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System Dynamics Usage in The Development of Sustainable Fishermen Village

A Capability Enhancement to the Policy Review and Implementation Team in Ministry of Marine Affairs and Fisheries

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ABSTRACT

The Ministry of Maritime Affairs and Fisheries (KKP) through the Biak Numfor Regency Fisheries Service, is developing Samber-Binyeri Village, as a pilot fishing village in Papua to enhance the economy. A number of issues and factors, including inadequate fishing equipment, infrastructure, availability of fuel, and a lack of knowledge and skills on fishing technology and practice, have contributed to the low income and productivity of traditional fishermen. Furthermore, poor health facilities and coastal waste management make the villages unhygienic to live in, messy, and unattractive for visitors and tourists. However, implementing new policies and management practices requires a proper understanding of current practice, culture, and its impact on its ecosystem, should the change be made. Therefore, it requires proficient teams to evaluate the current model and develop a new model that yields exemplary outcomes aligned with the objectives at minimum risk. For this reason, equipping the KKP team with knowledge related to system thinking and system dynamics is very important. A four-day' workshop in system thinking and system dynamics has been carried out in Bandung in two stages: stage one, a basic understanding of system thinking and system dynamics, and stage two, modeling optimization using Vensim software. The output of this workshop programs is: to define problems and dynamic hypotheses in each field or section as a basis for Sustainable development of Kampung Nelayan Maju.

Keywords: *System Thinking, System Dynamics, Causal Loop Diagram, Stock and Flow Diagram, Kampung Nelayan Maju Biak.*

INTRODUCTION

The current perception of fishing villages is associated with the term "slum". Therefore, a program is necessary to adjust the perception of fishing villages and dissociate them from the connotation of "slum". Slums, in this context, possess specific criteria such as disorganization, uncleanliness, poor health, and low productivity, each with corresponding parameters indicating their extent. Therefore, a program is necessary to adjust the perception of fishing villages and dissociate them from the connotation of "slum". The Ministry of Maritime Affairs and Fisheries (KKP) through the Biak Numfor Regency Fisheries Service has development program for fishing villages, in Samber-Binyeri Village, as a pilot fishing village, in Papua to enhance the economy. The program, called Kampung Nelayan Maju or Kalaju for short, aims to enhance the living standards of fishing villages by promoting productivity, orderliness, sanitation, health, and development. Its initiatives include training, empowerment, providing access to public facilities, and sustainability in the long run.

The Ministry of Maritime Affairs and Fisheries (KKP) needs to have special staff who develop models as supporting tools used to analyze policies that have been and will be implemented. These developments involve multiparty because of its dynamics and complexity. One methodology for policy analysis of dynamic and complex phenomena is a modelling methodology using a System Dynamics approach. According to (Richardson & Pugh III, 1981) system dynamics is a methodology for understanding certain kinds of complex problems. What is meant by methodology here is none other than the science of logic in scientific research, namely the overall system, methods, rules, and hypotheses used in understanding complex problems. System dynamics methodology is in line with the concept of paradigm popularized by Thomas Kuhn in his book entitled "The Structure of Scientific Revolutions", where paradigm is generally defined as a model or scheme.

The methodological approaches used in a scientific work can be grouped into two categories, namely: black box approach and structural approach. The black box approach is based on the requirement of data availability. Implicitly, the black box approach examines a phenomenon according to one-way thinking (cause to effect). Although this approach is widely used, it has a fundamental weakness as it is unable to answer the questions of ''why'' a phenomenon occurs and ''how'' to change the behavior of the phenomenon. In the structural approach, the emphasis of research is on the structure and behavior of the phenomenon, rather than solely on numerical data. This approach is anchored in the Systems Thinking paradigm, which maintains that changes in behavior or dynamics stem from a structure made up of interdependent elements.

The System Dynamics methodology is an appropriate strategy to address "how" and "why" research questions within a structural approach. System Dynamics methodology offers advantages over conventional approaches, which will be discussed in the following section.

