MODEL DEVELOPMENT OF NAVAL BASE DETERMINATION. A SYSTEM DYNAMICS AND INTERPRETATIVE STRUCTURAL MODELING (ISM) APPROACH

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The Navy Base as an integral component of the SSAT is the spearhead of the force in carrying out support for naval combat operations, especially as a support for the movement of KRI operations. During this time we have determined the location of the Navy Base only based on the results of the workgroup team's decision.??? (verb)This study aims to design and build a model of the selection of the Navy Base location with a dynamic System and Interpretative Structural Modeling (ISM) approach. This research is expected to contribute to the development of the Indonesian Navy base to support national maritime security. Based on the results of the research analysis as many as 4 main criteria and 15 sub-criteria that have interactions with base sustainability can be established. The sub-criterion of changing the value of sea security is influenced by 6 sub-criteria with Output, namely the value of national security. Aspects of the rate of base defense strength are influenced by 6 (six) sub-criteria with Output, namely the value of maritime potential development. The aspect rate of the number of SSATs is influenced by 5 (five) sub-criteria with outputs namely the development value of maritime potential. Base defense value, Marine Territorial Development value, sea security value.

Key Words: Naval Base, Indonesia Navy (TNI AL), Causal Loop Diagram (CLD), Interpretative Structural Modeling (ISM), System Dynamics, Integrated Weapon System (SSAT).

1. INTRODUCTION

As a component of national defense at sea, the Indonesia Navy is tasked with carrying out national defense policies namely maintaining national sovereignty and territorial integrity, protecting the honor and safety of the nation, carrying out military operations other than war and actively participating in the task of maintaining regional and international peace (Susilo, et al., 2019). In an effort to carry out national defense at sea, the Navy carries out tasks that constitute the manifestation of the three universal roles of the Navy, namely the military role, the role of the police and the role of diplomacy (Ministry of Defence, 2015).

The Indonesian Navy base as an integral component of the SSAT is the spearhead of the force in carrying out support for naval combat operations, especially as a support for the movement of KRI operations. The role of the Navy as a place to develop sea power into the area of operation or "deployment forces position" will have an important meaning in supporting the operational tasks of the Navy as an operational unit for internal security at sea (Susilo, et al., 2018). In addition, the Navy Base as a "Home Base" has a criterion of function in accordance with the 5Rs, namely: Rest, Refresh, Refuel, Repair and Replacement so that the Navy Base will provide a very meaningful role for the successful support of the Navy's operation~~al~~s (Suharyo, et al., 2017).

The Indonesian Navy has divided its command work area into 3 (three) Main Command areas, namely the Indonesian Fleet Command I in Jakarta, the Indonesian Fleet Command II in Surabaya, and the Indonesian Fleet Command III in Sorong. During this time ~~in~~ the determin~~ing~~ation of the location of the Navy Base is only based on the decision of the Navy Headquarters workgroup team (Yogi, et al., 2017).

This study aims to design and build a model of the selection of the Navy Base location with a dynamic System and Interpretative Structural Modeling (ISM) approach. The System Dynamic method is used to analyze the sustainability of the base. The ISM method is used to identify the relationship between the criteria in determining the location of the Base. This research is expected to contribute to the development of the Indonesian Navy base to support national maritime security.

There are several previous studies that are used as references. Research about naval bases with the title Solution Approaches For Facility Location Of Medical Supplies For Large-Scale Emergencies (Ordonez & Dessouky, 2007). A Linear Fuzzy Goal Programming Method For Solving Optimal Power Generation And Dispatch Problem Method A Linear Fuzzy Goal Program (Pal & Kumar, 2013). Fuzzy Goal Programming Method for Solving Multi-Objective Transportation Problem (Venkatasubbalah & Mouli, 2011).

