bueger, 2015; Susilo et al., 2019a): 1) those employing traditional security frameworks, 2) those employing non-traditional frameworks. Another important aspect of maritime security is the role of navies and coastguards in protecting the waters of their countries.

The concept of national security is rooted in the traditional perspective, which focuses on preserving the state's survival. Within this context, naval power represents sea power and serves as the dominant force in maritime affairs. Hence, maritime security is closely associated with the utilization of naval power (Susilo et al., 2019a), aiming to enhance capacities and positions. The Navy assumes various roles, encompassing diplomacy, law enforcement, and military functions (Poerwowidagdo, 2015). Several threats pose challenges to maritime security (Chapsos & Malcolm, 2017). These include 1) threats of violence, such as piracy, sabotage, and terrorism targeting vital assets; 2) navigation threats, which involve risks and challenges related to safe passage; 3) resource threats, encompassing damage and pollution to the sea and its ecosystem; and 4) threats to sovereignty.

### 2.2. Naval capability.

The Navy possesses diverse and extensive capabilities aimed at safeguarding a country's interests, both domestically and internationally. These capabilities encompass various aspects (Chapsos & Malcolm, 2017; Noraini et al., 2020; Singh & Verma, 2015):

a. Maritime Security: The Navy plays a crucial role in ensuring the security of a country's maritime borders. This involves tasks such as patrolling coastal waters, conducting surveillance operations, and intercepting any ships or vessels that may pose a threat to national security.
b. Power Projection: Another significant naval capability is its ability to project power globally. This enables the country to swiftly respond to potential threats and maintain a strong presence in strategic regions
c. Humanitarian Assistance and Disaster Relief: Besides their military responsibilities, Navies are often called upon to provide humanitarian aid and support during times of disasters or crises.
d. Additional Navy capabilities may involve conducting research and development in fields like oceanography and marine biology, enforcing international maritime laws, and supporting scientific explorations in remote areas of the world.

Naval capability is closely related to posture. Posture development is projected towards the maritime area, emphasizing an active defensive principle. This posture is specifically designed to tackle potential threats, address current challenges, and provide support to the defense forces. The components of posture include (Susilo et al., 2019a):

a. The Navy's strength is derived from various factors such as the modernization of main equipment and weapon systems, enhanced maintenance efforts, organizational development, support for facilities and infrastructure, professionalism, and the welfare of soldiers.
b. Capability: The capabilities of the Indonesian Navy are designed for intelligence, diplomacy, defense, security, regional empowerment, and support capabilities.
c. Power Projection: Navy deployment encompasses the organization, strength, and capability aspects. This is achieved through the establishment of a fleet command organizational structure, comprising centralized, territorial, and support unit forces.

## 3. Methods.

This study uses a descriptive statistical approach to analyze and interpret the data. Descriptive statistics are employed to summarize the pertinent aspects of the quantitative data concerning the evaluation of naval capability levels. The data collection process in this article involves two categories: primary data and secondary data. Primary data is sourced from experts in naval capabilities, including both practitioners and academics. The selection criteria for these experts are as follows: 1) Academics with at least a bachelor's degree (Khazaie & Khan, 2020); 2) Practitioners specializing in maritime security and the navy (Fallah & Ocampo, 2021); 3) Experts with a minimum of five years of work experience (Khalilzadeh et al., 2020); 4) Eight expert judgments, comprising four doctors and one doctoral student, as referenced in Almanasreh's (2019) research. Secondary data sources encompass various sources, such as news and information from print media, previous research findings from online sources, archives, regulations and policies, as well as official institutional documents and social media accounts.

This research took place in Jakarta and various deployment areas of naval bases in Indonesia, aiming to represent the sustainability of naval capabilities. The study was carried out between January 2022 and February 2023, utilizing a questionnaire distributed to experts, based on existing secondary data. The assessment of naval capabilities' sustainability has long been a topic of concern among researchers. In the context of Indonesia, there is a significant focus on studying the sustainability of naval capabilities due to the country's expansive territory and strategic global positioning. As a result, researchers perceive ample opportunities to contribute theoretically and explore potential avenues for advancement in this field.

