FINAL PROJECT – TI 141501

TUNA FISHERY POLICY ANALYSIS BY USING GAME THEORY APPROACH (CASE STUDY: *SENDANG BIRU*)

BUDIANTO
NRP 2513 100 139

Supervisor
Erwin Widodo, S. T., M. Eng., Dr. Eng.

INDUSTRIAL ENGINEERING DEPARTMENT
Faculty of Industrial Technology
Institut Teknologi Sepuluh Nopember
Surabaya 2017

APPROVAL SHEET

TUNA FISHERY POLICY ANALYSIS BY USING GAME THEORY APPROACH (CASE STUDY: *SENDANG BIRU*)

FINAL PROJECT

Submitted to Acquire the Requirement of Bachelor Degree at Undergraduate Program Industrial Engineering Department Industrial Technology Faculty Institut Teknologi Sepuluh Nopember Surabaya

Author:
BUDIANTO
NRP 2513 100 139

Approved by Final Project Supervisor

Erwin Widodo, S. T., M. Eng., Dr. Eng.
NIP. 197405171999031002

KEMENTERIAN RISET, TEKNOLOGI, DAN PENDIDIKAN TINGGI INSTITUT TEKNOLOGI SEPULUH NOPEMBER FAKULTAS TEKNOLOGI INDUSTRI DEPARTEMEN TEKNIK INDUSTRI

SURABAYA, 25 JULY 2017

ABSTRACT

Indonesia is the third largest fish producer in the world, after Japan and China in 2010, according to Food and Agricultural Organization (FAO). As the biggest archipelagic country, Indonesian maritime is one of its largest GDP contributor. Within the last decade, the fish industry has developed so much which followed by the significant number of exploration and exploitation activities. The problem of uncontrolled exploitations is the low stock of fish and fishery profit in the long period of time. The most recent issue of the high fish exploitation problem is the tuna fishery in *Sendang Biru* village. According to the local government data, the number of tuna catched in 2005 to 2010 is increasing yearly but from 2010 to 2015 the number is declining, although the number of fishing boat is increasing from 2005 to 2015. This phenomenon happened becaused of the over-exploitation on tuna.

This research is aimed to develop a sustainable policy for local government, fisherman, and fish trader in exploiting tuna in *Sendang Biru*, which combine system dynamics and cooperative game theory approach. The system dynamics approach is used to replicate the tuna fishery system behaviour in Sedang Biru. The output of this system dynamics approach is used as the payoff for the game theory approach. The best sustainable policy is local government need to set the local fishing ship limit around 200 units, fisherman has to set medium amount of fishing trip, and fish trader need to set high profit margin on trading tuna. In case, local government is not limiting the number of ship it is better for fisherman to set low amount of fishing trip.

Keywords: Tuna Fishery, System Dynamics, Cooperative Game Theory

PREFACE

Praise and gratitude writer prays to the Almighty God for the gracious mercy and tremendous blessing that enables the writer to accomplish the final project entitled "Tuna Fishery Policy Analysis by using Game Theory Approach (Case Study: *Sendang Biru*)".

On the process of doing this project, I am fully aware that there are many parties involved in supporting this project to be a success. Therefore, I would like to express special appreciation and gratitude to:

1. Writers' parents, sister, and brother that always gives moral and spiritual support during my bachelor study.
2. Erwin Widodo, S.T., M.Eng. Dr., as my supervisor who always give great help, advice, and motivation in finishing this project.
3. Mr. Guntoro, the administrator of *Sendang Biru* Village Government who provide the fishery data and information about the existing condition and possible improvement in *Sendang Biru* tuna fishery system.
4. Dr. Nurhadi Siswanto, S.T., M.S.I.E., as the head of Industrial Engineering Department Institut Teknologi Sepuluh Nopember who give easiness in administration of doing the final project.
5. Prof. Dr. Ir. Budisantoso Wirjodirdjo, M.Eng, as the head of Quantitative Modelling and Industrial Policy Analysis, who has provide me with systemic knowledge, especially system dynamics knowledge.
6. All Q-Laboratory assistants 2013 (Junda, Arum, Ocha, Uly, Desi, Suhawi, Sarika, Rara), 2014 (Vito, Faldy, Wiwit, Mayang, Zaki, Nabella, Sabrina, Ayun, Sandi, Bilays), and 2015 (Lorent, Christo, Monic, Raecky, Nabila P) as companion in finishing this project with joy and motivation.
7. Mr. Gatot Warsito who help contacted the concerned parties and allow me to continue his thesis research about tuna fishery in *Sendang Biru* Village.

8. Asyraf, Dickson, Suhunan, Sasando, Ramdhan, Didin, Fariz, Istna, Bobby, Firda, Clara and all “road to bali” member who struggling together with me and motivating each other in finishing this final project, always wishing all the best for us.
9. All CYPRIUM friends that always give motivation in finishing this project.
10. Everyone else that cannot be mentioned one by one in making this research a success, may God repay all the good deeds.

The writer also fully aware that this report still miss a lot of part. Therefore, any critics and suggestion regarding this report is welcomed. Hopefully this final report can give benefit to the readers and please your forgiveness if there are any unpleasant words and mistake during the process of making this report.

Surabaya, July 18th 2017

Writer

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

This chapter contains the intro of this research which consists of background, problem formulation, purposes of the research, benefit and the research outline.

1.1 Background

Indonesia is the third largest fish producer in the world, after Japan and China in 2010, according to Food and Agricultural Organization (FAO). The Indonesia maritime is one of the largest contributors for national GDP, as Indonesia is largest archipelagic country in the world. The fish industry has also developed so much which showed by the significant exploration and exploitation activities in the last decade. The uncontrolled exploitations can affect the low stock of fish and profit of the fish industry in the long period of time.

The most recent issue of the high fish exploitation is the tuna exploitation. According to Damianus Suryanto, Head Researcher of *Pusat Penelitian dan Pengembangan Perikanan*, tuna need to get special attention because it has the highest exploitation rate in Indonesia for the last decade (Kompas Daily, 2016). Most of the tuna from Indonesia (70% of them) is exported to Japan, Thailand, USA, China, and Europe, according to detikFinance on 2017 (https://finance.detik.com/industri/2551153/70-tuna-indonesia-diekspor-ke-thailand-hingga-amerika).

The largest tuna exporter with grade "A" in East Java is in the coast of *Sendang Biru*, Malang Regency. Here, there are more than 400 active tuna fishing boats listed by *Instalasi Pelabuhan Perikanan (IPP) Pondok Dadap* at 2015. The number of these fishing boats is always increasing for the last decade, followed by increasing number of fisherman. Tourism and fishery has become main source of income for the local citizen as well as local government.

Figure 1. 1 Map of Sendang Biru, Malang Regency

Source: (Warsito, 2017)

The process of tuna catching in Sendang Biru is done by local fishermen who sailing to catch tuna for several time in one month based on the season. Tuna is migrating out of Sendang Biru on the early of the year, migrating into Sendang Biru on the middle of the year, and migrating out again at the end of the year. Therefore, the number of sailing for tuna is higher in the middle of the year, and lower in the early and the end of the year. It takes around 1 week to 2 weeks for every trip of sailing for tuna. If tuna is scarce, the fishermen are forced to sail further and this caused the time, cost and effort higher. After being caught, the tuna then sold to *Pondok Dadap* fish market in Sendang Biru.

The production of tuna in Sendang Biru was increasing from 2005 to 2010, but it was decreasing after 2010 (based on the data reported on the Administration of Sendang Biru Village Government). According to Warsito (2017), the decreasing yield of tuna in *Sendang Biru* is because of the over-exploitation on tuna in the last several years. Therefore, in his research, the author suggests government to limit the number of tuna exploitation. This suggestion could be done by limiting the number of permitted boat for tuna fishing. He concluded that by applying that suggestion the government and fishermen will get more profit of tuna in the long run period.

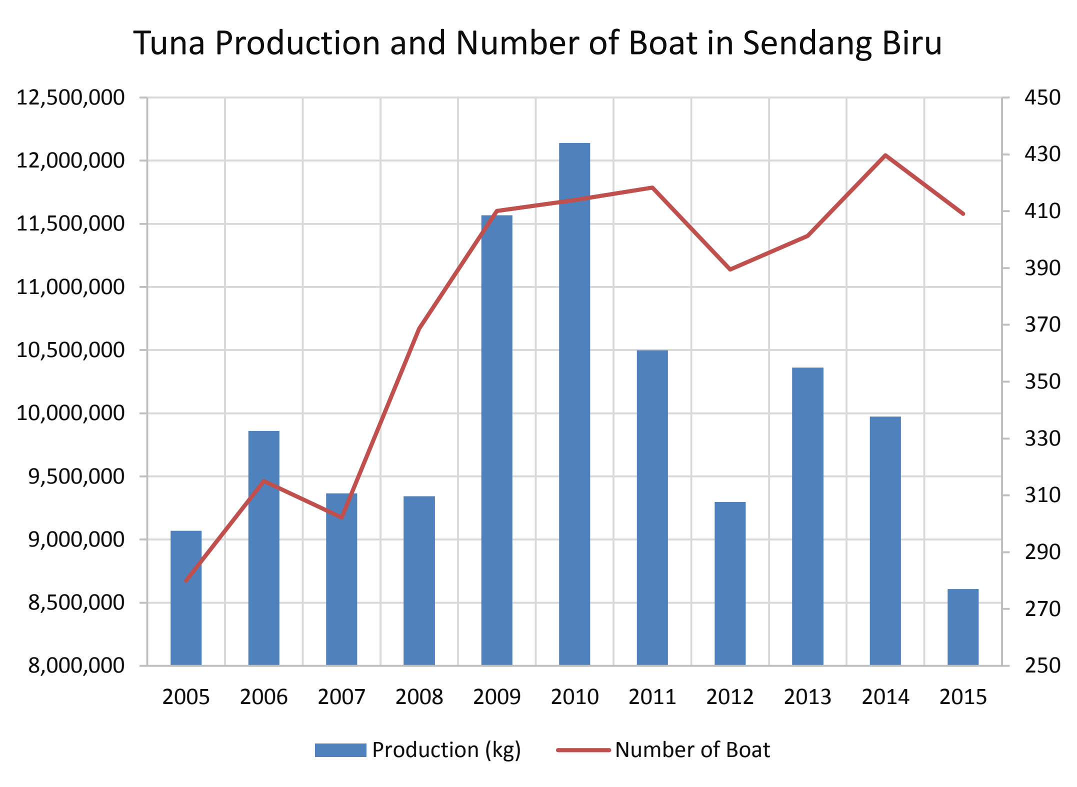


Figure 1. 2 Graph of tuna production in Sendang Biru from 2005 to 2015

Source: (Administration of Sendang Biru Village Government, 2015)

The problem of decreasing tuna production is really concerned by the government, fish trader and fishermen as they are the most responsible for it. The government able to limit the tuna fishing by limiting boat license. The fish traders able to set the tuna selling price, while fishermen able to determine the number of caught tuna. The government want the retribution fee high, but fishermen against it. Besides, the fish trader want to get highest possible profit by selling many tuna, but it will cause tuna depletion. Thus, in order to get higher sustainable profit, all of them need to cooperate.

This research is made in order to solve the tuna scarcity problem and try to take this problem not only considering the side of government but also the side of the fish traders and fishermen welfare. This research is the continuation and development of the research done by Warsito in 2017, which using Game Theory as the tools to view the problem of government, fish traders and fishermen simultaneously.

1.2 Problem Identification

Based on the background above, the problem identification in this research is: "What is the best strategy of the government, fish traders and fishermen of *Sendang Biru* in doing the exploitation of tuna, so all of them can get the highest profit for not only in the short run period but also in the long run period."

1.3 Research Objectives

The objectives of this research are mentioned in the following list.

1. To develop improvement model of tuna fishery system in the coast of *Sendang Biru,* by using systems dynamic approach.
2. To determine the best sustainable scenario to be applied by the local government, fish traders, and fishermen in term of profit achieved, by using game theory approach.

1.4 Benefits

The benefits obtained in this research are mentioned in the following list.

1. Able to generate the exploitation policy that consider the sustainability of tuna stock in the coast of *Sendang Biru*.
2. Able to generate a win-win solution for all local government, fish traders and fishermen in term of profit.