Research about System Dynamics and interpretative structural modeling (ISM) with the title Combining Soft System Methodology with Interpretative Structural Modeling and System Dynamics for Network Orchestration: Case Study of the Formal Science and Technology Collaborative Network in Iran (Shahabi, et al., 2019). Navy Ability Development Strategy using SWOT Analysis – Interpretative Structural Modeling (ISM) (Susilo, et al., 2019). Strategies to Accelerate Manufacturing Growth in India: A System Dynamics-Interpretative Structural Modeling Analysis (Ojha & Vrat, 2016). Development Causal Relationships for CPFR index: a System Dynamics Simulation Approach (Panahifar, et al., 2016). Simulation of Dynamics Behaviors for Shipping Equipment Support with System Dynamics Analysis Approach (Song & Yang, 2015). Modeling Dynamic Systems with Efficient Ensembles of Process-Based Models (Simidjievski, et al., 2016). System Dynamics Modeling And Simulating The Effects Of Intellectual Capital On Economic Growth (Beran, 2015). A System Dynamics Model for Simulating the Logistics Demand Dynamics of Metropolitans: A Case Study of Beijing, China (Qiu, et al., 2015).

This paper consists of several sections. Section 2 explains the naval base theory, dynamic system theory, Interpretative Structural modeling theory, data analysis, flow diagrams. Section 3 explains the results and discussion of the base model sustainability research. Section 4 explains the conclusions of the study.

2. MATERIAL/METHODS

2.1 Indonesia Naval Base.

The Navy Base as an integral part and the Integrated Armed Weapon System (SSAT) are the spearheads in supporting the success of the Navy's operational unit tasks both in peacetime and in times of war/critical. Thus, the main tasks and functions of the Navy Base are as follows (Susilo, et al., 2019):

a. Main Duty.

Organizing administrative and logistical support for elements of the Indonesian Navy (Ships, Pesuds and Marines) and implementing maritime potential development by utilizing the facilities and infrastructure owned by the Base itself and related facilities and infrastructure.

b. Additional tasks.

Organizing support for non-Indonesian Navy units according to their functions and needs.

c. Function.

The Navy Base has the following functions :

1) Supporting functions of the operating unit, which cover:

a) Functions of anchored facilities.
b) Function of maintenance and repair facilities.
c) The supply facility function.
d) Function of personnel maintenance facilities.
e) Function of base guidance facilities.

2) Maritime Security Function.
3) Maritime Potential Development Function.
4) Function of Territorial Development of the Sea.

In accordance with the main task, The Navy base must be able to guarantee the implementation of combat support, logistical support, administrative support and special support for the Navy's operational units in maritime control and support for the implementation of Maritime Potential Development, Territorial Development of the Navy, and TNI social communication. (Suharyo, et al., 2017).

The role of the Navy base in general in the SSAT has the same position, both with components of ships, aircraft and Marines. While the difference is only in the position of the base itself which is permanent/stationary. Because of these fixed characteristics, in supporting sea defense forces, bases must be in strategic positions. Starting with the Navy's strength and strength developed in the SSAT, the power is translated into an Integrated Marine Weapon System, which consists of Ships, Aircraft and Marines as a strategic force and Integrated Operations Support System (Yogi, et al., 2017).

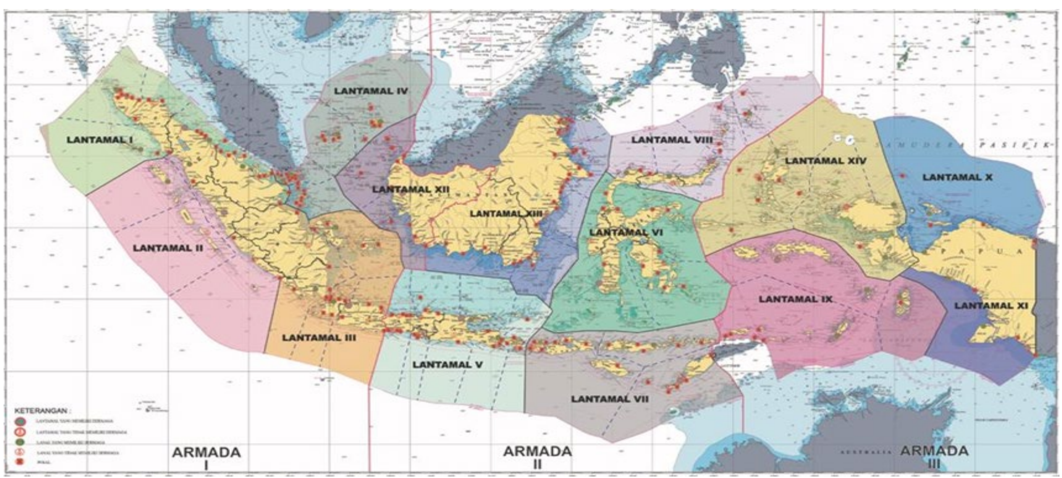

Fig. no. 1. Deployment of Indonesian Navy Base.