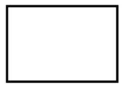
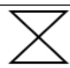
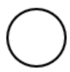
### 3.1. System dynamics.

Modeling serves as a valuable approach for addressing real-world problems, particularly when hands-on implementation or experimentation proves costly or challenging. By employing modeling techniques, one can effectively optimize their system before its actual deployment. The modeling process entails mapping real-world issues into a conceptual model, followed by analysis and optimization to derive implementable solutions (Sterman, 2010). Simulation, on the other hand, involves operating the system model itself. It serves as a preventive measure, allowing for the identification and mitigation of potential failures, unexpected bottlenecks, resource overuse, and optimization of overall system performance (Forrester, 2007).

The System Dynamics Society has defined System Dynamics (SD) as a method used to acquire knowledge and address complex relationships within systems. System dynamics was initially introduced by Jay W. Forrester in the 1950s as an approach to solve complex problems that arise because of trends, reasons and the influence of various variables within a device. The application of system dynamics was first explored in addressing control problems, such as fluctuations in stocks, volatility in business operations, and declining market shares. To represent the dynamics of a system, a stock-and-flow diagram is constructed, illustrating the simulation variables and parameterization. A model of the system is then prepared for simulation (Forrester, 2016). The variables within a dynamic structure are defined in Table 1.

System Dynamics models can be represented by a feedback diagram structure, commonly known as a causative Loop Diagram (CLD). This diagram illustrates the direction and po-

Table 1: Symbol of system dynamics.

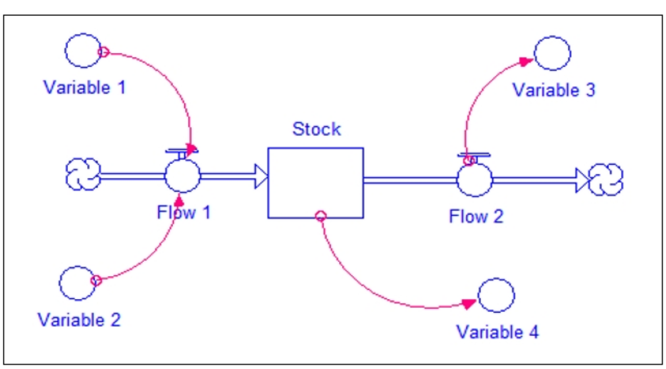
| Variable | Symbol | Explanation |
|---|---|---|
| Level |  | Presenting the accumulated quantity that accumulates over time, its value can change in line with changes in the rate |
| Rate |  | Presenting a flow rate that can change the level value |
| Auxiliary |  | Presenting auxiliary variables containing formulations that can be input to the rate. |

Source: Authors.

larity of variable flow modifications. The polarity of the flow can be either positive or negative. Another form of a diagram that collectively describes the structure of a system dynamics model is a flowchart. Flowcharts depict the relationships between variables, incorporating cause-and-effect diagrams with explicit, recognizable symbols for the involved variables (Sterman, 2018).

CLD is a visual language that connects various variables within a circular diagram. The use of arrows can indicate cause-and-effect relationships between variables. The source of the arrow represents the cause, while the arrowhead represents the effect Every modeler needs to have a thorough understanding of the processes occurring in the real world to ensure the logical consistency of the model with reality. This understanding is achieved by defining causal relationships between variables and distinguishing between dependent and independent variables (Schoenenberger et al., 2021). In this study, system dynamics analysis was conducted using STELLA 9 software.

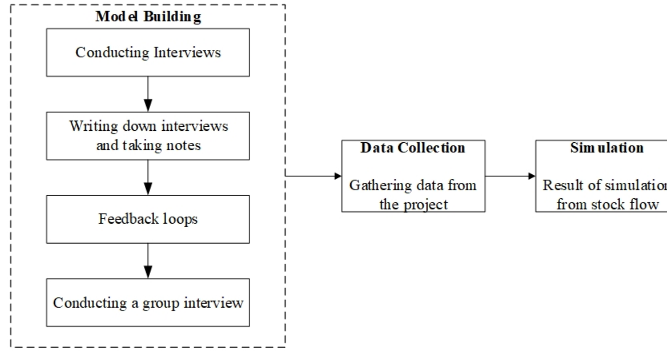
Figure 1: Minimal stock and flow diagrams in System Dynamics.




