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ASSIGNMENT OF NAVAL BASE DENPASAR ELEMENTS AS A SEARCH AND RESCUE UNIT AND ITS IMPACT ON THE SECURITY AND SAFETY OF THE BALI COASTAL MARINE

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ABSTRACT

Security and safety at sea is a matter of concern throughout the world. This is due to the high economic activity and marine resource management activities which also carry risks to the security and safety aspects for humans. Security and safety in Bali waters is one of the world's concerns because Bali is one indicator of world tourism activity and Bali waters is one of the coke points of crossing international trade routes. In maintaining sea security and safety in the Bali Coastal waters it is carried out through Naval Operations, National Search and Rescue Agencies, and other maritime agencies. This study discusses the assignment of Naval Base Denpasar elements in supporting Search and Rescue Operations and their impact on Security and Safety in Bali's Coastal Waters. The research begins with the identification of risks to security and safety at sea, followed by the assignment of SAR units using the Hungarian method to produce scenarios for the assignment of elements and dynamic system models to determine the impact of the resulting scenarios on aspects of sea security and safety. The research succeeded in identifying sources of threats and risks in the aspects of security and safety of the Bali coastal sea, assigned 6 (six) elements of the Naval Base Denpasar to 6 (six) Naval Posts, and provided an analysis of the impact of the assignment scenario on the security and safety of the Bali Coastal sea.

Keywords: *Marine Security and Safety, Search and Rescue, Naval Base Denpasar, Hungarian Assignment Method, Dynamic System.*

1. INTRODUCTION

Indonesia is the largest archipelagic country in the world which has around 17,508 (seventeen thousand five hundred and eight) islands with a total area of approximately 8 (eight) million square kilometers. The strategic position of the region makes Indonesia a world transportation crossing point with various modes of transportation through Indonesian territory and the high activity of marine management causes a higher and increased likelihood of security threats and accidents at sea (Kemenkumham, 2017).

The Government of the Republic of Indonesia proclaims Indonesia's return to the glory of the Sea by making Indonesia a World Maritime Axis. The World Maritime Axis is Indonesia's vision to become a maritime country that is sovereign, advanced, independent, strong, and able to make a positive contribution to regional and world security and peace in accordance with national interests. One of them is through the development of defense, security, and safety at sea (President of Indonesia, 2022).

Threats to the security of the state at sea may not only be military but also political, economic, social, and ecological (Buzan, 1991). Maritime security has traditionally been focused on national security in the sense of protecting a country's special territorial integrity from armed attacks or other forces and developing the country's interests elsewhere. Furthermore, IMO explains that Maritime Security is related to the protection of ships from unlawful actions, both intentional and planned, while Maritime Safety refers to preventing or reducing the occurrence of accidents at sea.

Bali's coastal waters have various types of maritime security threats, both from within the country and from abroad, ranging from illegal fishing, illegal entry, smuggling, territorial violations, and various other threats. The existence of tourism object management activities, dense sea traffic, fishing activities, and extreme weather changes are also

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factors that cause sea accidents in the waters of Bali. (Basarnas, 2017).

Naval Base Denpasar is one of the TNI AL bases which has the main task of maintaining security and safety in the coastal waters of Bali which has 6 (six) Naval Posts under it. In carrying out sea security operations the Naval Base Denpasar has several elements assigned to each naval post.

This research will discuss several sources of threats to sea security and safety in Bali's coastal waters, the assignment of Naval Base Denpasar elements and their impact on maritime security in Bali's coastal waters.

2. LITERATURE REVIEW

2.1 Risk Management.

Risk is a function of the probability of something that can be detrimental or undesirable, and the severity and magnitude of the consequences of the event (Berg, 2017). Uncertainty does not know what will happen in the future, the greater the uncertainty, the greater the risk (Indonesian National Standardization Agency, 2011). Uncertainty can disrupt, disrupt plans and cause losses due to unknown sources, delays, and sometimes too late to effectively mitigate the impact (Sidorendko, 2017). Risk can be defined as the chance of loss or an unfavorable outcome associated with an activity. The Risk Management process consists of the steps Establish the Context, Identification, Assessment, Potential Risk Treatment, Review, and Evaluation of the Risk (Paul, 2010).