2.2 Interpretative Structural Modeling (ISM)

Interpretive structural modeling (ISM) was first introduced by J. Warfield in 1975 to analyze systems with high complexity and find solutions to complex problems or involve many factors in them and interact with each other (Mohammed, et al., 2008). Interpretative Structural Modeling is a group review process in which structural models are produced in order to photograph the complex issues of a system, through carefully designed patterns using graphics and sentences (Gorvett & Liu, 2007).

ISM analyzes system elements and solves them in the form of graphs of direct relationships between elements and hierarchical levels. The elements can be policy objectives, organizational targets, assessment factors and others. Direct relationships can be in diverse contexts (Susilo, et al., 2019). This ISM technique can be used to carry out program analysis in accordance with the vision and mission. Broadly speaking, the ISM technique is divided into two parts, namely: classification of elements and arrangement of the hierarchy. The first step that needs to be done in the ISM analysis is to determine the elements that are in accordance with the existing problem (Pfohl, et al., 2011).

Subsequently we arranged sub-elements on each element selected. The selection of elements and the preparation of sub-elements is done from the results of discussions with experts. The results of the assessment are arranged in a Structural Self Interaction Matrix (SSIM) which is made in the form of a Reachability Matrix (RM) table by replacing V, A, X, O with numbers 1 and 0. The classification of elements is based on the Structural Self Matrix (SSM) which is based on VAXO system (Shahabadkar & Hebbal, 2012), likely :

Table 1. Reachability Matrix Role for ISM.

If the (i, j) entry in the SSIM is	**Entry in the initial reachability matrix**	
	(i, j)	**(j, i)**
V	1	0
A	0	1
X	1	1
O	0	0

Sources: (Shahabi, et al., 2019).

The matrix is then changed to a closed matrix. This is done to correct the matrix to meet the transitivity rules i.e. if A affects B and B affects C, then A must affect C (Gorvett & Liu, 2007).

2.3 Simulation Modeling

Modeling is a way to solve problems that occur in the real world. Modeling is done if direct implementation or experimentation is too expensive to do or difficult to do. Modeling allows the system to be optimized before it is implemented in the real world. Modeling includes the process of mapping problems from the real world to be modeled in the world model (abstraction process) ~~to~~ then be analyzed and optimized in order to obtain solutions that can be implemented in the real world (Sterman, 2000). Simulation is the operation of a system model. Simulations are used before changing something about an existing system, to reduce the impact of failure, to eliminate unexpected bottlenecks, to prevent excessive use of resources, and to optimize system performance (Forrester, 1994).

2.4 System Dynamics (SD)

The System Dynamics Society offers an updated definition by stating that SD is "a methodology for learning and managing complex feedback systems". System dynamics was first introduced by Jay W. Forrester in the 1950s, is a method of solving complex problems that arise due to the tendency of cause and effect of various variables in the system. The system dynamics method was first applied to management problems such as inventory fluctuations, labor instability, and a decline in a company's market share. From the system dynamics model in the form of a centralized diagram Flow, Diagrams are built to illustrate simulation and parameterization variables and the model formulation is ready to be simulated (Forrester, 1971). Variables in dynamic systems are described in Ta**ble 2**.

Table 2. 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.

The form of the System Dynamics model that represents the structure of the feedback diagram is a causal diagram or commonly known as a Causal Loop Diagram (CLD). This diagram shows the direction of the variable's flow change and its polarity. The flow polarity as expressed above is divided into positive and negative. Another form of a diagram that also illustrates the structure of the system dynamics model is the Flow Diagram. Flow diagrams represent the relationships between variables that have been made in a cause and effect diagram more clearly, using certain symbols for the various variables involved (Sushil, 1993).

Causal Loop Diagram (CLD) is in the form of a drawing language that connects various variables in a loop diagram. The use of arrows will indicate the variables that are cause and/or effect. The upstream of the arrow will show the cause, while the tip of the arrow shows the effect. Each modeler must first understand the processes that occur in the real world so that a logical model can resemble reality. The process of understanding can be done by distinguishing between cause and effect variables and/or by distinguishing between dependent and independent variables (Sterman, et al., 2007).