System dynamics modelling has rapidly developed since it was introduced by Jay W. Forrester in his book "Industrial Dynamics". Thinking involves modelling, whereby a model is essentially the result of an effort to create a replica of the real world. Hence, a model is an abstraction of a system. A model is a description of the structure of a phenomenon conveyed through communicable media forms (Sasmojo, 2004). For a model to be a reliable basis for understanding and designing policies that can impact the real world, it must have multiple points of contact with reality and undergo repeated comparisons with the real world through these points of contact. This approach enables the study of system dynamics while maintaining an objective and unbiased perspective. Simulation

Table 1. Conventional Approach vs Integrated System

No	Parameter	Approach	
		Silo	**Integrative**
1	Method	Static	Dynamics
2	Policy Analysis Model	Linear Thinking	System Thinking
3	Share information and Knowledge	Minimum	Maximum
4	Policy Analysis Processes	Expert Judgement	Model Simulation
5	Data collection Method	FGD	Group Model Building
6	Stake holder involvement	Exclusive	Inclusive
7	Working Principle	Functional	Holistic / Integrative
8	Model as a medium of communication / Tools dialogue	Minimum	Maximum

Source: Bapenas (2019)

is an analytical tool that aims to replicate the operation of a system to determine the behavior of the system using a model.

The capacity building workshop was a joint effort between System Dynamic Bootcamp Bandung team and PT Solusi Cerdas Gemilang, aims to build the capacity of participants (staff of KKP) in policy modelling skills using System Dynamics methodology. The outcomes of this activity are that participants are able to: a) understand the Systems Thinking paradigm in looking at a phenomenon b) understand the concepts of policy modelling using the System Dynamics methodology c) create a model using software and able to make a model simulation d) analyze and evaluate the results of the model and e) initiate policy recommendations based on the results of their model simulations.

METHODS

The process of the Capacity Building in terms of the ability and complexity of System Dynamics issues as well as the utilization of model development software (Vensim).

According to the block diagram above, Capacity Building has two-dimension capabilities and complexity, with the objectives to 1) enhancing Capability in System Dynamics modelling to improve system thinking skills, and the ability to construct phenomena, and expertise in operating Vensim software and 2) improving the ability to comprehend complex real-world phenomena and subsequently construct dynamic structures and behaviors. In this workshop, the System Dynamics Capacity Building program consists of four phases and delivered in four days accordingly (Figure 2).

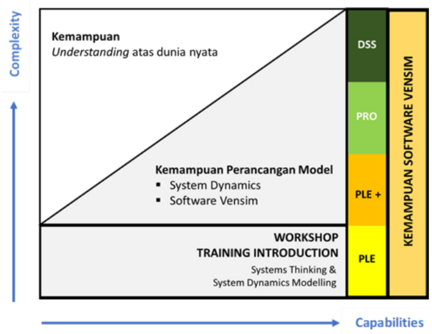


Figure 1. System Dynamics Capacity Building Approach

Source: SDBB, 2023

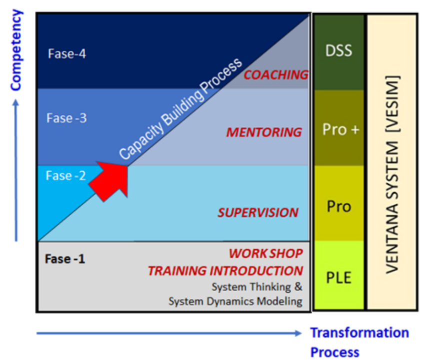


Figure 2. Transformation process Capacity Building System Dynamics

Source: SDBB, 2023

Phase I (Day1): Introduction to systems thinking and system dynamics
The first step is for the team to introduce two modelling method of system dynamics: (a) Causal loop diagram (CLD); (b) Stock and Flow diagram (SFD). CLD is to identify the main feedback loops that lead to growth in the system quantitatively; and SFD is used to create formal simulation models for policy testing and redesign quantitatively (Maldonado & Grobbelaar, 2017).