2.2 Assignment of Search and Rescue Units.

Search and Rescue are all efforts and activities to search for, help, save, and evacuate people who are facing emergencies and/or dangers in accidents, disasters, or conditions endangering humans (Kemenkumham, 2017). Search and Rescue is an act of searching for, and providing assistance to, people, ships, or other vehicles, who are, or are concerned about, in trouble or danger that threatens (National Search And Rescue, 2020).

Handling SAR incidents through several stages, namely: awareness; initial action; planning; operation, and conclusion. The implementation of sea SAR units can be aircraft or ships (IAMSAR, 2006). SAR elements must have several capabilities, including communication equipment; mobility; support equipment, and other equipment, and adequate supplies.

2.3 Marine Security and Safety.

Threats to state security may not only be military but also political, economic, social and ecological (Buzan, 1991). Geoffrey Till stated that maritime security is not only traditional in nature, such as the desire to exercise control (sea control) and dispatch expeditionary short-term military operations (expeditionary operations), but includes the objective of realizing the maintenance of good order at sea (maintaining good order at sea) wealth of various natural resources, acting as a medium/transportation route, as well as being an important aspect of environmental perception (Samiaji, 2015).

The Indonesia Ocean Justice Initiative, 2020 states that the critical meaning of maritime security is as follows: Maritime security as sovereign territory and sovereign rights that form a unit within the framework of the Unitary State of the Republic of Indonesia; Maritime security is the ability of the state to maintain and maintain sovereignty and sovereign rights in its sea area which have an impact on optimizing the country's economic activities; Guaranteed marine security stability can provide ecosystem conditions that support and help ensure the sustainability of marine economic resources.

There are various types of threats in the Indonesian Sea, including V*iolence* threats; natural resources tribulation; law transgression threats, and navigation hazards (Kartika, 2016).

3. MATERIAL AND METHODS

3.1 NATO Risk Assessment Methods.

Identification of risk sources is carried out by reviewing the literature, observing historical incident data for 5 (five) years, and interviewing experts in the field of maritime safety and security. Furthermore, risk measurement uses Relative Comparison Analysis to calculate and compare values on several indicators. The Relative Comparison value calculation uses the Risk Assessment Worksheet formulation issued by NATO. Comparative calculations on each indicator can produce an assessment as well as the relationship between the objects being compared.

Indicators for assessing risk sources consist of Probability (P), Onset Speed (F1), Forewarning (F2), Duration (F3), Intensity (F4), and Impact (I) (NATO, 2015). Furthermore, the formulation used to determine the relative value of threats is the result of multiplying the Probability value by the SUM factor value and multiplied by the Impact value. The mathematical formulation is as follows:

$$RV=P\sum(F)I \qquad \text{(i)}$$

3.2 Hungarian Methods.

The Hungarian assignment model is used to determine the minimum cost of assigning workers to jobs (Taha, 2017). General assignment model with n workers and n jobs. The assignment table shows the assignment of worker i to job j, where i and j = 1,2,3.....n. The Hungarian method is a classic

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method for solving assignment problems.

There are several steps in solving problems with the Hungarian Method according to work as follows: Step 1: find pi, the minimum cost element of row i in the original cost matrix, and subtract all elements of row i, i = 1, 2, 3...n. Step 2: for the matrix created in step 1, determine qj, the minimum cost element of column j, and subtract from all elements of column j, j = 1, 2, 3...n. Step 3: from the matrix in step 2, try to find a feasible assignment among all the resulting 0 (zero) entries. If such an assignment can find the optimal/feasible solution then the process is declared complete. However, if no optimal solution is found, then additional calculations are needed in steps 4 and 5. Step 4: draw the minimum number of horizontal and vertical lines in the last reduced matrix to cover all zero entries. Step 5: select the smallest uncovered entry, subtract from each uncovered entry, then add to each entry at the intersection of the two lines. Step 6: if no proper assignment can be found among the resulting null entries, repeat step 1. The Simplex explanation of the Hungarian method of assignment problems where and workers are assigned to n jobs can be represented as a Linear Programming model in the following way:
Let Cij be the cost of assigning worker i to job j, and determine:

$$Xij = \begin{cases} 1, \; if \; worker \; i \; job \; j \\ 0, \; else \end{cases}$$