2.5 Method and Steps

Based on the focus and purpose of the study, the type of research used in this study uses a quantitative analysis approach. The quantitative analysis approach is used with the aim of being able to understand what is happening to the object of research by providing quantitative descriptions and explanations in the form of measurable and clear numbers. Broadly speaking, the formulation of the model in this study is to develop the theory and concept of the ISM method, which is integrated with the development of the System Dynamics method into a Model of Choosing the Location of the Navy Base on Sustainability.

Table 3. Expert Choice for Research.

No	Research Respondents	Location	Number	Code
1	Operation Assistant for Fleet Command II	Surabaya	1	E1
2	Personnel Assistant for Fleet Command II	Surabaya	1	E2
3	Intelligence Assistant for Fleet Command II	Surabaya	1	E3
4	Maritime Potential Assistant for Fleet Command II	Surabaya	1	E4
5	Former Commander in Navy Base Command II	Surabaya	5	E5-E9

In this study, the research subjects as expert peoples consisted of nine people.-The personnel included all stakeholders related to the allocation of baselines based on sustainability. The instrument in this study was the result of a questionnaire which was the result of the process of collecting data. Furthermore, after the data collected is processed and analyzed we have the results of data processing. The results of the questionnaire are then processed by the ISM method through the Microsoft Excel program.

The results of the analysis are then carried out modeling System Dynamics to see the sustainability of the Base. Furthermore, it is conducted deepening and interpretation of results and conclusions that provide results and conclusions that make a real contribution to the development of science and technology, especially in the field of national defense at sea.

In determining research variables, it must consider all information and criteria that can affect performance. Characteristics and criteria for selection of problems and data can all be referred to as research variables. This activity is carried out through interviews with relevant officials/staff who have competence with base development issues. It was also carried out by studying references in the form of appreciation and conception about the development of bases as well as references about the Standardization of the Indonesian Navy Base.

The flowchart below shows the logical model for the sustainability of Naval Base Model.

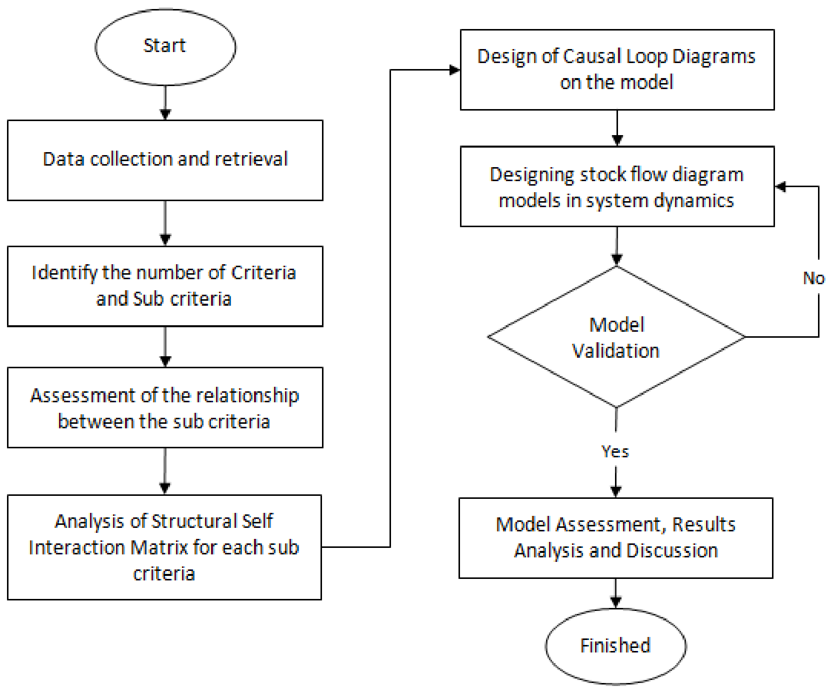

Fig. no. 2. Flowchart for the sustainability of Naval Base Model.

3. RESULT AND DISCUSSION

After brainstorming and conducting in-depth interviews supported by several previous research references, various criteria and sub-criteria for the sustainability model of the bases are determined as in **Table 4.** System identification aims to provide an overview of the system studied in the form of Causal Loop Diagrams. Based on the CLD description, then poured into the input-output diagram. Stock-flow diagrams illustrate the relationship between input and system output through a transformation process that is described as a box. A stock-flow diagram of the base sustainability system is presented in Fig**ure 4**.