Source: (Forrester, 2009; Morshedi & Kashani, 2020; Schoenenberger et al., 2021).

In this paper, a systematic procedure was followed to ensure data saturation. Additionally, data was collected in a zigzag pattern and documents were analyzed. While literature review is a common approach for building System Dynamics (SD) models, it does not provide definitive results due to varying limitations

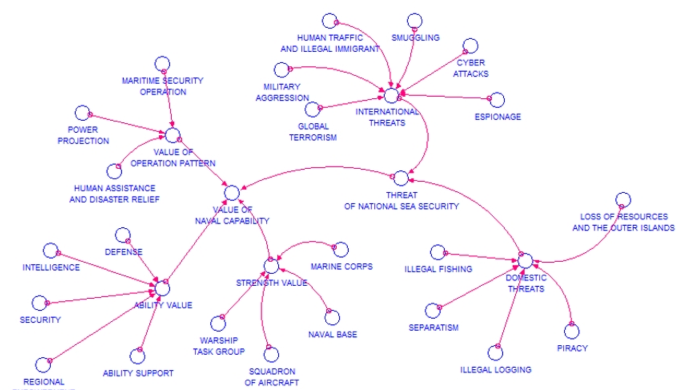
Figure 2: The flowchart of the study.




Source: Authors.

and potential inconsistencies across studies. The interviewees were selected theoretically to help the researchers construct the theory as well as possible. After that, a feedback loop consisting of causal relationships was extracted from the interviews, and a model was built using the identified relationships. Furthermore, group interviews were conducted with different experts to validate the model structure. Moreover, historical data from real projects were gathered. Finally, the model underwent a system dynamics validation test for further verification. The flowchart depicting the procedure followed in this study can be seen in Figure 2.

Figure 3: The causal feedback diagram of Naval Capability.




Source: Authors.

The feedback diagram serves as a representation of the interconnectedness of variables within the model, forming the foundation for simulation. To unveil the mechanism of interaction, a causal feedback diagram is created, focusing on the key variables, as shown in Figure 3. Constants are omitted from the diagram, and only the core variables are included. Figure 3 also shows that the four main variables build the dynamics of naval capability with several supporting sub-variables to produce a capability value against threats.

To ensure unbiased, strong, and dependable evaluations, the competence level is assessed by two separate teams comprising a maximum of four individuals each. These teams consist of both academic experts and practitioners. The assessment of abilities is conducted using a Likert scale, ranging from one to five, where one represents an unsatisfactory level and five signifies an excellent level (as presented in Table 2). To determine the final assessment results for proficiency at level three, the average rating is computed by considering various assessment methods and evaluations.

Table 2: Scale on capability assessment.

| Likert Scale | Descriptor | Attainment |
|---|---|---|
| 5 | Excellent | Mastery, excellent—Can lead changes, plan improvements, and grasp new techniques |
| 4 | Very Good | Proficient—Developed capability, can plan regular actions independently |
| 3 | Good | Developing capability above minimal or marginal can do basic things independently |
| 2 | Satisfactory | Just enough, minimal or marginal |
| 1 | Unsatisfactory | Lack of any capability |

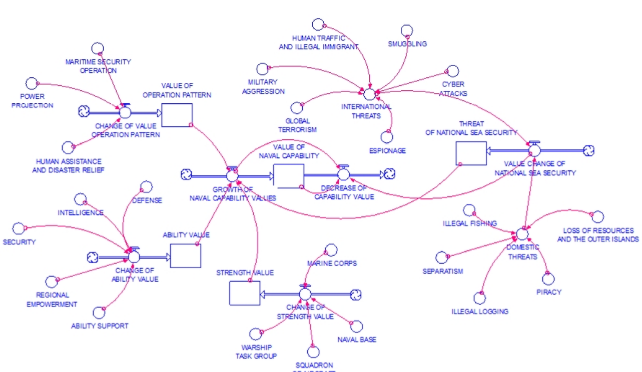
Source: Adopted from Subic et al. (2012) and Hong (2013).