Then the Linear Programming model can be written as follows:

$$\text{Minimize } Z = \sum_{i=1}^{n} \sum_{i=1}^{n} cijxij$$

Subjek to

$$\sum_{j=1}^{n} xij = 1, j = 1,2,3 \ldots\ldots n$$

$$\sum_{i=1}^{n} xij = 1, i = 1,2,3 \ldots\ldots n$$

$$Xij = 0 \text{ or } 1$$

3.3 Dynamic System Simulation.

Simulation is an activity to be able to draw conclusions about the behavior of the system by studying the behaviour of the model and some things that have similarities with the real system according to the study (Gotfried,1984). Simulation is used to study and analyze the performance of a system. One of the superior methods for analyzing systems is system dynamics. Dynamic simulation produces policy analysis by taking into account the time factor in the interaction between sub-systems.

The Dynamic System Model is structured in several stages, namely: identification of variables, preparation of Causal Loop Diagrams (CLD), preparation of Stock Flow Diagrams (SFD), Model Validation, and Policy Simulation. In this study modeling using the Stella Dynamic System 9.13 software application.

Defining that dynamic systems is a method for improving learning in complex systems. Furthermore, this method is illustrated like a simulation in an airplane cockpit for management to understand complex dynamics in learning, understand sources of resistance (obstacles) in policies and design more effective policies. Understanding this complexity, dynamic systems are based on the theory of non-linear dynamics and feedback control developed in the disciplines of mathematics, physics and engineering.

Dynamical systems try to study part of the overall system, but this does not mean ignoring the observed system with the environment. In the language of dynamic systems, variables that do not have a significant influence on the observed system will become limitations in the analysis of the dynamic system, thereby making the observed system a closed system.

When analyzing a system that has a feedback relationship, partial analysis cannot be carried out. Weaknesses in carrying out partial analysis make dynamic systems superior in analyzing systems that have feedback relationships (feedback loops) or cause and effect relationships (causal loops). In carrying out dynamic system analysis, steps are needed to be able to produce a good model of the observed system.

3.4 Research Methodology.

This research was carried out by identifying the risk sources and calculating the risk assessment. The results of the risk identification are then used as the basis for assigning elements of the Naval Base Denpasar. Element Assignment is carried out by identifying the capability of the element, identifying the characteristics of the operational area and type of threat as well as identifying the risk cost of element assignment. Next, iterate the Hungarian method of assignment costs on the Exel Solver software application. The resulting policy scenarios are then simulated in the dynamic system model of security and safety of the Bali coastal sea. The steps following Figure 1 as follows:

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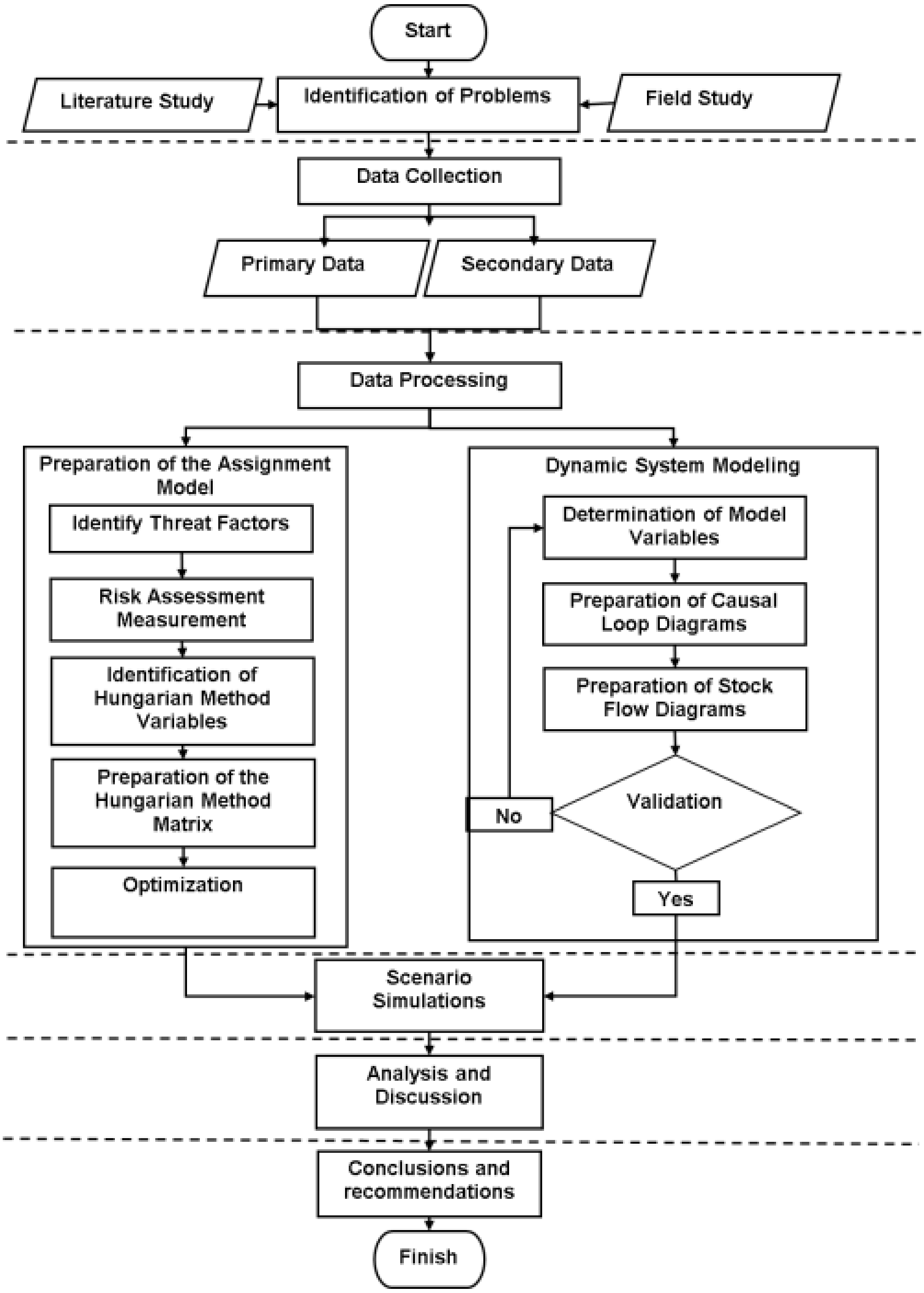

Figure 1. Research Flowchart.

4. RESULTS AND DISCUSSION.

This section will explain each stage the results of the research and their discussion.

4.1 Identification of Risk Sources and Calculation of Risk Assessment.

Based on the analysis report on the operational area (ADO) of the Naval Base Denpasar in 2022, there are various vulnerabilities/threats to the Security of the Bali Coastal Sea, including Illegal Fishing, Illegal Oil, Smuggling, Territorial Violations, Shipping Violations, Destruction of Marine Biota, Marine Pollution and Illegal Survey activities and other threats. While in the aspect of marine safety for 5 (five) years there were 102 (one hundred and two) incidents. A total of 17 incidents or 16.6% were in the working area of the Celukan Bawang Naval Post, 20 incidents or 19.6% occurred in the Karangasem Naval Post area, 12 incidents or 11.8% occurred in the Nusa Penida Naval Post area, a total of 29 incidents or 28.4 % occurred in the Benoa Posal Naval Post area, 10 incidents or 9.8% occurred in the

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Pengambengan Naval Post area and 14 incidents or 13.7% occurred in the Gilimanuk Naval Post area.

Identification of risk sources resulted in 13 (thirteen) risk sources of threats to sea security aspects and 13 (thirteen) sources of threat risks to sea safety aspects. The recapitulation of the results of the Expert Jugement in the risk assessment of the Security and Safety of the Bali Coastal Waters is the average of the assessment of each indicator for each threat source. The results of the recapitulation of risk assessment indicator values on aspects of Sea Security (SE) and Sea Safety (SA) are as follows:

Table 1. The average value of Risk Indicators.