Table 4. Result of Criteria and Sub Criteria for Naval Base Model.

Criteria	Sub Criteria	Code
Unit Operations Support (C-1)	Anchored Facilities	C-11
	Maintenance And Repair Facilities	C-12
	Supply Facilities	C-13
	Personnel Care Facilities	C-14
	Base Coaching Facilities	C-15
Support coaching Operations (C-2)	Sea Security	C-21
	Marine Territorial Development	C-22
	Fostering Of Maritime Potential	C-23
Environmental Aspects (C-3)	Geographical	C-31
	Resource	C-32
	Socio-cultural	C-33
	Climate & Weather	C-34
Defense Aspects (C-4)	SSAT Readiness	C-41
	Base Defense	C-42
	SSAT Dispersion	C-43

Based on the results of expert studies, 4 main criteria and 15 sub-criteria were established that have interactions with base sustainability. Then the interaction is carried out using the ISM method. The first step is to study the contextual relationship in the form of SSIM-VAXO matrix. The condition is explained in **Table** 5.

Table 5. Results of SSIM for Naval Base Model.

No	Code	Sub Criteria														
		15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
1	**C-11**	O	V	V	O	O	A	A	O	O	O	V	V	V	V	
2	**C-12**	V	O	A	O	O	A	O	O	O	O	V	O	X		
3	**C-13**	V	V	V	O	O	V	O	O	O	O	O	V			
4	**C-14**	O	V	V	O	O	O	O	O	O	O	A				
5	**C-15**	V	V	V	A	O	A	A	V	V	V					
6	**C-21**	A	A	X	A	A	A	A	A	X						
7	**C-22**	A	V	A	A	A	A	A	X							
8	**C-23**	A	A	A	A	A	A	A								
9	**C-31**	O	V	O	X	X	X									
10	**C-32**	V	V	V	O	O										
11	**C-33**	O	V	O	A											
12	**C-34**	O	O	O												
13	**C-41**	V	V													
14	**C-42**	A														
15	**C-43**															

The relationship between elements of the Naval base sustainability system is obtained from expert opinion. Structural Self Interaction Matrix (SSIM) is arranged based on the relationship between the elements of the goal. The Reachability Matrix was obtained from SSIM which was subsequently revised according to the transitivity rules. The essence of the reachability matrix is answering the question "Yes" or "No", is there a direct relationship between variables i and variable j. Interpretations of the Reachability Matrix elements associated with the Naval base sustainability criteria are presented in **Table 6.**

Table 6. Result of Reachability Matrix for Naval Base Model.

No	Code	Sub Criteria															DP	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
1	**C-11**	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	**7**	**4**
2	**C-12**	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	**4**	**10**
3	**C-13**	0	1	1	1	0	0	0	0	0	1	0	0	1	1	1	**7**	**4**
4	**C-14**	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	**3**	**12**
5	**C-15**	0	0	0	1	1	1	1	1	0	0	0	0	1	1	1	**8**	**3**
6	**C-21**	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	**3**	**12**
7	**C-22**	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	**4**	**10**
8	**C-23**	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	**3**	**12**
9	**C-31**	1	0	0	0	1	1	1	1	1	1	1	1	0	1	0	**10**	**2**
10	**C-32**	1	1	0	0	1	1	1	1	1	1	0	0	1	1	1	**11**	**1**
11	**C-33**	0	0	0	0	0	1	1	1	1	0	1	0	0	1	0	**6**	**8**
12	**C-34**	0	0	0	0	1	1	1	1	1	0	1	1	0	0	0	**7**	**4**
13	**C-41**	0	1	0	0	0	1	1	1	0	0	0	0	1	1	1	**7**	**4**
14	**C-42**	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	**3**	**12**
15	**C-43**	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	**5**	**9**

The next step is to isolate the reachability matrix, but before that it is necessary to make further corrections until it becomes a closed matrix that meets the transitivity rules. The transitivity principle is the completeness of the causal loop, for example A affects B and B affects C, so it can be said that A must affect C. From Table 6 above it can be seen that the highest power driver or key element which is a sub-criterion that has a very big role to encourage the operation of the Navy base sustainability system is a resource. The sub-criteria that have the second biggest thrust is geographical.