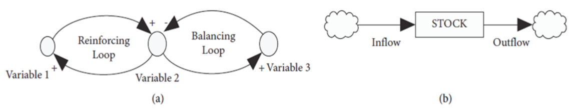


Figure 3. Components of System Dynamics

Next the team introduced phenomenon and structure. A phenomenon is formed by a number of components that are interrelated with each other. The number of components with their interrelationships, which form a phenomenon, is called the structure of the phenomenon. Structure consists of the physical structure (stocks and material flow networks) and the decision-making structure of the various actors in the system.

The decision-making structure here refers to the decision-making rules and information sources used for decision-making. The decision-making process involves dynamic phenomena. These dynamic phenomena are generated by the interacting physical structure and decision-making structure. The physical structure is formed by the accumulation (stock) and flow network of people, goods, energy, and materials.

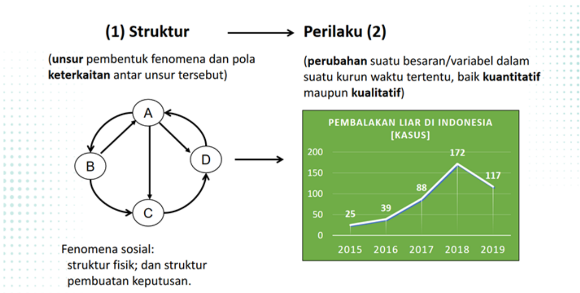


Figure 3. Elements of Phenomenon

Source: SDBB, 2023

While the decision-making structure is formed by the accumulation (stock) and network of information flows used by (human) actors in the system that describe the rules of the decision-making process.

Phase II (Day 2): Supervision
Participants design their own system dynamics models, and the modelling team provides supervision. Model development proceeds gradually, beginning with defining the problem related to the goals and objectives that the model will achieve. The second stage is model conceptualization, in which a data search involving stakeholders and several other sources occurs. This is followed by structural analysis. The third step involves conducting system dynamics modelling. The fourth step is to perform model testing, and the final step is to conduct final model testing. In the process of modelling, if there are any improvements or adjustments needed, the previous steps can be repeated (Figure 4)

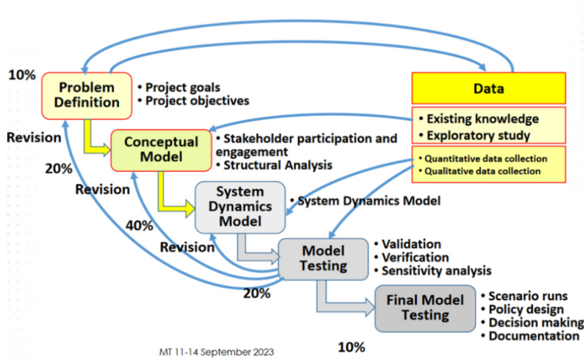


Figure 4. System dynamics modelling life-cycle

The group then started building Kalaju CLD model which includes parameters of economics, social and environmental. Below is the example of Kalaju CLD economic model

Phase III: Mentoring
Participants design their own Stock and Flow Diagram, and the team provide mentoring. SFD development can begin by identifying stocks in CLDs. A stock is an accumulation that generally

has units that do not rely on time, while a flow is an accumulator that has flow-like properties. Frequently, flow is defined as a decision. Several factors must be considered when developing system dynamics models, particularly mode specifications. Model specifications can be established based on the level of depth required for the development of the model. The greater the depth required, the more intricate the model will be constructed. On Day 3 they produce 2 SFD model which are Productivity, Financial and Social model. Below is the example of Productivity model.