Threat	Ave. *P*	*F1*	Ave. *F2*	Factor *F3*	*F4*	Ave. *I*
SE1	2,33	1,00	2,16	2,33	1,83	2,50
SE2	2,33	1,00	2,00	2,16	1,33	2,66
SE3	1,00	1,16	1,83	1,83	1,16	2,33
SE4	1,00	1,00	2,16	2,00	1,00	2,16
SE5	1,16	2,00	2,00	1,66	1,00	2,33
SE6	1,16	2,00	1,83	2,00	1,33	3,00
SE7	2,66	1,00	1,16	2,00	2,00	1,66
SE8	1,33	1,00	2,00	2,00	1,00	2,33
SE9	2,00	2,00	2,00	2,33	2,00	3,00
SE10	1,00	2,33	2,00	1,00	1,33	2,16
SE11	1,00	1,00	2,00	3,00	1,00	2,50
SE12	2,00	2,00	2,00	2,00	1,00	2,66
SE13	1,33	2,33	2,00	2,00	1,00	3,00
SA1	2,58	2,54	2,54	2,58	2,54	2,58
SA2	2,22	2,25	2,25	2,29	2,29	2,32
SA3	2,38	2,38	2,38	2,38	2,41	2,41
SA4	2,03	2,03	2,03	2,03	2,03	2,06
SA5	2,64	2,64	2,61	2,64	2,64	2,61
SA6	2,48	2,51	2,48	2,51	2,51	2,54
SA7	2,58	2,54	2,54	2,54	2,51	2,54
SA8	2,38	2,45	2,41	2,41	2,45	2,48
SA9	2,25	2,25	2,25	2,29	2,25	2,29
SA10	2,16	2,16	2,16	2,16	2,12	2,16
SA11	2,61	2,61	2,61	2,58	2,58	2,58
SA12	2,32	2,35	2,38	2,35	2,38	2,38
SA13	2,38	2,45	2,41	2,41	2,452	2,45

Furthermore, the computational results of the Risk Assessment value show that the relative risk value in the maritime security aspect has a value of 348.5 which is included in the "medium" category. While the relative risk value on the safety aspect of 732.305 is included in the "high" category. The average value of marine security and safety risks is 540.4 in the "moderate" level category.

The highest threat in terms of security is smuggling (SE9) with a relative score of 50.00 with a risk weight of 0.143, followed by the second position of the Bali Coastal waters vulnerable to illegal fishing (SE1) with a relative score of 42.778 with a risk weight of 0.123. In third place, the vulnerability that occurs is illegal oil (SE2) with a relative score of 40.444 and a weight of 0.116, followed by regional violations (SE12) with a relative score of 37.333 and a risk weight of 0.107.

In the aspect of marine safety, the Bali Coast is at high risk of missing fishermen (SA5) with a relative risk value of 72.906 and a risk weight of 0.100. The second highest risk is Ship Accident due to Waves (SA11), with a relative risk value of 70.040 and a risk weight of 0.096. Followed by the third highest risk of Ship Aground (SA1) with a relative risk value of 68.101 and a weight of 0.093. Man Over Board/MOB (SA7) is in fourth place with a relative risk value of 65.115 and a risk weight of 0.099, and in fifth position is Tourist Accident (SA6) with a relative risk value of 63.503 and a weight of 0.093.

4.2 Assignment of Naval Base Denpasar Elements.

Based on the results of identification of sources and relative risk values of threats which show the highest threat in terms of safety, the approach to assigning elements of the Denpasar Lanal is directed to Search and Rescue operations.

The elements of Naval Base Denpasar to be assigned consist of 6 (six) elements. The characteristics of each elements that will be assigned are as follows:

Table 2. Technical Data Elements of Naval Base Denpasar.

Units	Tonase (Ton)	Long (M)	Draft (M)	Speed (Knot)	Endurance (Jam)
U1	1,2	4.7	0,25	14	2
U2	1,1	4.5	0,25	12	2
U3	20	18	0,75	25	10
U4	3	7,5	1.2	20	4
U5	3	7.5	1.3	30	6
U6	4	12	1	35	11

Furthermore, the operational area for the assignment of elements is a naval post under the ranks of the Naval Base Denpasar, namely the Celukan Bawang Naval Post, Karangasem Naval Post, Nusa Penida Naval Post, Benoa Naval Post, Pengamengan Naval Post and Gilimanuk Naval Post. Each post has a work area with regional characteristics and various types of threats.