The modeling in this research is used to model the sustainability system of the Indonesian Navy base in Surabaya. The results of the modeling are expected to be helpful in making decisions regarding the reduction of land for the Navy base due to economic growth and population. The implementation of data modeling can be seen in the following Figure 3 Causal Loop Diagram.

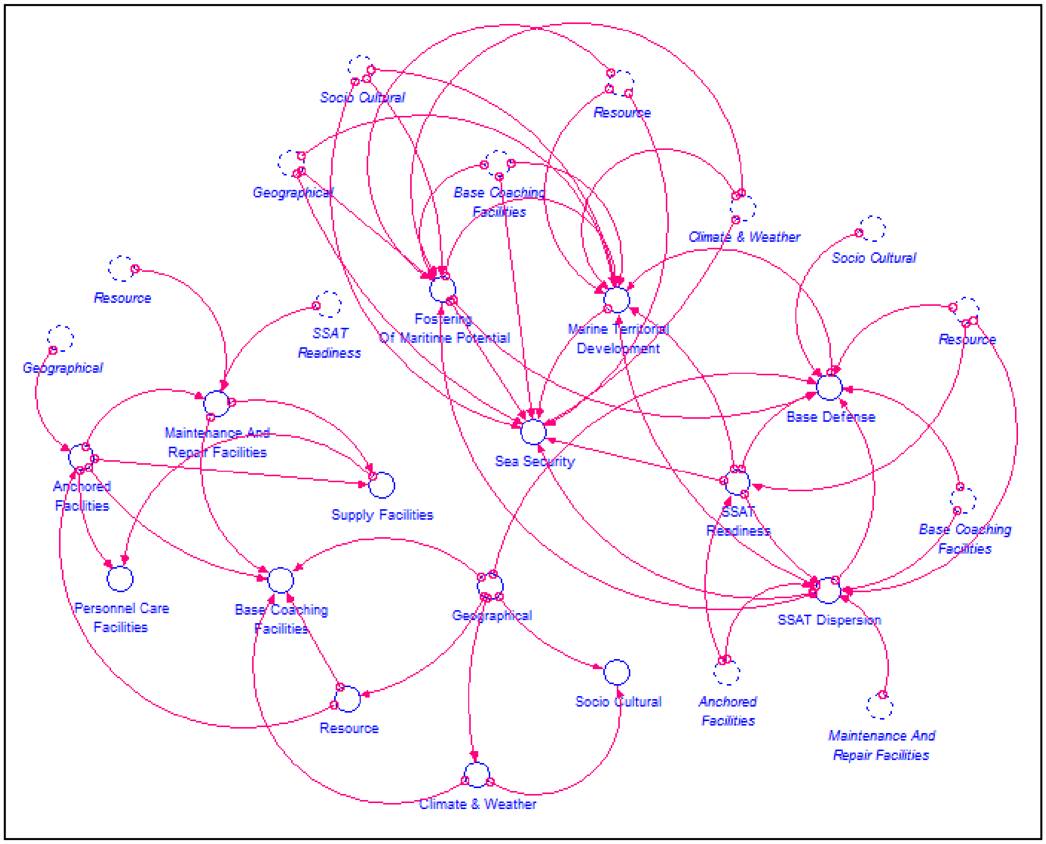

Fig. no. 3. Result of Causal Loop Diagram for Naval Base Model.

For the causal loop diagram the current base sustainability diagram can be seen in Figure 3 above. Causal loop diagram illustrates the relationship between Unit Operations Support, Support coaching Operations, Environmental Aspects, Defense Aspects. These four aspects are the main criteria in the model. Each main criterion has supporting sub-criteria which have their respective interrelations. This diagram shows the causes and effects of the system structure. Existing variables are variables based on modeling that has been done using expert opinion through the ISM method to identify the relationship between related criteria and sub-criteria.