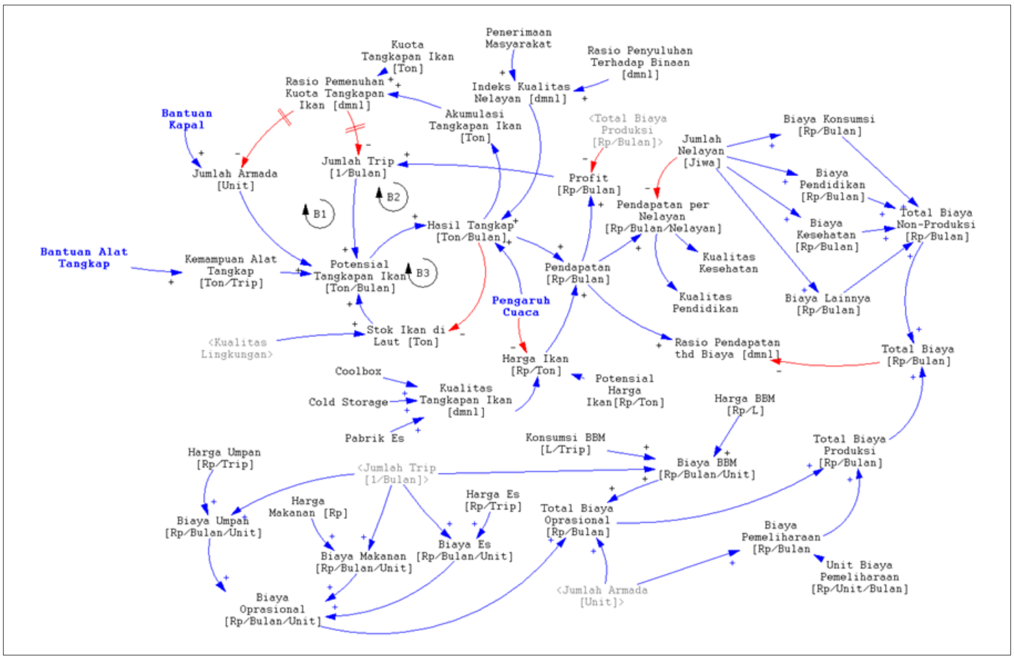


Figure 5. Kalaju CLD Economics model

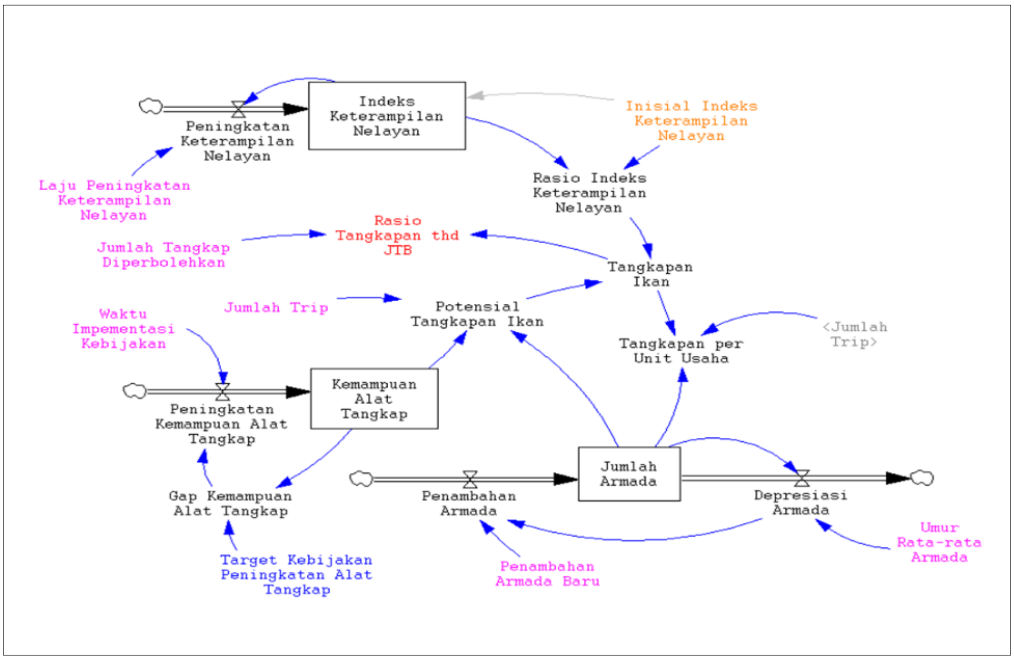


Figure 6. Kalaju SFD Productivity model

In the Kalaju programme, fishermen will be integrated with the cooperative. The cooperative will assist the fishermen in facilitating the fishermen's workshop and operational needs. This activity will take place together with the fishermen mentoring activities.