The assignment risk cost variable is prepared by assessing the assignment risk value of each element faced with the area of operation and the type of threat in each postal work area. The assessment is carried out by expert judgment by several experts in the field of SAR operations.

The resulting assignment risk cost identification results are shown in the assignment cost matrix table as follows:

Table 3. Relative Assignment Risk Cost.

	Operation Area					
Units	***W1***	***W2***	***W3***	***W4***	***W5***	***W6***
U1	13,00	18,00	17,75	17,25	14,00	12,25
U2	13,00	18,00	19,25	17,25	14,25	12,00
U3	13,00	13,25	14,25	13,25	13,25	10,00

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U4	13,00	14,50	13,25	14,00	13,25	9,00
U5	14,00	15,25	14,00	14,25	13,00	11,00
U6	13,00	13,25	13,00	15,50	14,25	10,00

The next stage is to carry out optimization steps to obtain a minimum assignment fee. Optimization uses the Hungarian method in the Exel Solver application with the results according to the following table:

Table 4. Optimization of the Hungarian Method Assignments.

	Operation Area					
Units	***W1***	***W2***	***W3***	***W4***	***W5***	***W6***
U1	1	0	0	0	0	0
U2	0	0	0	0	1	0
U3	0	0	0	1	0	0
U4	0	0	0	0	0	1
U5	0	0	1	0	0	0
U6	0	1	0	0	0	0

The results of the assignment model iteration succeeded in placing each element in the operating area with minimum risk costs. The resulting minimum relative risk cost is 76.75. Element U1 was assigned to the Celukan Bawang Naval Post (W1); Element U2 is assigned to Posal Pengambengan Naval Post (W5); Element U3 assigned to Benoa Naval Post (W4); Element U4 assigned to Gilimanuk Naval Post (W6); Element U5 assigned to Nusa Penida Naval Post (W3); and Element U6 assigned to Karangasem Naval Post (W2).

4.3 Analysis of the Assignment of Denpasar Lanal Elements Impact.

To analyze the assignment scenario, several stages were carried out, namely model building, scenario development, scenario simulation and results analysis.

a. Development of a Dynamic Model for Marine Security and Safety.

Analysis of the impact of the assignment was carried out by developing a dynamic model for Bali Coastal Marine Security and Safety. With models like the following Figure 2:

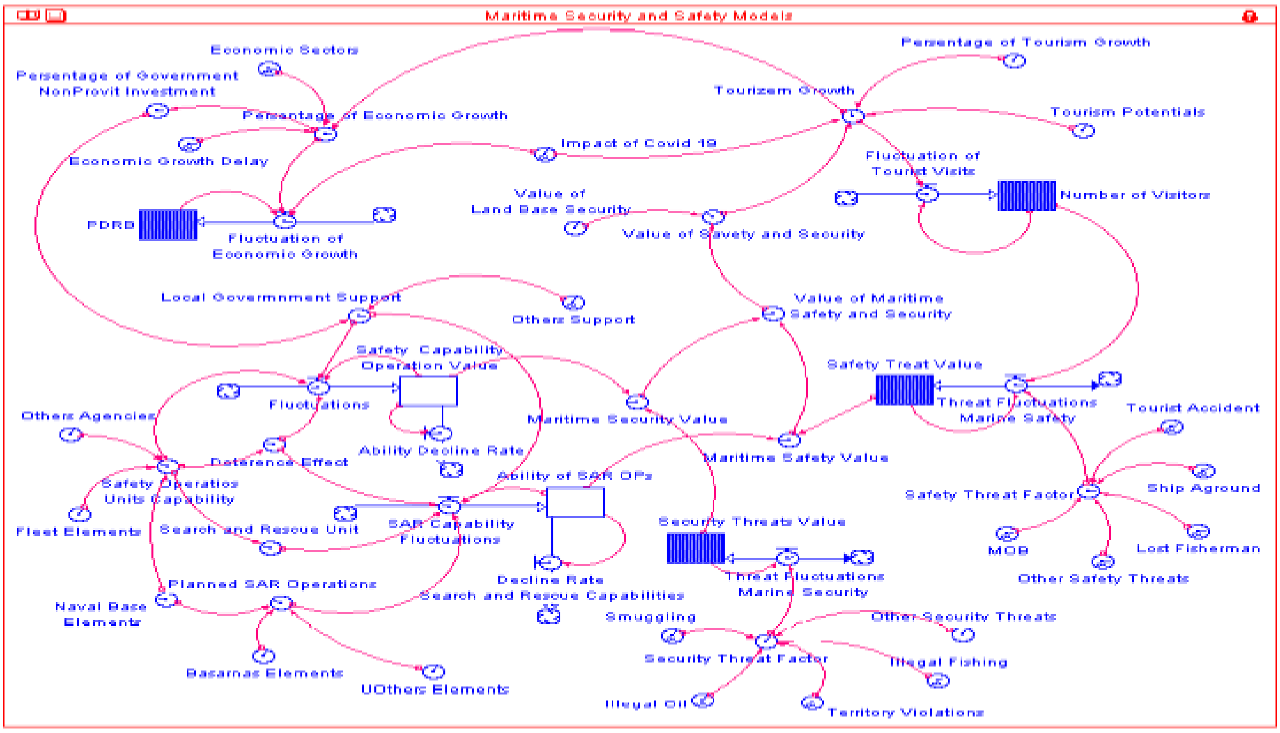

Figure 2. Dynamic Model of Bali Coastal Marine Security and Safety.

Before being used to simulate the assignment scenario, verification and validation steps were carried out on the model. Verification is carried out to ensure that all units in the model are realistic, logical and consistent. Model validation is done to find out whether the model is able to represent the actual system.

The results of model verification show that the model built is consistent. Model validation was carried out by testing the structure and adequacy of limits, modelling behaviour testing, and model replication testing. The results of model testing show that the built model is valid.

b. Assignment Scenario Development.

The policy scenario that will be analyzed in the dynamic system model is the assignment scenario of the Naval Base Denpasar element based on the degree of elemental strength that is ready for

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operation and the assignment area of the Naval Base Denpasar. The simulation was carried out for 15 years from 2018-2032. Scenarios are developed into 3 (three) policy scenarios as follows:

1) The existing scenario is the current scenario of assigning elements to Naval Base Denpasar where assignments of new elements are placed in 3 posts, namely Benoa Naval Post, Pengambengan Naval Post and Gilimanuk Naval Post. The percentage of element strength that is ready for operation is calculated based on the average technical condition readiness of elements of the Naval Base Denpasar at this time which is 37.6% and the operational area covered is calculated from the placement of elements ready for operation at this time which is 50%. The average score of the elements used is 43.8.
2) Scenario 1. In scenario 1, an effect analysis of the assignment scenario will be carried out based on the results of the assignment model. The results of the assignment model succeeded in placing 37.6% of the total strength of the Naval Base Naval Base Denpasar element in all operational areas 100%. The average score of the Naval Base Denpasar elements degree used was 68.8.
3) Scenario 2. In scenario 2, a policy analysis will be carried out for the assignment of Elements of the Denpasar Lanal in accordance with the improvement plan and procurement of elements to fulfill 75% of the strength to be assigned to all work areas of the Naval Base Denpasar 100%. The average score of the Lanal Denpasar elements used is 80.5.
4)

c. Assignment Scenario Simulation.

The simulation results for the existing scenario are shown in the dynamic system graph as follows:

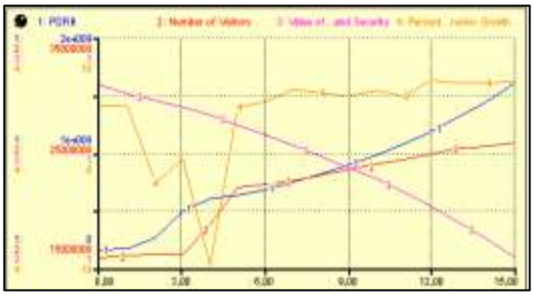

Figure 3. Graph of Simulation Results.