Table 3: Naval capability level.

| Level | Grade | Range | Description |
|---|---|---|---|
| 5 | Very capable | 4.01-5 | The predictable process dynamically changes and adapts to effectively meet relevant current and projected business goals |
| 4 | Highly capable | 3.01-4 | The established process performs consistently within defined limits to achieve its process outcomes |
| 3 | Barely capable | 2.01-3 | The managed process performs using a defined process that is based upon software engineering principles and capable of achieving its process outcomes |
| 2 | Not capable | 1.01-2 | The performed process executes in a managed fashion (planned, tracked, verified, and adjusted) based on defined objectives |
| 1 | Very not capable | 0-1 | The implemented process achieves its process purpose |

Source: Adopted from Hong (2013) and Rout (1998).

Figure 4: The stock-flow model of Naval Capabilities.




Source: Authors.

A stock-flow model is a quantitative approach that can explain logical relationships, feedback patterns, and system control principles. Based on the causal feedback diagram, the variables are divided into stock, flow, and supplementary variables. Stock refers to variables that accumulate over time, flows refer to variables that change over time, and incremental variables refer to intermediate variables. Furthermore, flows impact stocks through inflows or outflows, establishing connections between various stocks within the system (Li et al., 2020).

The stock-flow model allows investigation and visualization of the effects of different measures (Sterman, 2010). The meaning of the shape in the stock-flow model is shown in Figure 1. Within the System Dynamics (SD) model, there are primarily six types of variables: level variables, rate variables, auxiliary variables, constants, flow variables, and sink variables. Level variables and rate variables hold the most essential information. Furthermore, rate variables denote cumulative quantities, while level variables represent the rate at which quantities change as they accumulate. Constants, on the other hand, remain constant over time.

Based on the causal feedback diagram, this study develops a stock-and-flow model to assess the Indonesian Naval capability in addressing sea security threats. The model incorporates variables represented in Figure 4. They are Operation Pattern, Ability, Strength, and the threat to national sea security. Each level variable encompasses sub-variables that represent influential factors. For instance, the Operation Pattern variable consists of three sub-variables: maritime security operation, power projection, and humanitarian assistance and disaster relief. The stock-and-flow model employed in this study captures the dynamic process of Indonesian Naval capabilities. Another variable is capability value, which is measured and simulated to make the SD model closer to the real situation.

## 4. Result and Discussion.

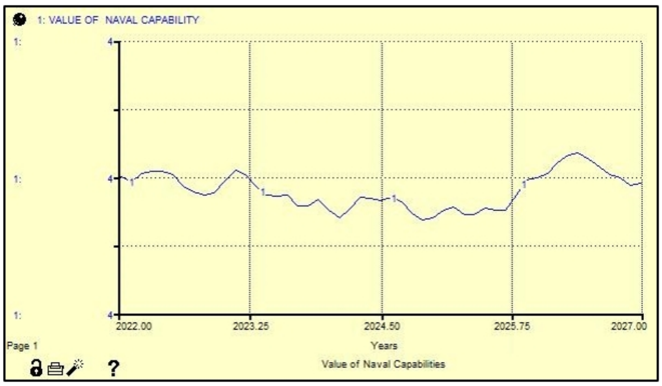
Scenario analysis in system dynamics modeling (SDM) is a valuable tool for exploring a spectrum of potential future outcomes, based on different policies and actions. In SDM, the values of variables and parameters can be modified to depict various actions and scenarios. The simulation results will vary based on these different inputs (Bottero et al., 2020).

To assess naval capabilities, the framework proposed in this study was tested using the example of Indonesia's national maritime security and naval capabilities. The Indonesian Sea holds significant global importance due to its vast size and its crucial role in international trade, national defense, and natural resources. Positioned between Asia and Australia, and the Pacific Ocean and the Indian Ocean, it occupies a strategic location (Susilo et al., 2020). The Indonesian Sea is susceptible to various crimes and disasters. Criminal activities at sea encompass theft, robbery, drug smuggling, human trafficking, and ship piracy (Wahyudi et al., 2019). Furthermore, Indonesia's marine areas frequently experience natural disasters such as tsunamis, earthquakes, and storms.