1.5 Research Scope

The research scope consists of limitation and assumption which will be explained below.

1.5.1 Limitation

The limitations used in this research are aimed to focus the research area and boundary. The limitations are mentioned in the following list.

1. The observation is conducted in the coast of Sendang Biru and Pondok Dadap fish market.
2. The product observed in this research is only tuna, including several species of tuna, because of the high exploitation rate for the last decade.

3. The fishermen observed is local fishermen which legally registered by the local government.
4. The fishery data for the research is collected from 2005 to 2015.

1.5.2 Assumption

The assumptions used in this chapter that applied on this research are mentioned in the following list.

1. All of the caught tuna is reported to the administration section of the local government.
2. The tuna exploitation data is recorded accurately by the local government.
3. There are no illegal fishing of tuna in the coast of *Sendang Biru*.
4. The duration of every fishing trip is one week, constrained by the amount of fuel, ice and other technical factors.

1.6 Research Outline

The research outline is composed of several chapters in the research and it will be explained below.

CHAPTER 1 INTRODUCTION

This chapter explains about background, problem formulation, objectives, benefits, research scope and the outline that is used in the research.

CHAPTER 2 LITERATURE REVIEW

This chapter explains about the theories and basic concept that have been developed and are used in this research. This literature review is used to justify the suitable method used in the research.

CHAPTER 3 RESEARCH METHODOLOGY

This chapter explains about the steps of research process. Generally, the steps of this research are divided into four steps which are; variable identification and conceptual modeling step, model simulation step, generating best strategies step, and analysis and conclusion making step.

CHAPTER 4 DESIGNING SIMULATION MODEL

This chapter consists of model simulation and formulation about the tuna fishery system in *Sendang Biru*. It started by identifying the system framework, strategic form of the game, system modelling.

CHAPTER 5 GAME THEORY ANALYSIS

This chapter consists of analysis and interpretation of the result of all selected scenario by using game theory method. The best selected scenario will be put as recommendation for the decision maker.

CHAPTER 6 CONCLUSION AND RECOMMENDATION

This chapter consists of conclusion and the recommendation of the research. The conclusion can be used as guide and reference to the policy makers and involved parties in the tuna fishery system, while the recommendations is for the better further future research.

CHAPTER 2
LITERATURE REVIEW

This chapter explains about the theories and basic concept that have been developed and are used in this research. This literature review is used to justify the suitable method used in the research.

2.1 Tuna Fishery

Family of tuna and its derivatives that included in principal market tuna species are; skipjack, yellowfin breed, bigeye, albacore, and bluefin breed. They are the mostly caught and traded tuna species. The characteristic of tuna that mostly found in Indonesia are tropical tuna, which are skipjack and yellowfin. They are living at the temperature around 18^{o}C and usually swim with schooling behavior. They usually form parabolic-shaped schools to encircle their prey.

2.1.1 Migration

All family of tuna move constantly to search for food and to keep water passing over their gills. Migration will cause seasonal movement pattern over long distance for the purpose of feeding or reproduction. Fishermen are sometimes able to predict on the basis of oceanic conditions where the fish are likely to appear and then, they can transfer their operations to those areas.

2.1.2 Involved Party

There are three most involved party in the tuna fishery system, they are government, fish traders and fishermen.

1. Government has the role to make regulation on the tuna fishery; such as the number of fishing ship, etc.
2. Fish trader has the role to buy tuna from fishermen and sell it to the international buyers. The price of selling tuna to international buyers is fixed, but the price of buying from fishermen can be adjusted.
3. Fishermen has the role to catch tuna and sell it to fish traders. They has the control on how many trip of fishing they will go.

2.2 System Dynamics

System dynamics is an approach to understand the nonlinear behavior of complex systems over time using stocks, flows, internal feedback loops, and time delay (Sterman, 2004). System dynamics try to simulate the real case problem into mathematical model. This method will analyze how one factor interact with other factors and how it is affected by them.

2.2.1 Steps of Modelling System Dynamics

According to Sterman, there are four basic steps of modelling the dynamic system, which are:

1. Problem identification, is the process in determining the problem, variable (dependent and independent), limitation, and assumption.
2. Making hypothesis, is the process in formulating initial hypothesis and mapping (making causal loop diagram).
3. Formulation of mathematical model, is the process in specifying the model structure, rule, and interaction between variable, which specifically model in the mathematical formula (making stock and flow diagram).
4. Testing, is the process in comparing result of simulation model and the real system (verification and validity testing).

2.2.2 Causal Loop Diagram

Causal loop diagram is the representation on how the system work. It shows how all elements interact one another. Each element will be connected by an arrow to another element. The element which the arrow come from, will affect the element which the arrow pointed. Each arrow also has sign (polarity), either + (positive) or – (negative). Positive polarity means, the element with the pointed arrow will increase if the element before it increase and vice versa. In the other hand, negative polarity means, the element with the pointed arrow will increase if the element before it decrease and vice versa.

For example, causal loop diagram of the population system will have three basic elements which are population, growth rate, and death rate (as shown by figure below). Higher growth rate will increase population, so there is an arrow from growth to population with positive polarity. Higher population also increasing both growth rate and death rate, so there are an arrow to growth rate and an arrow to the death rate with both positive polarity. Higher death rate, in the other hand, will decrease the number of population, so there is an arrow from death rate to population with negative polarity.

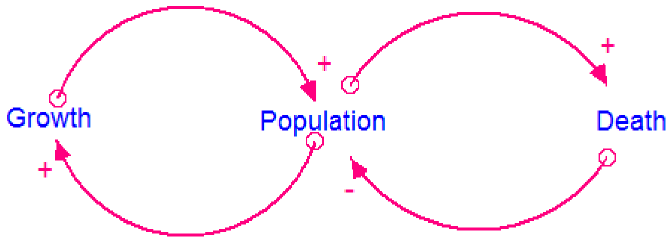


Figure 2. 1 Example of population system causal loop diagram

2.2.3 Stock Flow Diagram

Stock flow diagram is the detail representation on the system. It is made based on the causal loop diagram. Here, the relationship between each element is not shown by polarity, but by the mathematical equation. There are several basic type of element in stock flow diagram, which are:

1. Stock, used as accumulations. It collect whatever flows into them, net of whatever flows out of them.
2. Flow; is used to fill and drain accumulations. The unfilled arrow head on the flow pipe indicates the direction of positive flow.
3. Converter, serves a utilitarian. It holds values for constants, defines external inputs to the model, calculates algebraic relationships, and serves as the repository for graphical functions. In general, it converts inputs into outputs.
4. Connector, is used to connect model elements. There are two distinct types of connector: the action connector and the information connector. Action connectors are signified by a solid, directed wire. Information connectors are signified by a dashed wire.

The example of stock flow diagram for population system is shown by figure below. Growth rate and death rate is represented by the flow, while the population is represented by the stock. The growth rate will be the input for the population stock, while the death rate will decrease the population stock. There are two connectors that connect population to growth rate and death rate. The number population information will define the number of growth rate and death rate.

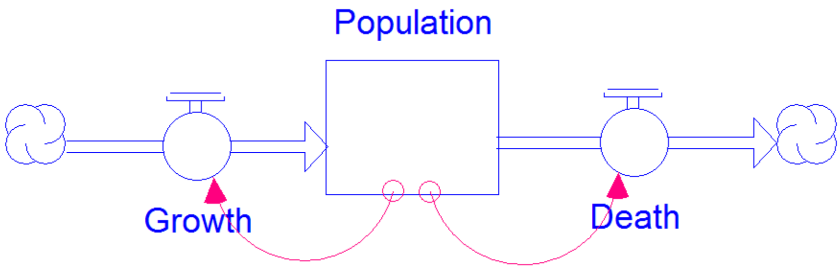


Figure 2. 2 Example of population system stock flow diagram

2.3 Game Theory

Game theory is a decision making method that apply mathematical model of conflict and cooperation between several parties with different interest. According to Leyton-Brown & Shoham (2008), game theory is the study of interaction among independent, self-interested agent. So, it involves more than one decision makers (called players). Each player has its own goals and strategy. The strategy made by each player is affected by the strategy of the other player. The outcome of the strategy made by each player is called payoff. The selected payoff can be vary from the type of game that is applied. The type of strategy, type of game, and solution for the game will be explained below.

2.3.1 Type of Strategy

Strategy is all the possible decision that available for the player in the game. Strategy will be vary for each player. There are two type of strategy which will be explained below.

1. Pure Strategy

Pure strategy is the condition where player will make decision only on one of its strategy. The chosen strategy will give each player its best solution. Pure strategy is applied when there is saddle point (equilibrium points) on the payoff matrix as shown by figure below.

		Your opponent		
		I	II	III
	A	-2	1	1
You	B	-3	0	2
	C	-4	-6	4

Figure 2. 3 Saddle point on payoff matrix
Source: (Widodo, 2016)

2. Mixed Strategy

Mixed strategy is an active randomization with given probabilities that determines the player's decision (Turocy & Stengel, 2001). So, each player will have to apply more than one decision. The frequency of chosen strategies played by each player is determined by game theory method, such as complementary slackness and graphical method.

2.3.2 Type of Game

Based on the payoff value, there are two type of games:

1. Zero Sum Game

   This is the type of game where the sum of payoff value for player 1 and player 2 will be zero. The payoff value for player 1 will be the same as negative value for player 2 and vice versa.

2. Non Zero Sum Game

   This is the type of game where the sum of payoff value for player 1 and player 2 don't have to be zero. This type of game is frequently found in the daily life, because there are conditions where both player will be benefited and there are conditions where both player will be lose. So, this game will direct the players to cooperate.

Based on the characteristic, there are two type of games:

1. Non-cooperative Game

   This type of game see every player to be rival from each other. There are no communication from one player to another. This type of game usually applied in the zero sum game.

2. Cooperative Game

   This type of game accommodate all players to do communication and coordination in choosing the best strategy for all players. The strategy chosen by each player maybe not optimal for itself, but the strategy chosen will be optimal for total value of the game for both players. Thus, in cooperative game, the focus is on what groups of players, rather than individual players, can achieve (Widodo, 2016).

Based on the number of player, there are two type of games:

1. Two-player Game

   This is the type of game with only two player. The matrix payoff will be only one for both of the player.

2. N-player Game

   This is the type of game with more than two player. The matrix payoff for this game can be one or more than one.

2.3.3 Solution for the Game

There are several method to find the solution for the game, they are maximin-minimax, domination method, and graphical method.

1. Domination Method

   Domination method is used to eliminate the strategy with the lowest or weakest payoff value. This method is used as the first step in simplifying the payoff matrix.

2. Maximin-Minimax

This method is done by finding the maximum value between the minimum values on the row strategies (find solution for lowest loss), and find the minimum value between the maximum values on the column strategies (find solution for greatest profit). This method is usually used for the zero-sum game, where the players have opposite self-interest.

3. Graphical Method

   This method is used when one of the player have only 2 strategies and there is no any saddle point. Probability to play the first strategy is denoted by P and the second probability should be 1-P. Then, draw the graph of matrix game and plot the strategy of other player on it (as shown by figure below). The chosen strategy is the highest un-dominated point for maximizing target, and lowest un-dominated point for minimizing target.

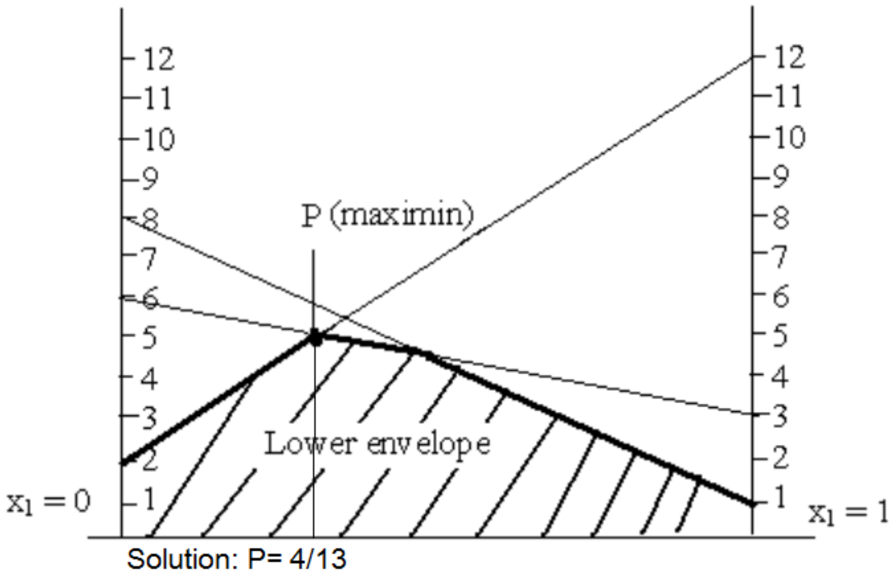


Figure 2. 4 Example of graphical method implementation

Source: (Leyton-Brown & Shoham, 2008)

2.4 Related Research

There are several related researches that have been done before. They are about the fishing regulation topics with various method, and the similar method for various kind of problem. They are used as references for this research.