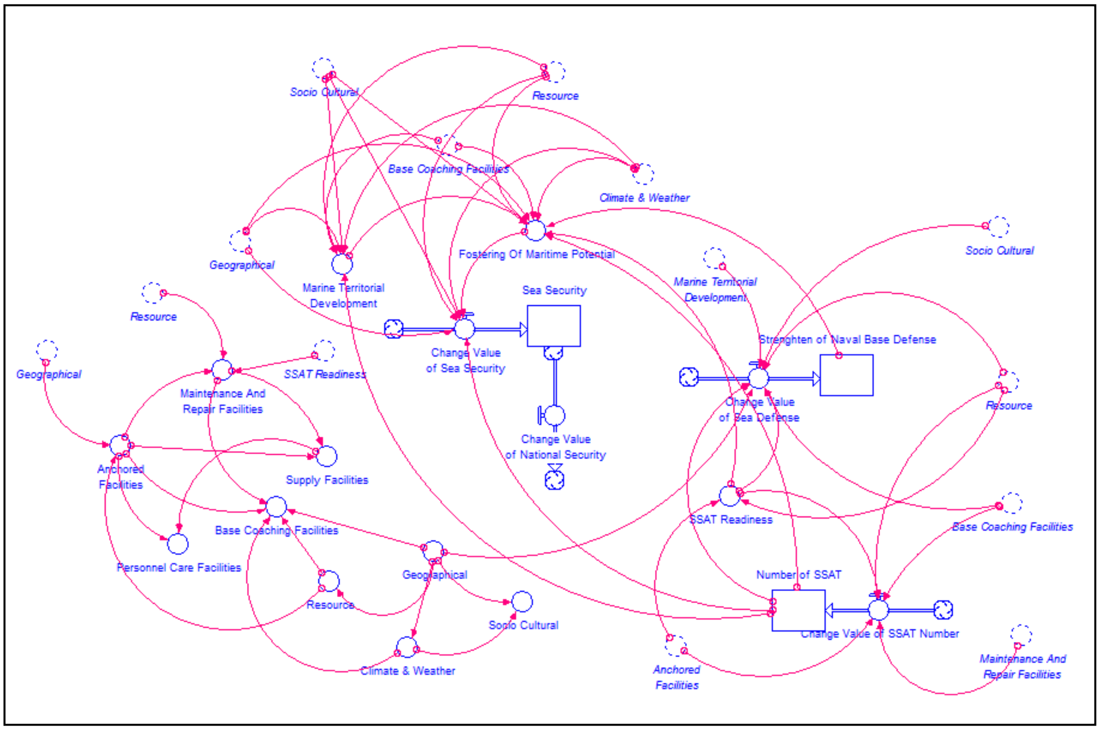

Fig. no. 4. Result of Stock Flow Diagram for Naval Base Model.

Figure 4 above shows the base sustainability stock-flow diagram. The model was made with observations for 3 months. Sea Security, Base Defense, and number of SSATs are described as a level about changes in the value of the number of SSAT. The sub-criteria aspects of the change in the value of sea security are influenced by 6 sub-criteria, including Geographical, the number of SSAT, resources, climate and weather, fostering of maritime potential, and socio-culture. The output of the sea security rate is the value of national security.

Aspects of base defense strength are influenced by 6 (six) sub-criteria, among others, Socio-culture, Base Coaching Facilities, Resources, Number of SSAT's, Marine Territorial Development, SSAT Readiness. The output from the aspect of the base defense force rate is the development value of maritime potential. The aspect rate of the number of SSAT is influenced by 5 (five) sub-criteria including Maintenance And Repair Facilities, Anchored Facilities, Base Coaching Facilities, resources, SSAT readiness. The output aspect rate of the number of SSAT's is the value of fostering maritime potential.

4. CONCLUSION AND FUTURE WORK

The Navy Base is one component in the SSAT that has the task of carrying out support for the KRI's operational tasks. Based on the results of research analysis in designing and building a base location selection model using the System dynamics and Interpretative Structural Modeling (ISM) approach, there are 4 (four) main criteria and 15 sub-criteria that have interactions with base sustainability.

The sub-criterion of changing the value of sea security is influenced by 6 (six) sub-criteria with Output, namely the value of national security. Aspects of the rate of base defense strength are influenced by 6 (six) sub-criteria with Output, namely the value of maritime potential development. The aspect rate of the number of SSATs is influenced by 5 (five) sub-criteria with outputs namely the development value of maritime potential, Base defense value, Marine Territorial Development value, sea security value.

In this study several additional criteria and sub-criteria as well as aspects of economic and geostrategic growth need to be continued.In future studies quantitative values from several related criteria can be drawn up to determine the extent of the overall base sustainability value.In further research, it can be suggested to add the defense industry development factor in the sub-criteria to increase the number of SSAT.

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