Enhancing naval capabilities against these threats has emerged as a pressing challenge for achieving regional stability. To simulate the dynamic process of naval capability in addressing national maritime security threats, this paper utilizes STELLA 9 software. From 2022 to 2027, the naval capability value fluctuates between 3.77 and 3.78, signifying a highly capable (level

4). This value is dynamic, influenced by environmental and internal factors, with a model range from 0 to 5.

Figure 5: The output value of naval capabilities in 5 years.




Source: Authors.

Figure 5 illustrates the progressive growth of naval capabilities. From 2022 to 2024, there will be a slight decline in naval capabilities. This decline can be attributed to dynamic and uncertain factors, including external and internal threats. However, the development of various strengths and the incorporation of additional main equipment and weapon systems and operational patterns will enhance defense capabilities. Consequently, it is crucial to implement a strategy that combines delaying tactics with the continuous enhancement of naval power projection capabilities to effectively address existing maritime security threats.

President Jokowi has put forward several proposals to implement specific aspects of the doctrine, which involve initiatives like constructing ports and enhancing naval capabilities (Sambhi, 2015). At the same time, the actions undertaken by stakeholders in response to threats, including the development and deployment of naval capabilities, also impact the parties involved. These stakeholders share common concerns regarding territorial control, resource management, and national maritime security, as highlighted by research conducted by Sakuwa (2017). Safeguarding and improving maritime communication routes through enhancing naval capabilities have gained significant importance on the national strategic agenda.

Furthermore, between 2024 and 2027, the naval capability is projected to experience a gradual increase while remaining within the range of 3.78, indicating a highly capable level. The ongoing development and construction of naval forces are expected to be completed by 2024, enabling their deployment in alignment with the existing threat capacity in national waters. There are efforts to assess foreign naval capabilities, explore opportunities to assert presence and challenge foreign military access and operations. Military coercion tactics involve activities such as monitoring, interfering with, and obstructing foreign military operations in international waters, all aimed at maintaining regional stability (Patalano, 2018). The development and establishment of naval capabilities, along with the formation of asymmetrical forces, can confer advantages. Certain countries perceive these actions as necessary to assert territorial claims and safeguard national interests in maintaining their maritime security (Emmers, 2009).

## 4.1. *Scenario Analysis.*

The next step of this paper considers different scenarios: inertia and a strategic scenario. The inertia assumes that there is an increase in threats, while the strategic scenario is an action that may be taken when the threat increases by increasing the pattern of operations, capabilities, and strength. To represent these scenarios in the system dynamics model, different parameter values have been assigned: (1) the threat level can reach up to level 5, and (2) strategic measures are implemented to address the increased threats.

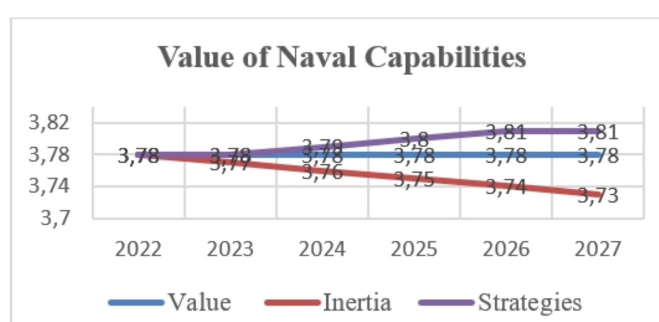
In detail, low values have been set for the inertia scenario, to represent a no-intervention policy. On the other hand, moderate values have been set for this parameter to represent the actions of strategic scenarios in the HR model. Scenario simulations have been carried out for 5 years. This simulation has been developed for variables identified as threats. The main objective is to examine the possibility of its influence over time and how it affects the naval capability in dealing with evolving threats. Table 4 and Figure 6 illustrate the simulation, providing a visual comparison of the scenarios' evolution over time.