Table 2. 1 Related research with similar topic

No	Research	Method	Objective
1	(Sliskovic, et al., 2006) Influence of Variable Catch Factors on Sardine Population Level in Eastern Adriatic Tested by System Dynamics	System Dynamics	Formulate the optimal fishing effort for the sardine in the Eastern Adriatic
2	(Adisetya, 2016) *Dinamika Pendapatan Nelayan Perikanan Demersal Pesisir Rembang Terkait Adanya Kebijakan Pengelolaan Ikan Berkelanjutan (Sebuah Pendekatan Sistem Dinamika)*	System Dynamics	Maximizing the sustainable income of local fishermen in the coast of Rembang
3	(Warsito, 2017) *Dinamika Kesejahteraan Berkelanjutan Nelayan* *Berbasis Ikan Tuna di Sendang Biru Kab. Malang*	System Dynamics	Formulate the policy for sustainable management of tuna fisheries

Based on the previous researches, the fishery system problem is commonly solved using the system dynamics approach. The main reason to use this approach is the high complexity (feedback loop existed and non-linearity) on the system behavior.

Table 2. 2 Related research with similar method

No	Research	Method	Objective
1	(Widiastuti, 2015) Analysis of Livestock Strategy to Support Ecotourism Development in *Kabupaten Malang* by Using Game Theory	System Dynamic and Game Theory	Determining the win-win solution for *Dinas Peternakan* and *Dinas Pariwisata* Kabupaten Malang
2	(Rohmaniah, 2015) *Analisis Kebijakan Pengembangan Ekowisata Berbasis Sektor Pertanian dan Dampaknya Terhadap Pendapatan Asli Daerah (PAD) dan Produk Domestik Bruto (PDRB) di Kabupaten Malang (Pendekatan Sistem Dinamik)*	System Dynamic and Game Theory	Determining the win-win solution for *Dinas Pertanian* and *Dinas Pariwisata* Kabupaten Malang
3	(Hidayat, 2016) *Penerapan* Game Theory *Sebagai Solusi Pemberdayaan Sumur Pompa Dalam untuk Proses Irigasi Pertanian di Kabupaten Madiun*	Game Theory	Determining the win-win solution for *Dinas PU dan Pengairan*, *Kelompok Tani*, and *Himpunan Petani Pemakai Air*
4	(Melati, 2017) *Analisa Strategi* Economic Dispatch *dengan Pendekatan* Game Theory *pada Sistem Kelistrikan Jawa Bali 500kV*	Game Theory	Minimizing cost of electricity by considering the interest of gas generator and coal generator

Game theory approach is well-known for the application in solving multi-player problem. This research try to combine the system dynamics approach to describe tuna fishery system and game theory approach to determine the best strategy for the government, KUD Mina Tani, and fishermen.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter explains about the steps of research process. Generally, the steps of this research are divided into four steps which are; variable identification and conceptual modeling step, model simulation step, generating best strategies step, and analysis and conclusion making step. Below is this research methodology flowchart.

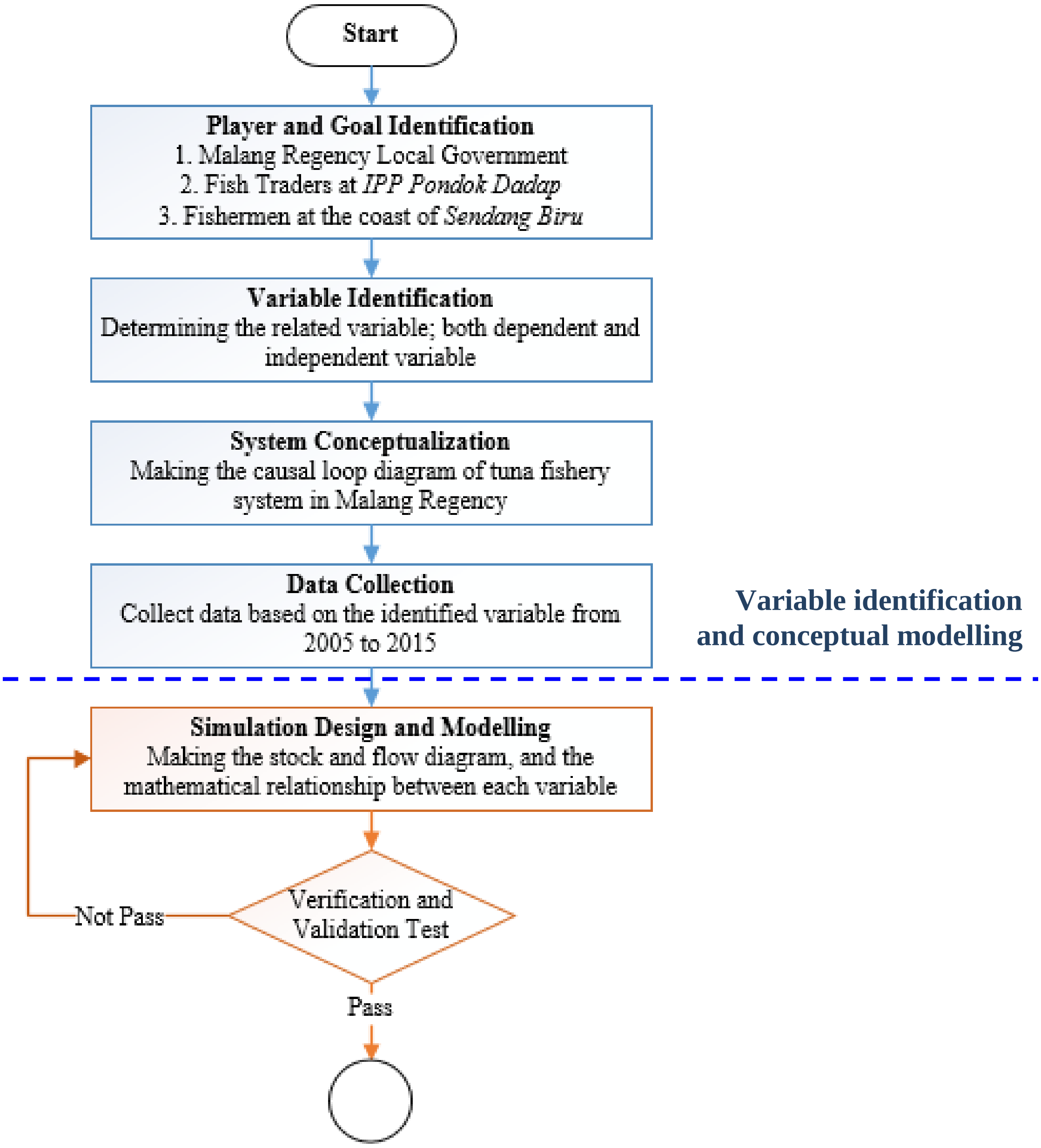


Figure 3. 1 Flowchart of research methodology

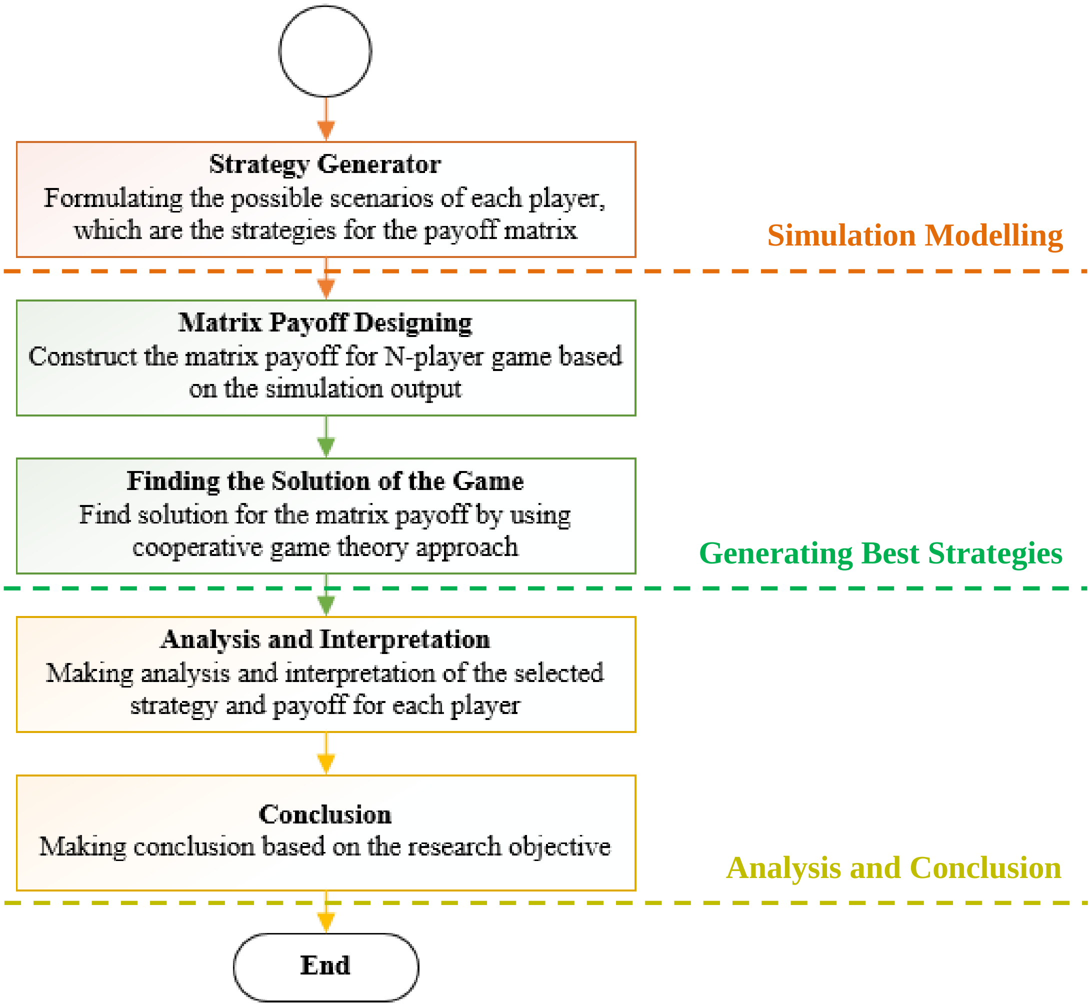


Figure 3. 1 Flowchart of research methodology (con't)

3.1 Variable Identification and Conceptual Modeling Stage

This stage identify the player, goal, and variable for this research. Then, the conceptual model of the tuna fishery system can be made and the data can be collected. This stage aims to give initial description of tuna fishery system and the related variables.

3.1.1 Player and Goal Identification

The sub-stage defines the player of the tuna fishery system at the coast of Sendang Biru and the goal of each player.

3.1.2 Variable Identification

This sub-stage identify all the variables that involved in the system, the dependent variable as well as the independent variable. The interaction of each variable is also explained here.

3.1.3 System Conceptualization

This sub-stage consist of the conceptual model of the tuna fishery system in the coast of Sendang Biru. The player and variable is used as the input of the conceptual system and the goal is the indicator of the system output. The conceptual model will be described in the form of causal loop diagram.

3.1.4 Data Collection

This sub-stage consist of the data collected for the research. The data collected is based on the variable identified before. The data is collected from *Instalasi Pelabuhan Perikanan (IPP) Pondok Dadap* and from external sources.