Phase IV: Coaching

The modelling team provides related models and preparation of human resources to build internal capacity by internal participants (Training of Trainers/TOT). This phase start with simulation of the model as shown in the graph below (examples)

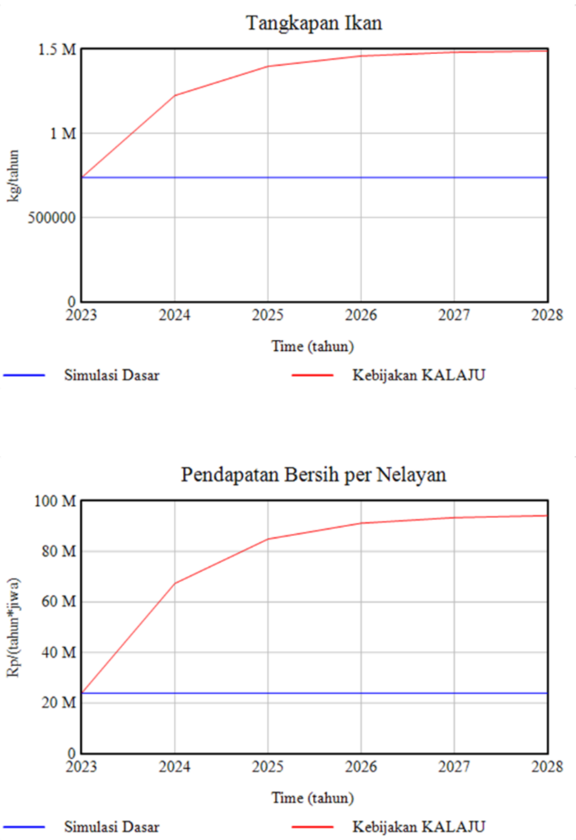


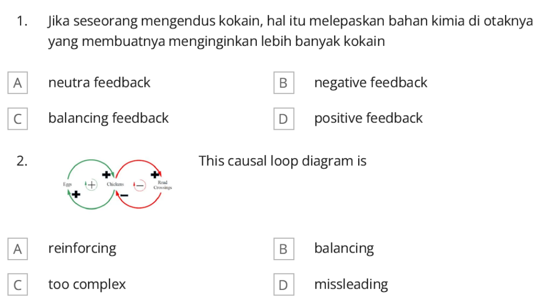
Figure 7. Model simulation to produce before and after Kalaju implementation

The model is simulated using a timestep of 1/512. This is because the smallest delay in the model has a value of 1/365. The model was simulated for 5 years from the initial year 2023 to 2028. The model was simulated twice. First is the basic simulation. The basic simulation is a baseline simulation or Business as usual (Scheinbaum) is a simulation without any policy interference that will be carried out. In this simulation, it is conditioned that there is no change at all while the Kalaju program is implemented. Second is the Kalaju Policy simulation. This simulation is an interference of the Kalaju program that will be implemented in the fishing village. The difference between the two simulations can be seen in the following table.

Participant then prepared to become a trainer by analyze and evaluate the model using some simulation and different nada to achieve optimum result. Before the program is closed, the participants were evaluated for their understanding of the concept od system dynamics.