Table 4: Scenarios for the simulation of naval capabilities.

| Year | Value | Inertia | Strategies |
|---|---|---|---|
| 2022 | 3.78 | 3.78 | 3.78 |
| 2023 | 3.78 | 3.77 | 3.78 |
| 2024 | 3.78 | 3.76 | 3.79 |
| 2025 | 3.78 | 3.75 | 3.8 |
| 2026 | 3.78 | 3.74 | 3.81 |
| 2027 | 3.78 | 3.73 | 3.81 |

Source: Authors.

Figure 6: Histogram of Scenario results for naval capabilities.




Source: Authors.

In the first scenario (inertia), the threat level increases, but no action is taken for 5 years. As a result, there is a declining trend in the naval capabilities value. The threat level is assumed to reach level 5, with values ranging from 4.2 to 4.5, which has a negative impact on the capability value, causing it to decrease from 3.78 to 3.73. However, even with this decrease, the capability value remains at a highly capable level, indicating a significant level of capability. Naval capabilities play a significant role in enhancing the influence of maritime powers and their engagement in global affairs. However, it also has weaknesses, including the potential for increased uncertainty and the risk of miscalculations (Gartzke & Lindsay, 2020). To effectively address these challenges, it is recommended to develop naval capabilities that can address a wide range of missions, spanning from modern conflicts to non-war military operations (Olivier & Balestrini-Robinson, 2014).

In the second scenario, the threat level is increased to level 5, accompanied by strategic actions such as enhancing strengths, capabilities, and operational patterns. As a result, there is a positive trend in naval capabilities, with the value increasing from 3.78 to 3.81. continues to experience an upward trend in level 4 (highly capable). However, Indonesia acknowledges that its current naval capabilities are insufficient to fully address the security challenges it faces, both internally and externally (Noraini et al., 2020). Displaying naval capabilities through patrols and exercises has been employed as a measure to counter threats to national maritime security (Kipgen, 2018). In the future, stakeholders can take advantage of their strategic territorial location and increase their naval capabilities to prevent aggressive actions from countries in the Pacific (Paszak, 2021). Strengthening naval capabilities is crucial for power projection in the Indian Ocean region and to address development and national security requirements (Singh & Verma, 2015).

## Conclusions

Sustainability in the development of naval capabilities toward national maritime security is a fundamental aspect of dealing with future wars. Analyzing the framework through scenarios and simulations allows for a comprehensive assessment. In this context, Indonesia's national maritime security and naval capabilities serve as a practical example to test the proposed framework.

According to the study findings, the naval capability value remains consistently high from 2022 to 2027, ranging from 3.77 to 3.78, indicating a highly capable status. From 2022 to 2024 (24 months), there is a slight decline in naval capabilities. However, between 2024 and 2027 (36 months), there is a gradual increase in naval capability, although it remains within the highly capable range of 3.78. It is anticipated that the ongoing development and construction of naval forces will be completed by 2024, enabling their deployment in alignment with the existing threat capacity in the national maritime domain.

In the context of inertia, the threat is assumed to increase significantly to level 5, ranging from 4.2 to 4.5. As a result, the naval capability value decreases from 3.78 to 3.73. Despite this decline, the naval capability remains at a highly capable level 4. On the other hand, in the second scenario, the increase in the threat value to level 5 is accompanied by strategic actions, including the development of strengths, capabilities, and patterns of operations. As a result, there is an upward trend in the value of naval capabilities, rising from 3.78 to 3.81. This trend indicates a continuous improvement at the highly capable level 4.

### *Limitation & Future Work.*

There are several limitations in this research. Firstly, it did not consider the influence of economic growth and the development of the defense industry on the trend of changing naval capabilities, particularly due to the COVID-19 pandemic. Future research could incorporate economic variables and the defense industry as well as global impacts such as the Ukrainian War. Second, this study selected several important variables to develop the model and may miss some critical variables. Each pair of variables requires a single formula or function, while some variables are difficult to measure. In the future, the SD model can be used to analyze more system issues and users should increase its validity, and establish causal relationships. Third, there is still limited spatial scale in the simulation and impact evaluation of the strategy. A potential solution is to integrate a combined approach that evaluates the naval capability development strategy's impact on both tangible and intangible national maritime security threats.

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