3.2 Simulation Modeling Stage

This stage consist of the simulation modelling and strategy designing. The simulation modelling is using the system dynamic approach. The mathematical formula also described here.

3.2.1 Simulation Design and Modelling

This sub-stage developed the conceptual model into the simulation model. The simulation model is in the form of stock flow diagram using the STELLA© (iSee System) Software. The simulation design also need to pass the verification and validation process.

3.2.2 Strategy Designing

This sub-stage defines the scenario for each player. The scenario is used as the strategy for each player as the decision variable.

3.3 Generating Best Strategy Stage

This stage is conducted after by designing matrix payoff and using game theory approach to achieve the value of the game, which is the best strategy for the interest all of players.

3.3.1 Matrix Payoff Designing

This sub-stage consists of the design of the matrix payoff of each player. The payoff value is based on the output of the system dynamic simulation.

3.3.2 Finding Solution of the Game

This sub-stage find the solution of the game for every matrix payoff. The solution is found by using game theory approach and using the Gambit Software.

3.4 Analysis and Conclusion Stage

This stage consist of the analysis on the strategy chosen for every player and the interpretation of the payoff result. Based on the analysis, the conclusion and recommendation are made.

3.4.1 Analysis and Interpretation

This sub-stage compare the chosen strategies to the unchosen strategies, analyze how it is better and the interpretation on real activity for the player. The output must be win-win solution for all the players.

3.4.2 Conclusion and Recommendation

This sub-stage consists the conclusion for the research and the recommendation for the players and the future research.

CHAPTER 4
DESIGNING SIMULATION MODEL

This chapter consists of model simulation and formulation about the tuna fishery system in *Sendang Biru*. It started by identifying the system framework, strategic form of the game, system modelling.

4.1 System Framework

The system framework specify the variable of tuna fishery system into controlled input (decision variable), uncontrolled input (parameter), and goal output (response).

Figure 4. 1 Research Framework Combination of SD and GT Approach

Sistem dynamics simulation is used as the tool to find payoff in the game theory payoff matrix. Then, the choosen strategy for all of the players is calculated using the Nash Equilibrium, in game theory approach. Controlled input is the strategy of the players in game, uncontrolled input is the behavior of the system which none of the player can control, and goal output is the payoff of each player based on the controlled and uncontrolled input.

4.2 Strategic Form

The strategic form in game theory is in the form of payoff matrix. In this case, the payoff matrix of 3-player game. The players involved and the strategy they have is shown below.

1. Government: Fishing ship limit (less, medium, many)
2. KUD Mina Tani: Profit margin in trading tuna (low, medium, high)
3. Fisherman: Number of fishing trip (less, medium, many)

Based on the player and strategy above, the payoff matrix of the game is formulated below.

Figure 4. 2 Strategic Form for Tuna Fishery Game in *Sendang Biru*

The payoff for each strategy combination is in billions of rupiah, for government is the retribution amount, for fisherman is the fishing income, and for KUD Mina Tani is the revenue in trading tuna.

4.3 System Modelling

The tuna fishery system in Malang is modelled into three sector, which are; tuna population sector, fishery sector, and finance sector. The conceptual model is shown in causal loop diagram, while the simulation model is shown in stock and flow diagram. Both model is made using Stella (isee System) Software.

4.3.1 Conceptual Model

The conceptual model of Malang tuna fishery system is shown by the causal loop diagram below. Overall, the tuna population sector positively affected the finance sector, and finance sector also positively affected the fishery sector, but the fishery sector affect the tuna population sector negatively. Thus, this system has a negative loop which will decrease from time to time if one of the sector is not balanced.

Figure 4. 3 Causal Loop Diagram for Tuna Fishery Conceptual Model

The causal loop diagram in the tuna fishery system consist of 48 variables. The positive relationship between variable is denoted by green arrow, while the negative relationship is denoted by red arrow.

This diagram shows that the number of catch-fishermen revenue-expense for buying new ship-purchasing-effort- the number of catch has a positive loop. This means that the number of catch should be increasing from time to time, but it is not true, because the number of catch also have a negative loop to the stock of tuna. The dynamics of this problem will be described more on the next section.

4.3.2 Simulation Model

The simulation model of Malang tuna fishery system is shown by the stock and flow diagram below. The data used in the simulation model is shown by

Appendix 1 and Appendix 2 in the Appendix section, while the data summary is shown by Appendix 3. The detail of variables equation can be seen in Appendix 4.

Figure 4. 4 Stock and Flow Diagram for Tuna Fishery Simulation Model

This simulation model is made based on the causal loop diagram. The description and formula for each variable will be explained by tables below.

Table 4. 1 Variables description and formula for the tuna population sector

Based on the research about the number resources of pelagic fish in Indonesian FMA 573 Indian Ocean water area by hydro acoustic method (Ma'amun, et al., 2007), the density of tuna population in *Sendang Biru* water area is 0.94 ton/km^2, while the water area of the *Sendang Biru* is around 25,000 km^2. Based on this data, the stock of tuna in *Sendang Biru* in 2005 can be estimated around 23,500,000 kg in 2005. In addition, the growth coefficient of tuna in size and number is 1.13 per year based on the research about animal behavior on marine conservation (Reynolds & Jennings, 2000). The other technical and historical data is provided by the Administration of Sendang Biru Village Government (Appendix 1, 2, and 3).

Table 4. 2 Variables description and formula for the finance sector

Table 4.2 Variables description and formula for the finance sector (con't)

Table 4. 3 Variables description and formula for the fishery sector

Table 4.3 Variables description and formula for the fishery sector (con't)

The fishery simulation model is then verified and validated. The detail of the verification and validation process and result is discuss in the next section.

4.3.3 Verification and Validation

Verification is a process to check whether the simulation model already fit the conceptual model. Verification consist of equation and dimentional-consistency test.

Figure 4. 5 Equation Verification by Using Model Diagnostics Features

Equation verification test is done by using model diagnostic features provided by Stella Software and the dimentional-consistency test is done by using the check units command in Stella Software. The result of equation verification tests is shown by figure 4.5 and the result of dimentional-consistency is shown by figur 4.6 below. The fishery simulation model appears to pass both of these verification test.

Figure 4. 6 Dimentional Consistency Test by Using the Check Units Command

Table 4. 4 Comparison between actual and simulation result on number of catch

Based on this data, the paired t-test is performed. The hypothesis for the paired t-test are:

H_0 = There is no different between actual and simulation result
H_a = There is different between actual and simulation result

Based on these hypothesis, the p-value from the paired t-test is compared with the significant level (α=alpha) which is 0.05. The result of paired t-test is calculated by Excel Data Analysis ToolPak, which is shown by figure below.

Figure 4. 7 Paired t-Test Validation Result

From the paired t-test result, the p-value is 0.417 which is more than the significant level (α) and the H_0 hypothesis is accepted. Thus, the conclusion is there are no significant different between actual and simulation result, and the model can be confirmed as valid.

Furthermore, the comparison of the actual and simulation behavior pattern is also similar, that they have the increasing trend from 2005 to 2010 and have decreasing trend from 2010 to 2015. The behavior of the actual and simulation result can be seen by figure below.

Figure 4. 8 Validation Graph between Real and Simulation Result

The detail of the simulation graph is shown by figure 4.8 below. This graph shows the oscillation of stock of tuna and number of catch, which cause by the migration of tuna. The number of local ship is having increasing trend in the beginning of simulation and shows decreasing trend in the end of simulation, which is caused by the decreasing stock of tuna.

Figure 4. 9 System Behavior Graph on the Tuna Fishery Simulation

Based on this result, the model can be confirmed as verified, validated, and representative of the real system. Thus, this fishery model can be used as research tool to observe the different results (payoff) of different input (strategy) between all involved parties. The research about these payoff and strategy between players is discussed in the next chapter.

CHAPTER 5
GAME THEORY ANALYSIS

This chapter consists of analysis and interpretation of the result of all selected scenario by using game theory method. The best selected scenario will be put as recommendation for the decision maker.

5.1 Game Theory Approach

Game theory approach is used to find the best sustainable solution for all the involved parties; government, fisherman, and KUD Mina Tani, in exploiting tuna. Therefore, the simulation is set with the parameter from 2015 to 2025.

5.1.1 Interface for Finding Payoff

The payoff of each player is obtained by changing the input (strategy) in the simulation. The simulation interface for finding the payoff is shown by figure below, where each player has its own decision variable (shown by Input Variable Box) and its own payoff (Response Variable Box). In addition, the behavior of the system in each chosen scenario is shown by the System Performance Graph.

Figure 5. 1 Interface of the Tuna Fishery Simulator

5.1.2 Payoff Matrix Formulation

Based on the result of the simulator on tuna fishery, the payoff matrix can be formulated. The payoff matrix involved 3 players and 3 strategies for each player. The players involved and their strategies are;

1. Government: Fishing ship limit (less, medium, many)
2. KUD Mina Tani: Profit margin in trading tuna (low, medium, high)
3. Fisherman: Number of fishing trip (less, medium, many)

The tuna price and maintenance cost from 2016 to 2025 used in the simulation is forcasted using time series menu in Minitab 16 Statistical Software. The result of these forcasted can be seen in Appendix 5 and 6. Based on these data, the payoff matrix for the tuna fishery game from 2016 to 2025 can be formulated as shown by figure below.

Figure 5. 2 Payoff Matrix (Normal Form) of Tuna Fishery Game

If the choosen strategy for local government is less, fisherman is less and fish trader is low, then the payoff for each of them respectively are 43 billion rupiah for local government, 898 billion rupiah for fisherman, and 567 billion rupiah for fish trader. The best solution (choosen strategy) for all of the involved parties is determined in the next section.

5.1.3 Finding the Best Solution

The best solution is determined by game theory Nash Equilibrium method. In this case, there are two different solution for the choosen strategy; the non-cooperative solution and cooperative solution.

The non-cooperative solution is calculated based on the payoff matrix shown by figure 5.3 below. This matrix value is inputed into the Gambit 14.1.0 Software, and the equilibrium point is determined using the Nash Equlibrium method. The process of the finding determining equilibrium point using Gambit Software is shown by Appendix 7 and the result are shown below.

Figure 5. 3 Non-cooperative Nash Equilibrium Point

The choosen strategy for non-cooperative solution for local government is set high limit of local ship, for fisherman is less in doing fishing trip, and for fish trader is set high profit margin. However, this result is not the best because this choosen strategy not giving the highest total value from all players. Thus, the cooperative game theory is applied.

The first step of doing cooperative game theory is by changing the normal form of payoff matrix into the coalition form, then the solution of the game is determine using Nash Equilibrium method. In order to found the most highest possible payoff, the payoff of each player need to be sum. The sum up payoff matrix is shown by figure 5.4 below.

Figure 5. 4 Utility-Sum Payoff Matrix

The coalition form of the tuna fishery game is shown by figure 5.4 below, where the distribution of payoff in the choosen cooperative strategy (med, med, high) is corrected. The choosen strategy from the coalition matrix is then determined using Nash Equilibrium method.

Figure 5. 5 Nash Equilibrium on the Coalition Form

5.2 Result Analysis

Applying the non-cooperative game theory method on the tuna fishery game, the best chosen sustainable strategy for all parties in exploiting tuna are;

1. Local Government : Set high limit for local ship amount
2. Fisherman : Set low amount of fishing trip
3. Fish Trader : Set high profit margin

In the other hand, applying the cooperative game theory method, the best chosen sustainable strategy for all parties in exploiting tuna are;

1. Local Government : Set medium limit for local ship amount
2. Fisherman : Set low amount of fishing trip
3. Fish Trader : Set high profit margin

Both of this result protect the over-exploitation on tuna. In the non-cooperative method, fisherman has the biggest role in protecting the exploitation rate by setting low amount of fishing trip. In the cooperative method, fisherman and local government work together in protecting the exploitation rate. Fish trader also take part in preventing the over-exploitation. The high fish trader profit margin will cause low tuna buying price from fisherman and decrease the profit of fisherman. The low profit of fisherman make the number of fisherman lower and this decrease the number of exploitation. The performance graph of the non-cooperative and cooperative strategy is shown by figure below.