RESULTS AND DISCUSSIONS

Following the pretest and posttest conducted during this workshop, it was observed that participants' knowledge and understanding of system dynamics had increased significantly. The successful commencement of the workshop can be attributed to various factors, with the participants' interest and enthusiasm during the capacity building session being a major contributing factor. Examples of the posttest exam and score is shown below



1. Jika seseorang mengendus kokain, hal itu melepaskan bahan kimia di otaknya yang membuatnya menginginkan lebih banyak kokain

A neutra feedback
B negative feedback
C balancing feedback
D positive feedback

2. This causal loop diagram is

A reinforcing
B balancing
C too complex
D missleading

Figure 8. Example of the examination

A total of 13 people had trained and 6 people are passed (> 50) and become a champion or the trainer for internal organization. The improvement of knowledge level about System Dynamics is shown in Figure 10.

	Names	Score	Accuracy	Q1 36%	Q2 73%	Q3 73%	Q4 45%	Q5 45%	Q6 36%	Q7 82%	Q8 64%
1	Rani	6900	100% (10 / 10 pts)	✓	✓	✓	✓	✓	✓	✓	✓
2	Alde	4800	80% (8 / 10 pts)	✓	✓	✓	✓	✓	✗	✗	✓
2	okribs	4800	80% (8 / 10 pts)	✗	✓	✓	✓	✓	✓	✓	✗
3	aguuusss	4200	70% (7 / 10 pts)	✓	✓	✓	✓	✗	✗	✓	✓
4	The	3600	60% (6 / 10 pts)	✗	✓	✓	✗	✗	✗	✓	✓
4	Prita	3600	60% (6 / 10 pts)	✓	✗	✗	✓	✗	✓	✗	✓
5	Daus	3000	50% (5 / 10 pts)	✗	✗	✓	✗	✗	✗	✓	✓
5	Munawar	3000	50% (5 / 10 pts)	✗	✗	✗	✗	✓	✓	✓	✗
5	didi	3000	50% (5 / 10 pts)	✗	✓	✓	✗	✗	✗	✓	✗
6	achmat marsito	2400	40% (4 / 10 pts)	✗	✓	✗	✗	✓	✗	✓	✓
7	Julham	1800	30% (3 / 10 pts)	✗	✓	✓	✗	✗	✗	✓	✗

Figure 9. Score of posttests after workshop

Source: author, 2023

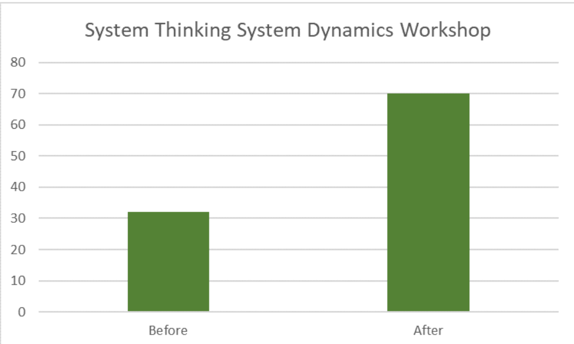


Figure 10. Result of avg score in System Dynamics

Source: author, 2020

As can be seen from Fig. 10 there was a significant increase of the knowledge and skills of the participant. The cognitive part about conceptual increase from 32 score to 72 with 50% of participant passed as a trainer of system dynamics for the organization.

CONCLUSION AND RECOMMENDATION

The aims of the workshop are to improve the capacity and skill of the KKP staff particularly in policy developing and reviewing function, therefore they can be the internal trainer to develop and review policy using system dynamics. The aims have been achieved in the workshop, by looking at the model's simulations that they have created and the improvement of the knowledge in system thinking and system dynamics. The level of knowledge has been improved significantly before and after the workshop, shown by the score of the cognitive test on the concept of system dynamics.

The workshop was conducted in a short time, to a small group of persons in managerial level, and with a minimum data set provided by the KKP office. Therefore, continual coaching on the model development in using the tools dynamics is recommended for the implementation of the Kalaju policy across Indonesia. Continual monitoring and evaluation of the development of skills and knowledge of the staff need to be planned and involvement of higher-level management in the evaluation of the actual usage of system dynamics in the evaluation of policy is needed. A larger data also needed to be able to create and simulate many models resulting more accurate result to be applied in real world.

Figure 11. The System Dynamic Workshop Participants

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