Based on The graph, it shows that the value of marine security and safety has decreased every year. This is due to an increase in tourism activities economic activities and sea transportation as well as extreme weather conditions which are not matched by an increase in the ability to operate security and safety at sea. Furthermore, the simulation results of the existing scenario, Scenario 1 and Scenario 2 are shown in the following table:

Table 5. Bali Coastal Sea Security and Safety Values.

Years	Marine Security and Safety Value		
	Existing	Scenario 1	Scenario 2
2023	0,75	0,77	0,79
2024	0,73	0,76	0,78
2025	0,71	0,75	0,77
2026	0,7	0,74	0,76
2027	0,68	0,72	0,75
2028	0,67	0,71	0,73
2029	0,64	0,69	0,72
2030	0,62	0,67	0,7
2031	0,6	0,65	0,68
2032	0,57	0,63	0,66

Based on the scenario simulation results table above, it can be seen that the security and safety values in the existing assignment scenario show that the security and safety values of the Bali Coastal Sea in 2031 and 2032 are at the level of the "safe enough" category. If it is not immediately followed up, a decrease in the value of security can have a negative impact on the management of the coast of Bali, especially in the tourism sector.

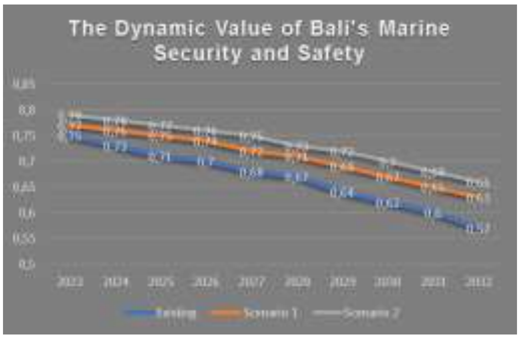

Figure 4. Graph of Comparison of Policy Scenario Simulation Results.

The comparison graph of the simulation results shows that the existing scenario produces an average value of sea security and safety of 0.66. In the scenario 1 simulation, the Bali coastal sea security and safety value has an average of 0.7 or an increase of 6%. Whereas in scenario 2 the simulation produces a value of sea security and safety with an average of 0.73 or an increase of 10%.

5. CONCLUSION.

Identification of variable sources of risk of threats to security and safety of the sea in the management of Bali's coastal waters using historical incident data observations and expert interviews. Identification of risk sources resulted in 13 (thirteen) threat sources in the Maritime Security aspect, and in the safety aspect 13 (thirteen) threat sources were identified. Calculation of Risk Assessment to measure potential risks using Relative Comparation

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shows that sea safety threats have a "high" risk with a relative risk value of 732.305. and threats to maritime security aspects have a "medium" risk level.

The assignment of Naval Base Denpasar elements to support OMSP Search and Rescue operations in the coastal waters of Bali using the Hungarian method succeeded in properly assigning Naval Base Denpasar elements to 1 (one) operating area, with a minimum relative total risk cost of 76.75.

The Bali coastal marine security and safety dynamic model was built by developing 3 (three) sub-models, namely the marine security and safety sub-model, the tourism industry sub-model and the Bali economy sub-model. The model can be used to analyze the impact of the scenario of the assignment of elements of the Naval Base Denpasar on the value of Security and Safety of the Bali Coastal Sea.

Analysis of the impact of the assignment scenario for Naval Base Denpasar elements was carried out by simulating scenarios on the Dynamic System. Scenario 1 results in a change in the value of sea security and safety with an average value increase of 6% from the existing scenario. Scenario 2 simulation results in a change in the average value of sea security and safety with an increase of 10% from the existing scenario.

FUTURE RESEARCH

There are several things that can be examined in further research to deepen the identification of internal and external sources of marine security and safety risks at each decision level, selection of the appropriate type of ship to carry out operations in the Bali waters area, set covering analysis to determine the number of elements that needed to cover the entire area of Bali waters. Furthermore, it can also carry out an analysis of the Risk Management of Bali Coastal Waters and determine a Risk Control Policy Strategy.

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