Figure 5. 6 System Performance Graph for the Non-cooperative Game

Figure 5. 7 System Performance Graph for the Cooperative Game

Comparing these two system performance graphs, the non-cooperative method still show the over-exploitation pattern, where stock of tuna (blue line) increasing in the early of the simulation but decreasing in the end of the simulation, this is because of the highly increasing number of fishing ship (purple line). In the other hand, the cooperative method shows more sustainable pattern, where the stock of tuna, number of catch, and number of ship remain more constant from time to time.

Therefore, in the long period of time, it is better for both fisherman and local government to cooperate. Local government need to limit the number of ship around 200 unit and each fisherman need to do medium amount of fishing trip. In case the local government is not limiting the number of ship limit, it is better for the fisherman to do low amount of fishing trip, in order to slow the number of over-exploitation rate.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

This chapter consists of conclusion and the recommendation of the research. The conclusion can be used as guide and reference to the policy makers and involved parties in the tuna fishery system, while the recommendations is for the better further future research.

6.1 Conclusion

The conclusion after conducting this research are:

1. The model of tuna fishery system is build using the system dynamics approach in this research; conceptual and simulation model. The conceptual model is described using the causal loop diagram and the simulation model is described using the stock-and-flow diagram. The existing simulation model is held on 2005 to 2015. The result of the existing model is the number of tuna caught is increasing from 2005 to 2010 but decreasing from 2010 to 2015, due to over-exploitation. The improvement simulation model for the better result is held from 2016 to 2025, with 3 changing variable; local ship limit (by local government), number of fishing trip (by fisherman), and tuna trading profit margin (by fish trader). These changing variable are used as the strategy input to the game theory approach, and the result of each variable combination is used as the payoff input to the game theory approach. The chosen improvement model is determined by game theory approach.
2. Based on the result of the simulation model, the payoff matrix is constructed. There are two approach in determining the best sustainable solution for the tuna fishery problem; the non-cooperative game and cooperative game approach. The non-cooperative game approach utilize the Nash Equilibrium method on the payoff matrix (normal form) and the chosen strategy is local government set high limit on number of boat, fisherman set low fishing trip amount, and fish trader set high profit margin. In the other hand, the cooperative game approach change the

normal form payoff matrix into the coalition form and then utilize the Nash Equilibrium method to find the best strategy; local government set medium limit on number of boat, fisherman set medium fishing trip amount, and fish trader set high profit margin. Both of this method create a sustainable fishery, the different is the non-cooperative method emphasize the protection of over-exploitation only on fisherman, while the cooperative method emphasize the protection of over-exploitation on both fisherman and local government. The non-cooperative method also show the sign of over-exploitation pattern in the end of the simulation (shown by the high number of local ship), while the cooperative method show the constant number of catch, stock of tuna and number of local ship. Therefore, the best strategy is for local government to set the number of local ship around 200 units and fisherman need to set medium amount of fishing trip. In case, local government is not limiting the number of ship it is better for fisherman to set low amount of fishing trip to protect the exploitation rate no too high.

6.2 Recommendation

The recommendation for the better future research are:

1. In this research, foreign ship contribution to local government is not included into the local government earning which in the real case it does. Considering the foreign ship contribution might give different result to the descision makers.
2. Simulation on the longer period of time might give more insight on the best sustainable result and this research result need to be compared to the fishery MSY, MEY, and MScY management approach.
3. This combined system dynamics and game theory method is expandable and adaptable to different kind of fishery in a different place with more involved parties.

BIBLIOGRAPHY

Adisetya, K., 2016. *Dinamika Pendapatan Nelayan Perikanan Demersal Pesisir Rembang Terkait Adanya Kebijakan Pengelolaan Ikan Berkelanjutan (Sebuah Pendekatan Sistem Dinamika),* Surabaya: Jurusan Teknik Industri-ITS.

detikFinance, 2014. *70% Tuna Indonesia Diekspor ke Thailand Hingga Amerika.* [Online] Available at: https://finance.detik.com/industri/2551153/70-tuna-indonesia-diekspor-ke-thailand-hingga-amerika [Diakses 9 March 2017].

Food and Agricultural Organization of the United Nations, 2010. Recent Development in the Tuna Industry. *FAO Fisheries and Aquacultural Technical Paper,* Volume 543, p. 17.

Hidayat, M. N., 2016. *Penerapan Game Theory Sebagai Solusi Pemberdayaan Sumur Pompa Dalam untuk Proses Irigasi Pertanian di Kabupaten Madiun,* Surabaya: Jurusan Teknik Industri-ITS.

Leyton-Brown, K. & Shoham, Y., 2008. *Essentials of Game Theory.* London: Morgan & Claypool.

Ma'amun, A., Hidayat, T., Nurulludin & Priatna, A., 2007. Distribution and Potential Resources of Pelagic Fish in Fisheries Management Area of The Republic Indonesia 573 (FMA 573) Indian Ocean. *Jurnal Penelitian Perikanan Indonesia,* Volume 23, p. 47.

Melati, A. A., 2017. *Analisa Strategi Economic Dispatch dengan Pendekatan Game Theory pada Sistem Kelistrikan Jawa Bali 500kV,* Surabaya: Jurusan Teknik Indutri-ITS.

Reynolds, J. D. & Jennings, S., 2000. *The Role of Animal Behavior in Marine Conservation,* Cambridge: Cambridge University Press.

Rohmaniah, A., 2015. *Analisis Kebijakan Pengembangan Ekowisata Berbasis Sektor Pertanian dan Dampaknya Terhadap Pendapatan Asli Daerah (PAD) dan Produk Domestik Bruto (PDRB) di Kabupaten Malang (Pendekatan Sistem Dinamik),* Surabaya: Jurusan Teknik Industri-ITS.

Schaefer, M. B., 1957. A study of the dynamics of the fishery for yellowfin tuna in the Eastern Tropical Pacific Ocean. *Inter-American Tropical Tuna Commission Bulletin,* 2(Inter-American Tropical Tuna Commission), pp. 243-285.

Sliskovic, M., Munitic, A. & Jelic-Mrcelic, G., 2006. *Influence of variable catch factors on sardine population level in eastern Adriatic tested by System Dynamics,* Croatia: Faculty of Marine Studies-University of Split.

Sterman, J. D., 2004. *Business Dynamics: Systems Thinking and Modelling for a ComplexWorld,* New York: McGraw.

Turocy, T. L. & Stengel, B. v., 2001. *Game Theory,* Texas: CDAM Research.

Warsito, G., 2017. *Dinamika Kesejahteraan Berkelanjutan Nelayan Berbasis Ikan Tuna di Sendang Biru Kab. Malang,* Surabaya: Magister Analisa Sistem dan Riset Operasi- STTAL.

Whelan, J. G., 1994. *Renewable Resource Depletion: The Fish Banks Model,* Cambridge: Sloan School of Management-MIT.

Widiastuti, N. A., 2015. *Analysis of Livestock Strategy to Support Ecotourism Development in Kabupaten Malang by Using Game Theory,* Surabaya: Jurusan Teknik Industri-ITS.

Widodo, E., 2016. *Presentation 2: Two-person, Zero-sum game with equilibrium points.* Surabaya(Jawa Timur): ITS.

APPENDIX

Appendix 1. Tuna Fishery Production, Effort, CPUE, Number of Ship, Tuna Price, and Revenue Data on *Sendang Biru* Village from 2005 to 2015

Year	Month	Production	Effort	CPUE	Trip	Operating Ship		Number of Ship		Tuna Price	Revenue			Local Boat Rev. After Retribution
						Local	Foreign	Local	Foreign		KUD Mina Tani	Fisherman	Local Boat	
		(kg)	(effort)	(kg/effort)	(trip)	(ship)				(Rp/kg)	(Rp)			
2005	1	22,420	50	448	2	20	5	150	130	30,000	192,175,308	480,438,269	257,377,644	249,656,315
	2	35,522	64	555	2	27	5	150	130	30,000	304,474,988	761,187,469	407,779,002	395,545,631
	3	83,827	105	798	3	30	5	150	130	30,000	718,516,731	1,796,291,827	962,299,193	933,430,217
	4	629,183	507	1241	3	115	54	150	130	30,000	5,392,996,274	13,482,490,686	7,222,762,867	7,006,079,981
	5	1,643,910	1,120	1468	4	150	130	150	130	30,000	14,090,655,748	35,226,639,370	18,871,413,948	18,305,271,530
	6	1,820,505	1,120	1625	4	150	130	150	130	30,000	15,604,325,285	39,010,813,213	20,898,649,936	20,271,690,438
	7	1,995,255	1,120	1781	4	150	130	150	130	30,000	17,102,189,524	42,755,473,810	22,904,718,112	22,217,576,569
	8	1,582,181	1,120	1413	4	150	130	150	130	30,000	13,561,552,857	33,903,882,143	18,162,794,005	17,617,910,185
	9	815,081	765	1065	3	130	125	150	130	30,000	6,986,405,863	17,466,014,657	9,356,793,566	9,076,089,759
	10	316,585	477	664	3	129	30	150	130	30,000	2,713,587,839	6,783,969,598	3,634,269,428	3,525,241,345
	11	83,248	166	501	2	78	5	150	130	35,000	832,483,757	2,081,209,392	1,114,933,603	1,081,485,595
	12	40,754	100	408	2	45	5	150	130	30,000	349,322,077	873,305,193	467,842,067	453,806,805
2006	1	35,765	74	480	2	32	5	152	163	30,000	306,556,131	766,390,328	369,728,241	358,636,394
	2	70,124	123	571	2	41	20	152	163	30,000	601,065,381	1,502,663,452	724,927,096	703,179,284
	3	148,744	184	807	3	41	20	152	163	30,000	1,274,950,461	3,187,376,154	1,537,679,870	1,491,549,474
	4	553,700	405	1368	3	85	50	152	163	30,000	4,746,000,401	11,865,001,002	5,724,010,068	5,552,289,766
	5	1,958,789	1,256	1559	4	151	163	152	163	30,000	16,789,618,301	41,974,045,753	20,249,459,772	19,641,975,979
	6	2,071,764	1,256	1649	4	151	163	152	163	30,000	17,757,978,981	44,394,947,452	21,417,370,815	20,774,849,691
	7	2,150,015	1,260	1706	4	152	163	152	163	30,000	18,428,700,914	46,071,752,284	22,226,308,610	21,559,519,352
	8	1,711,925	1,252	1367	4	150	163	152	163	30,000	14,673,640,684	36,684,101,709	17,697,442,039	17,166,518,778
	9	764,607	737	1038	3	120	126	152	163	30,000	6,553,773,012	16,384,432,530	7,904,310,901	7,667,181,574
	10	313,930	474	662	3	91	67	152	163	30,000	2,690,829,252	6,727,073,130	3,245,329,210	3,147,969,333
	11	52,623	109	484	2	34	20	152	163	30,000	451,051,414	1,127,628,536	543,999,709	527,679,718
	12	28,549	70	405	2	30	5	152	163	30,000	244,706,497	611,766,242	295,133,235	286,279,238

Appendix 1. Tuna Fishery Production, Effort, CPUE, Number of Ship, Tuna Price, and Revenue Data on *Sendang Biru* Village from 2005 to 2015 (con't)

Year	Month	Production	Effort	CPUE	Trip	Operating Ship		Number of Ship		Tuna Price	Revenue			Local Boat Rev. After Retribution
						Local	Foreign	Local	Foreign		KUD Mina Tani	Fisherman	Local Boat	
		(kg)	(effort)	(kg/effort)	(trip)	(ship)				(Rp/kg)	(Rp)			
2007	1	18,720	38	495	2	14	5	156	152	35,000	187,200,623	468,001,557	236,886,853	229,780,248
	2	29,352	47	625	2	14	9	156	146	35,000	293,517,084	733,792,711	379,469,128	368,085,054
	3	139,466	169	824	3	38	19	156	146	35,000	1,394,661,503	3,486,653,758	1,803,067,053	1,748,975,041
	4	944,564	702	1,346	3	117	117	156	146	35,000	9,445,637,469	23,614,093,673	12,211,649,688	11,845,300,197
	5	1,821,887	1,203	1,515	4	155	146	156	146	35,000	18,218,870,540	45,547,176,350	23,553,991,508	22,847,371,763
	6	1,893,209	1,203	1,574	4	155	146	156	146	35,000	18,932,088,047	47,330,220,118	24,476,063,986	23,741,782,067
	7	1,936,666	1,207	1,605	4	156	146	156	146	35,000	19,366,663,330	48,416,658,326	25,037,898,075	24,286,761,133
	8	1,679,949	1,188	1,414	4	156	141	156	146	35,000	16,799,485,062	41,998,712,656	21,718,960,439	21,067,391,626
	9	667,041	651	1,024	3	94	123	156	146	35,000	6,670,413,536	16,676,033,841	8,623,743,357	8,365,031,056
	10	146,941	211	695	3	38	33	156	146	35,000	1,469,406,833	3,673,517,083	1,899,700,423	1,842,709,410
	11	62,144	103	601	2	33	19	156	146	35,000	621,438,607	1,553,596,518	803,417,514	779,314,989
	12	26,377	66	401	2	28	5	156	146	35,000	263,767,364	659,418,409	341,007,651	330,777,421
2008	1	15,430	41	380	2	15	5	187	182	35,000	154,302,326	385,755,816	195,673,240	189,803,043
	2	38,529	81	474	2	25	16	187	182	35,000	385,294,683	963,236,707	488,598,330	473,940,380
	3	110,275	170	649	3	25	32	187	182	35,000	1,102,747,293	2,756,868,233	1,398,411,423	1,356,459,080
	4	640,046	622	1029	3	154	53	187	182	35,000	6,400,460,503	16,001,151,257	8,116,526,000	7,873,030,220
	5	1,670,512	1,282	1303	4	182	139	187	182	35,000	16,705,124,583	41,762,811,459	21,184,034,798	20,548,513,754
	6	2,026,454	1,458	1390	4	183	182	187	182	35,000	20,264,542,273	50,661,355,683	25,697,789,115	24,926,855,441
	7	2,121,107	1,475	1438	4	187	182	187	182	35,000	21,211,071,763	53,027,679,408	26,898,098,250	26,091,155,303
	8	1,695,765	1,475	1150	4	187	182	187	182	35,000	16,957,648,322	42,394,120,805	21,504,264,176	20,859,136,251
	9	697,943	872	800	3	157	134	187	182	35,000	6,979,431,209	17,448,578,023	8,850,727,983	8,585,206,143
	10	218,379	407	536	3	64	72	187	182	35,000	2,183,785,845	5,459,464,614	2,769,293,645	2,686,214,835
	11	83,018	203	409	2	53	48	187	182	40,000	948,779,415	2,371,948,538	1,203,162,302	1,167,067,433
	12	25,256	75	338	2	32	5	187	182	40,000	288,639,097	721,597,744	366,027,841	355,047,006
2009	1	23,429	57	411	2	23	6	208	202	43,000	287,836,396	719,590,989	365,009,922	354,059,624
	2	56,342	107	527	2	32	21	208	202	43,000	692,201,429	1,730,503,572	877,791,667	851,457,917
	3	290,316	417	696	3	92	48	208	202	43,000	3,566,734,596	8,916,836,489	4,523,033,002	4,387,342,012

Appendix 1. Tuna Fishery Production, Effort, CPUE, Number of Ship, Tuna Price, and Revenue Data on *Sendang Biru* Village from 2005 to 2015 (con't)

Year	Month	Production	Effort	CPUE	Trip	Operating Ship		Number of Ship		Tuna Price	Revenue			Local Boat Rev. After Retribution
						Local	Foreign	Local	Foreign		KUD Mina Tani	Fisherman	Local Boat	
		(kg)	(effort)	(kg/effort)	(trip)	(ship)				(Rp/kg)	(Rp)			
2009	4	714,423	599	1193	3	147	52	208	202	43,000	8,777,194,249	21,942,985,622	11,130,499,953	10,796,584,955
	5	2,011,327	1,441	1396	4	206	155	208	202	43,000	24,710,584,698	61,776,461,745	31,335,886,392	30,395,809,801
	6	2,492,170	1,640	1519	4	208	202	208	202	43,000	30,618,084,056	76,545,210,140	38,827,280,506	37,662,462,091
	7	2,505,958	1,640	1528	4	208	202	208	202	43,000	30,787,482,277	76,968,705,691	39,042,097,090	37,870,834,177
	8	2,171,293	1,640	1324	4	208	202	208	202	43,000	26,675,885,216	66,689,713,040	33,828,115,310	32,813,271,851
	9	931,440	931	1001	3	168	143	208	202	40,000	10,645,023,634	26,612,559,084	13,499,124,173	13,094,150,448
	10	260,432	449	580	3	83	67	208	202	40,000	2,976,360,900	7,440,902,251	3,774,370,707	3,661,139,586
	11	78,782	183	430	2	59	32	208	202	40,000	900,362,250	2,250,905,624	1,141,763,722	1,107,510,811
	12	32,058	83	385	2	36	6	208	202	40,000	366,378,345	915,945,861	464,610,220	450,671,913
2010	1	18,589	49	376	2	20	5	214	200	30,000	159,334,217	398,335,542	205,957,581	199,778,854
	2	39,891	71	565	2	24	12	214	200	30,000	341,923,094	854,807,736	441,974,454	428,715,221
	3	84,177	120	702	3	28	12	214	200	26,000	625,311,643	1,563,279,108	808,286,357	784,037,766
	4	832,750	705	1180	3	141	94	214	200	26,000	6,186,140,650	15,465,351,624	7,996,289,760	7,756,401,067
	5	2,311,457	1,646	1404	4	212	200	214	200	26,000	17,170,820,163	42,927,050,406	22,195,236,290	21,529,379,201
	6	2,310,812	1,656	1396	4	214	200	214	200	26,000	17,166,030,704	42,915,076,761	22,189,045,371	21,523,374,010
	7	2,574,369	1,656	1555	4	214	200	214	200	26,000	19,123,884,524	47,809,711,311	24,719,793,916	23,978,200,099
	8	2,289,685	1,651	1387	4	213	200	214	200	26,000	17,009,089,743	42,522,724,358	21,986,181,344	21,326,595,904
	9	1,052,630	1,072	982	3	188	169	214	200	26,000	7,819,537,423	19,548,843,558	10,107,640,703	9,804,411,482
	10	495,466	783	633	3	129	132	214	200	30,000	4,246,849,296	10,617,123,239	5,489,535,311	5,324,849,252
	11	107,408	235	457	2	82	35	214	200	30,000	920,636,995	2,301,592,487	1,190,027,934	1,154,327,096
	12	24,263	59	413	2	24	6	214	200	30,000	207,965,637	519,914,092	268,819,218	260,754,642
2011	1	22,279	61	364	2	25	6	218	200	35,000	222,791,723	556,979,308	290,256,822	281,549,118
	2	47,956	101	473	2	27	24	218	200	35,000	479,559,710	1,198,899,275	624,778,495	606,035,140
	3	160,898	255	632	3	53	32	218	200	35,000	1,608,981,207	4,022,453,017	2,096,207,910	2,033,321,673
	4	625,836	587	1066	3	92	104	218	200	35,000	6,258,364,663	15,645,911,657	8,153,503,258	7,908,898,160
	5	1,993,034	1,603	1244	4	218	183	218	200	35,000	19,930,339,550	49,825,848,875	25,965,583,217	25,186,615,720
	6	2,109,158	1,673	1260	4	218	200	218	200	35,000	21,091,580,923	52,728,952,306	27,478,468,103	26,654,114,060

Appendix 1. Tuna Fishery Production, Effort, CPUE, Number of Ship, Tuna Price, and Revenue Data on *Sendang Biru* Village from 2005 to 2015 (con't)

Year	Month	Production	Effort	CPUE	Trip	Operating Ship		Number of Ship		Tuna Price	Revenue			Local Boat Rev. After Retribution
						Local	Foreign	Local	Foreign		KUD Mina Tani Fisherman Local Boat Fisherman	Local Boat		
		(kg)	(effort)	(kg/effort)	(trip)	(ship)				(Rp/kg)	(Rp)			
2011	7	2,144,018	1,673	1281	4	218	200	218	200	35,000	21,440,179,492	53,600,448,730	27,932,628,212	27,094,649,365
	8	2,013,982	1,673	1204	4	218	200	218	200	35,000	20,139,824,780	50,349,561,949	26,238,504,114	25,451,348,991
	9	831,808	898	926	3	158	141	218	200	35,000	8,318,083,610	20,795,209,025	10,836,939,914	10,511,831,717
	10	380,850	608	626	3	98	105	218	200	35,000	3,808,497,226	9,521,243,066	4,961,774,556	4,812,921,319
	11	119,716	276	434	2	91	47	218	200	35,000	1,197,163,645	2,992,909,113	1,559,685,031	1,512,894,480
	12	49,828	153	325	2	71	6	218	200	35,000	498,283,471	1,245,708,678	649,172,128	629,696,964
2012	1	15,675	44	354	2	17	6	218	172	35,000	156,751,863	391,879,658	219,319,013	212,739,443
	2	25,475	55	460	2	22	6	218	172	35,000	254,753,128	636,882,821	356,437,260	345,744,143
	3	267,199	382	700	3	108	19	218	172	35,000	2,671,992,262	6,679,980,656	3,738,511,901	3,626,356,544
	4	630,511	601	1049	3	139	61	218	172	35,000	6,305,108,574	15,762,771,436	8,821,778,332	8,557,124,982
	5	1,759,308	1,549	1136	4	216	172	218	172	35,000	17,593,084,568	43,982,711,421	24,615,324,289	23,876,864,561
	6	1,799,997	1,558	1155	4	218	172	218	172	35,000	17,999,973,217	44,999,933,044	25,184,621,618	24,429,082,970

	7	1,918,337	1,558	1231	4	218	172	218	172	35,000	19,183,371,410	47,958,428,524	26,840,370,509	26,035,159,394
	8	1,786,752	1,558	1147	4	218	172	218	172	35,000	17,867,517,893	44,668,794,732	24,999,297,052	24,249,318,140
	9	866,038	986	878	3	199	129	218	172	35,000	8,660,383,697	21,650,959,242	12,117,156,167	11,753,641,482
	10	169,551	332	511	3	66	44	218	172	35,000	1,695,506,530	4,238,766,324	2,372,264,108	2,301,096,184
	11	37,644	100	378	2	44	6	218	172	35,000	376,439,600	941,098,999	526,694,610	510,893,772
	12	20,041	60	335	2	24	6	218	172	35,000	200,407,257	501,018,143	280,399,359	271,987,378
2013	1	28,309	62	456	2	26	5	214	187	40,000	323,535,185	808,837,964	431,380,247	418,438,840
	2	43,438	77	564	2	32	6	214	187	40,000	496,436,580	1,241,091,450	661,915,440	642,057,977
	3	135,637	202	671	3	48	19	214	187	40,000	1,550,136,320	3,875,340,800	2,066,848,427	2,004,842,974
	4	727,117	610	1192	3	128	75	214	187	38,000	7,894,414,071	19,736,035,178	10,525,885,428	10,210,108,865
	5	2,138,031	1,601	1336	4	213	187	214	187	38,000	23,212,910,715	58,032,276,787	30,950,547,620	30,022,031,191
	6	2,148,379	1,605	1339	4	214	187	214	187	38,000	23,325,253,642	58,313,134,104	31,100,338,189	30,167,328,043
	7	2,144,174	1,605	1336	4	214	187	214	187	40,000	24,504,843,116	61,262,107,790	32,673,124,155	31,692,930,430
	8	1,796,009	1,498	1199	4	214	161	214	187	40,000	20,525,818,786	51,314,546,964	27,367,758,381	26,546,725,629
	9	806,780	863	934	3	165	123	214	187	40,000	9,220,343,455	23,050,858,637	12,293,791,273	11,924,977,535

Appendix 1. Tuna Fishery Production, Effort, CPUE, Number of Ship, Tuna Price, and Revenue Data on *Sendang Biru* Village from 2005 to 2015 (con't)

Year	Month	Production	Effort	CPUE	Trip	Operating Ship		Number of Ship		Tuna Price	Revenue			Local Boat Rev. After Retribution
						Local	Foreign	Local	Foreign		KUD Mina Tani	Fisherman	Local Boat	
		(kg)	(effort)	(kg/effort)	(trip)	(ship)				(Rp/kg)	(Rp)			
2013	10	290,163	456	637	3	81	71	214	187	40,000	3,316,153,785	8,290,384,462	4,421,538,380	4,288,892,228
	11	103,667	188	550	2	59	35	214	187	40,000	1,184,767,511	2,961,918,778	1,579,690,015	1,532,299,314
	12	36,253	98	368	2	25	25	214	187	40,000	414,324,791	1,035,811,977	552,433,055	535,860,063
2014	1	17,323	49	354	2	19	5	210	213	40,000	197,982,147	494,955,367	249,927,957	242,430,119
	2	29,962	57	522	2	23	5	210	213	40,000	342,428,305	856,070,762	432,273,355	419,305,154
	3	80,722	128	632	3	37	5	210	213	40,000	922,536,196	2,306,340,491	1,164,587,773	1,129,650,140
	4	589,607	533	1106	3	96	82	210	213	38,000	6,401,444,626	16,003,611,566	8,081,031,583	7,838,600,635
	5	1,736,502	1,387	1252	4	214	133	210	213	38,000	18,853,453,454	47,133,633,635	23,800,151,637	23,086,147,088
	6	2,172,668	1,719	1264	4	217	213	210	213	38,000	23,588,971,752	58,972,429,380	29,778,157,410	28,884,812,687
	7	2,176,230	1,719	1266	4	217	213	210	213	41,000	25,492,984,238	63,732,460,595	32,181,737,528	31,216,285,402
	8	2,106,477	1,715	1228	4	216	213	210	213	41,000	24,675,873,535	61,689,683,837	31,150,236,393	30,215,729,301
	9	775,728	849	914	3	129	154	210	213	41,000	9,087,095,173	22,717,737,932	11,471,333,015	11,127,193,025
	10	233,531	393	595	3	78	53	210	213	41,000	2,735,643,564	6,839,108,909	3,453,411,429	3,349,809,087
	11	31,995	74	430	2	32	5	210	213	40,000	365,660,903	914,152,259	461,601,636	447,753,586
	12	22,229	57	387	2	23	5	210	213	40,000	254,043,418	635,108,544	320,698,374	311,077,423
2015	1	8,418	26	325	2	8	5	198	199	43,000	103,423,570	258,558,926	132,739,497	128,757,312
	2	20,266	40	509	2	15	5	198	199	43,000	248,982,669	622,456,673	319,558,049	309,971,307
	3	52,692	90	588	3	25	5	198	199	43,000	647,354,940	1,618,387,350	830,850,927	805,925,399
	4	611,231	609	1003	3	128	75	198	199	43,000	7,509,413,068	18,773,532,671	9,637,993,658	9,348,853,849
	5	1,632,744	1,433	1139	4	209	149	198	199	43,000	20,059,432,395	50,148,580,988	25,745,378,561	24,973,017,204
	6	1,845,316	1,636	1128	4	210	199	198	199	43,000	22,671,021,190	56,677,552,974	29,097,235,225	28,224,318,168
	7	1,862,456	1,636	1138	4	210	199	198	199	45,000	23,945,863,678	59,864,659,196	30,733,438,176	29,811,435,031
	8	1,668,526	1,497	1115	4	210	164	198	199	45,000	21,452,473,727	53,631,184,318	27,533,284,407	26,707,285,874
	9	625,862	732	856	3	144	100	198	199	45,000	8,046,794,724	20,116,986,810	10,327,698,825	10,017,867,860
	10	250,348	448	559	3	90	60	198	199	43,000	3,075,702,066	7,689,255,166	3,947,525,158	3,829,099,403
	11	15,808	40	397	2	15	5	198	199	43,000	194,206,482	485,516,205	249,255,278	241,777,620
	12	13,259	40	333	2	15	5	198	199	43,000	162,892,123	407,230,308	209,064,708	202,792,767

Appendix 2. Tuna Fishery Cost, Fuel Price, Fuel Consumption, and Profit Data on *Sendang Biru* Village from 2005 to 2015

Year	Month	Maintenance Cost	Administration Cost	Fuel Price	Fuel Consume per Trip	Fuel Cost	Logistic Cost	Fix Cost	Variable Cost	Total Cost	Local Boat Profit
		(Rp/month)		(Rp/liter)	(liter/Trip)	(Rp/Ship/Trip)		(Rp/month)			
2005	1	112,500,000	15,000,000	2,100	700	1,470,000	4,000,000	127,500,000	218,800,000	346,300,000	(96,643,685)
	2	112,500,000	15,000,000	2,100	750	1,575,000	4,000,000	127,500,000	301,050,000	428,550,000	(33,004,369)
	3	112,500,000	15,000,000	2,100	750	1,575,000	4,000,000	127,500,000	501,750,000	629,250,000	304,180,217
	4	112,500,000	15,000,000	2,100	700	1,470,000	4,000,000	127,500,000	1,887,150,000	2,014,650,000	4,991,429,981
	5	112,500,000	15,000,000	2,100	500	1,050,000	4,000,000	127,500,000	3,030,000,000	3,157,500,000	15,147,771,530
	6	112,500,000	15,000,000	2,100	450	945,000	4,000,000	127,500,000	2,967,000,000	3,094,500,000	17,177,190,438
	7	112,500,000	15,000,000	2,100	450	945,000	4,000,000	127,500,000	2,967,000,000	3,094,500,000	19,123,076,569
	8	112,500,000	15,000,000	2,100	450	945,000	4,000,000	127,500,000	2,967,000,000	3,094,500,000	14,523,410,185
	9	112,500,000	15,000,000	2,100	600	1,260,000	4,000,000	127,500,000	2,051,400,000	2,178,900,000	6,897,189,759
	10	112,500,000	15,000,000	2,100	600	1,260,000	4,000,000	127,500,000	2,035,620,000	2,163,120,000	1,362,121,345
	11	112,500,000	15,000,000	2,100	800	1,680,000	4,000,000	127,500,000	886,080,000	1,013,580,000	67,905,595
	12	112,500,000	15,000,000	2,100	800	1,680,000	4,000,000	127,500,000	511,200,000	638,700,000	(184,893,195)
2006	1	114,000,000	15,200,000	4,300	700	3,010,000	4,200,000	129,200,000	464,495,894	593,695,894	(235,059,500)
	2	114,000,000	15,200,000	4,300	750	3,225,000	4,200,000	129,200,000	612,882,119	742,082,119	(38,902,836)
	3	114,000,000	15,200,000	4,300	750	3,225,000	4,200,000	129,200,000	919,323,179	1,048,523,179	443,026,295
	4	114,000,000	15,200,000	4,300	700	3,010,000	4,200,000	129,200,000	1,828,952,583	1,958,152,583	3,594,137,183
	5	114,000,000	15,200,000	4,300	500	2,150,000	4,200,000	129,200,000	3,835,231,788	3,964,431,788	15,677,544,191
	6	114,000,000	15,200,000	4,300	450	1,935,000	4,200,000	129,200,000	3,705,377,483	3,834,577,483	16,940,272,207
	7	114,000,000	15,200,000	4,300	450	1,935,000	4,200,000	129,200,000	3,730,080,000	3,859,280,000	17,700,239,352
	8	114,000,000	15,200,000	4,300	450	1,935,000	4,200,000	129,200,000	3,680,674,967	3,809,874,967	13,356,643,811
	9	114,000,000	15,200,000	4,300	600	2,580,000	4,200,000	129,200,000	2,436,489,536	2,565,689,536	5,101,492,037
	10	114,000,000	15,200,000	4,300	600	2,580,000	4,200,000	129,200,000	1,842,723,179	1,971,923,179	1,176,046,155
	11	114,000,000	15,200,000	4,300	800	3,440,000	4,200,000	129,200,000	522,960,530	652,160,530	(124,480,812)
	12	114,000,000	15,200,000	4,300	800	3,440,000	4,200,000	129,200,000	461,435,762	590,635,762	(304,356,524)
2007	1	117,000,000	15,600,000	4,300	700	3,850,000	5,000,000	132,600,000	247,800,000	380,400,000	(150,619,752)
	2	117,000,000	15,600,000	4,300	750	4,125,000	5,000,000	132,600,000	257,259,036	389,859,036	(21,773,982)
	3	117,000,000	15,600,000	4,300	750	4,125,000	5,000,000	132,600,000	1,029,036,145	1,161,636,145	587,338,896

Appendix 2. Tuna Fishery Cost, Fuel Price, Fuel Consumption, and Profit Data on *Sendang Biru* Village from 2005 to 2015 (con't)

Year	Month	Maintenance Cost	Administration Cost	Fuel Price	Fuel Consume per Trip	Fuel Cost	Logistic Cost	Fix Cost	Variable Cost	Total Cost	Local Boat Profit
		(Rp/month)		(Rp/liter)	(liter/Trip)	(Rp/Ship/Trip)		(Rp/month)			
2007	4	117,000,000	15,600,000	4,300	700	3,850,000	5,000,000	132,600,000	3,093,874,699	3,226,474,699	8,618,825,498
	5	117,000,000	15,600,000	4,300	500	2,750,000	5,000,000	132,600,000	4,806,867,470	4,939,467,470	17,907,904,293
	6	117,000,000	15,600,000	4,300	450	2,475,000	5,000,000	132,600,000	4,636,301,205	4,768,901,205	18,972,880,862
	7	117,000,000	15,600,000	4,300	450	2,475,000	5,000,000	132,600,000	4,664,400,000	4,797,000,000	19,489,761,133
	8	117,000,000	15,600,000	4,300	450	2,475,000	5,000,000	132,600,000	4,664,400,000	4,797,000,000	16,270,391,626
	9	117,000,000	15,600,000	4,300	600	3,300,000	5,000,000	132,600,000	2,340,000,000	2,472,600,000	5,892,431,056
	10	117,000,000	15,600,000	4,300	600	3,300,000	5,000,000	132,600,000	936,000,000	1,068,600,000	774,109,410
	11	117,000,000	15,600,000	4,300	800	4,400,000	5,000,000	132,600,000	618,361,446	750,961,446	28,353,543
	12	117,000,000	15,600,000	4,300	800	4,400,000	5,000,000	132,600,000	530,024,096	662,624,096	(331,846,675)
2008	1	140,250,000	18,700,000	5,500	700	3,010,000	5,500,000	158,950,000	254,619,200	413,569,200	(223,766,157)
	2	140,250,000	18,700,000	5,500	750	3,225,000	5,500,000	158,950,000	428,871,143	587,821,143	(113,880,763)
	3	140,250,000	18,700,000	5,500	750	3,225,000	5,500,000	158,950,000	643,306,714	802,256,714	554,202,366
	4	140,250,000	18,700,000	5,500	700	3,010,000	5,500,000	158,950,000	3,928,410,514	4,087,360,514	3,785,669,705
	5	140,250,000	18,700,000	5,500	500	2,150,000	5,500,000	158,950,000	5,558,708,571	5,717,658,571	14,830,855,182
	6	140,250,000	18,700,000	5,500	450	1,935,000	5,500,000	158,950,000	5,434,262,743	5,593,212,743	19,333,642,698
	7	140,250,000	18,700,000	5,500	450	1,935,000	5,500,000	158,950,000	5,561,380,000	5,720,330,000	20,370,825,303
	8	140,250,000	18,700,000	5,500	450	1,935,000	5,500,000	158,950,000	5,561,380,000	5,720,330,000	15,138,806,251
	9	140,250,000	18,700,000	5,500	600	2,580,000	5,500,000	158,950,000	3,807,619,200	3,966,569,200	4,618,636,943
	10	140,250,000	18,700,000	5,500	600	2,580,000	5,500,000	158,950,000	1,554,130,286	1,713,080,286	973,134,550
	11	140,250,000	18,700,000	5,500	800	3,440,000	5,500,000	158,950,000	955,302,857	1,114,252,857	52,814,576
	12	140,250,000	18,700,000	5,500	800	3,440,000	5,500,000	158,950,000	573,181,714	732,131,714	(377,084,709)
2009	1	156,000,000	20,800,000	4,500	700	3,150,000	7,000,000	176,800,000	458,432,000	635,232,000	(281,172,376)
	2	156,000,000	20,800,000	4,500	750	3,375,000	7,000,000	176,800,000	665,897,143	842,697,143	8,760,774
	3	156,000,000	20,800,000	4,500	750	3,375,000	7,000,000	176,800,000	2,848,560,000	3,025,360,000	1,361,982,012
	4	156,000,000	20,800,000	4,500	700	3,150,000	7,000,000	176,800,000	4,487,808,000	4,664,608,000	6,131,976,955
	5	156,000,000	20,800,000	4,500	500	2,250,000	7,000,000	176,800,000	7,608,045,714	7,784,845,714	22,610,964,086
	6	156,000,000	20,800,000	4,500	450	2,025,000	7,000,000	176,800,000	7,508,800,000	7,685,600,000	29,976,862,091

Appendix 2. Tuna Fishery Cost, Fuel Price, Fuel Consumption, and Profit Data on *Sendang Biru* Village from 2005 to 2015 (con't)

Year	Month	Maintenance Cost	Administration Cost	Fuel Price	Fuel Consume per Trip	Fuel Cost	Logistic Cost	Fix Cost	Variable Cost	Total Cost	Local Boat Profit
		(Rp/month)		(Rp/liter)	(liter/Trip)	(Rp/Ship/Trip)		(Rp/month)			
2009	7	156,000,000	20,800,000	4,500	450	2,025,000	7,000,000	176,800,000	7,508,800,000	7,685,600,000	30,185,234,177
	8	156,000,000	20,800,000	4,500	450	2,025,000	7,000,000	176,800,000	7,508,800,000	7,685,600,000	25,127,671,851
	9	156,000,000	20,800,000	4,500	600	2,700,000	7,000,000	176,800,000	4,876,827,429	5,053,627,429	8,040,523,019
	10	156,000,000	20,800,000	4,500	600	2,700,000	7,000,000	176,800,000	2,421,120,000	2,597,920,000	1,063,219,586
	11	156,000,000	20,800,000	4,500	800	3,600,000	7,000,000	176,800,000	1,259,885,714	1,436,685,714	(329,174,904)
	12	156,000,000	20,800,000	4,500	800	3,600,000	7,000,000	176,800,000	755,931,429	932,731,429	(482,059,516)
2010	1	160,500,000	21,400,000	4,500	700	3,150,000	8,750,000	181,900,000	475,738,462	657,638,462	(457,859,608)
	2	160,500,000	21,400,000	4,500	750	3,375,000	8,750,000	181,900,000	570,274,725	752,174,725	(323,459,504)
	3	160,500,000	21,400,000	4,500	750	3,375,000	8,750,000	181,900,000	1,026,494,505	1,208,394,505	(424,356,739)
	4	160,500,000	21,400,000	4,500	700	3,150,000	8,750,000	181,900,000	5,037,230,769	5,219,130,769	2,537,270,298
	5	160,500,000	21,400,000	4,500	500	2,250,000	8,750,000	181,900,000	9,312,527,473	9,494,427,473	12,034,951,728
	6	160,500,000	21,400,000	4,500	450	2,025,000	8,750,000	181,900,000	9,223,400,000	9,405,300,000	12,118,074,010
	7	160,500,000	21,400,000	4,500	450	2,025,000	8,750,000	181,900,000	9,223,400,000	9,405,300,000	14,572,900,099
	8	160,500,000	21,400,000	4,500	450	2,025,000	8,750,000	181,900,000	9,172,721,978	9,354,621,978	11,971,973,926
	9	160,500,000	21,400,000	4,500	600	2,700,000	8,750,000	181,900,000	6,462,329,670	6,644,229,670	3,160,181,812
	10	160,500,000	21,400,000	4,500	600	2,700,000	8,750,000	181,900,000	4,442,851,648	4,624,751,648	700,097,603
	11	160,500,000	21,400,000	4,500	800	3,600,000	8,750,000	181,900,000	2,033,000,000	2,214,900,000	(1,060,572,904)
	12	160,500,000	21,400,000	4,500	800	3,600,000	8,750,000	181,900,000	580,857,143	762,757,143	(502,002,501)
2011	1	163,500,000	21,800,000	4,500	700	3,850,000	8,500,000	185,300,000	611,224,865	796,524,865	(514,975,747)
	2	163,500,000	21,800,000	4,500	750	4,125,000	8,500,000	185,300,000	684,343,243	869,643,243	(263,608,103)
	3	163,500,000	21,800,000	4,500	750	4,125,000	8,500,000	185,300,000	2,008,398,649	2,193,698,649	(160,376,976)
	4	163,500,000	21,800,000	4,500	700	3,850,000	8,500,000	185,300,000	3,405,395,676	3,590,695,676	4,318,202,485
	5	163,500,000	21,800,000	4,500	500	2,750,000	8,500,000	185,300,000	9,810,000,000	9,995,300,000	15,191,315,720
	6	163,500,000	21,800,000	4,500	450	2,475,000	8,500,000	185,300,000	9,570,200,000	9,755,500,000	16,898,614,060
	7	163,500,000	21,800,000	4,500	450	2,475,000	8,500,000	185,300,000	9,570,200,000	9,755,500,000	17,339,149,365
	8	163,500,000	21,800,000	4,500	450	2,475,000	8,500,000	185,300,000	9,570,200,000	9,755,500,000	15,695,848,991
	9	163,500,000	21,800,000	4,500	600	3,300,000	8,500,000	185,300,000	5,589,755,676	5,775,055,676	4,736,776,041

Appendix 2. Tuna Fishery Cost, Fuel Price, Fuel Consumption, and Profit Data on *Sendang Biru* Village from 2005 to 2015 (con't)

Year	Month	Maintenance Cost	Administration Cost	Fuel Price	Fuel Consume per Trip	Fuel Cost	Logistic Cost	Fix Cost	Variable Cost	Total Cost	Local Boat Profit
		(Rp/month)		(Rp/liter)	(liter/Trip)	(Rp/Ship/Trip)		(Rp/month)			
	10	163,500,000	21,800,000	4,500	600	3,300,000	8,500,000	185,300,000	3,462,311,351	3,647,611,351	1,165,309,968
	11	163,500,000	21,800,000	4,500	800	4,400,000	8,500,000	185,300,000	2,340,966,486	2,526,266,486	(1,013,372,007)
	12	163,500,000	21,800,000	4,500	800	4,400,000	8,500,000	185,300,000	1,824,129,730	2,009,429,730	(1,379,732,765)
2012	1	163,500,000	21,800,000	4,500	700	3,850,000	10,000,000	185,300,000	459,791,878	645,091,878	(432,352,435)
	2	163,500,000	21,800,000	4,500	750	4,125,000	10,000,000	185,300,000	625,228,426	810,528,426	(464,784,284)
	3	163,500,000	21,800,000	4,500	750	4,125,000	10,000,000	185,300,000	4,595,428,934	4,780,728,934	(1,154,372,390)
	4	163,500,000	21,800,000	4,500	700	3,850,000	10,000,000	185,300,000	5,793,377,665	5,978,677,665	2,578,447,317
	5	163,500,000	21,800,000	4,500	500	2,750,000	10,000,000	185,300,000	11,005,126,904	11,190,426,904	12,686,437,657
	6	163,500,000	21,800,000	4,500	450	2,475,000	10,000,000	185,300,000	10,878,200,000	11,063,500,000	13,365,582,970
	7	163,500,000	21,800,000	4,500	450	2,475,000	10,000,000	185,300,000	10,878,200,000	11,063,500,000	14,971,659,394
	8	163,500,000	21,800,000	4,500	450	2,475,000	10,000,000	185,300,000	10,878,200,000	11,063,500,000	13,185,818,140
	9	163,500,000	21,800,000	4,500	600	3,300,000	10,000,000	185,300,000	7,947,593,909	8,132,893,909	3,620,747,573
	10	163,500,000	21,800,000	4,500	600	3,300,000	10,000,000	185,300,000	2,649,197,970	2,834,497,970	(533,401,785)
	11	163,500,000	21,800,000	4,500	800	4,400,000	10,000,000	185,300,000	1,274,802,030	1,460,102,030	(949,208,258)
	12	163,500,000	21,800,000	4,500	800	4,400,000	10,000,000	185,300,000	701,141,117	886,441,117	(614,453,739)
2013	1	160,500,000	21,400,000	5,500	700	3,850,000	10,500,000	181,900,000	737,016,000	918,916,000	(500,477,160)
	2	160,500,000	21,400,000	5,500	750	4,125,000	10,500,000	181,900,000	938,925,000	1,120,825,000	(478,767,023)
	3	160,500,000	21,400,000	5,500	750	4,125,000	10,500,000	181,900,000	2,112,581,250	2,294,481,250	(289,638,276)
	4	160,500,000	21,400,000	5,500	700	3,850,000	10,500,000	181,900,000	5,527,620,000	5,709,520,000	4,500,588,865
	5	160,500,000	21,400,000	5,500	500	2,750,000	10,500,000	181,900,000	11,285,290,000	11,467,190,000	18,554,841,191
	6	160,500,000	21,400,000	5,500	450	2,475,000	10,500,000	181,900,000	11,106,600,000	11,288,500,000	18,878,828,043
	7	160,500,000	21,400,000	5,500	450	2,475,000	10,500,000	181,900,000	11,106,600,000	11,288,500,000	20,404,430,430
	8	160,500,000	21,400,000	5,500	450	2,475,000	10,500,000	181,900,000	11,106,600,000	11,288,500,000	15,258,225,629
	9	160,500,000	21,400,000	5,500	600	3,300,000	10,500,000	181,900,000	6,821,892,000	7,003,792,000	4,921,185,535
	10	160,500,000	21,400,000	5,500	600	3,300,000	10,500,000	181,900,000	3,366,648,000	3,548,548,000	740,344,228
	11	160,500,000	21,400,000	5,500	800	4,400,000	10,500,000	181,900,000	1,753,730,000	1,935,630,000	(403,330,686)
	12	160,500,000	21,400,000	5,500	800	4,400,000	10,500,000	181,900,000	733,378,000	915,278,000	(379,417,937)

Appendix 2. Tuna Fishery Cost, Fuel Price, Fuel Consumption, and Profit Data on *Sendang Biru* Village from 2005 to 2015 (con't)

Year	Month	Maintenance Cost	Administration Cost	Fuel Price	Fuel Consume per Trip	Fuel Cost	Logistic Cost	Fix Cost	Variable Cost	Total Cost	Local Boat Profit
		(Rp/month)		(Rp/liter)	(liter/Trip)	(Rp/Ship/Trip)		(Rp/month)			
2014	1	162,750,000	21,700,000	5,500	700	5,250,000	10,500,000	184,450,000	603,132,353	787,582,353	(545,152,234)
	2	162,750,000	21,700,000	5,500	750	5,625,000	10,500,000	184,450,000	754,713,235	939,163,235	(519,858,081)
	3	162,750,000	21,700,000	5,500	750	5,625,000	10,500,000	184,450,000	1,801,020,221	1,985,470,221	(855,820,081)
	4	162,750,000	21,700,000	5,500	700	5,250,000	10,500,000	184,450,000	4,523,492,647	4,707,942,647	3,130,657,988
	5	162,750,000	21,700,000	5,500	500	3,750,000	10,500,000	184,450,000	12,187,102,941	12,371,552,941	10,714,594,147
	6	162,750,000	21,700,000	5,500	450	3,375,000	10,500,000	184,450,000	12,043,500,000	12,227,950,000	16,656,862,687
	7	162,750,000	21,700,000	5,500	450	3,375,000	10,500,000	184,450,000	12,043,500,000	12,227,950,000	18,988,335,402
	8	162,750,000	21,700,000	5,500	450	3,375,000	10,500,000	184,450,000	11,984,463,235	12,168,913,235	18,046,816,066
	9	162,750,000	21,700,000	5,500	600	4,500,000	10,500,000	184,450,000	5,791,985,294	5,976,435,294	5,150,757,731
	10	162,750,000	21,700,000	5,500	600	4,500,000	10,500,000	184,450,000	3,494,338,235	3,678,788,235	(328,979,149)
	11	162,750,000	21,700,000	5,500	800	6,000,000	10,500,000	184,450,000	1,053,088,235	1,237,538,235	(789,784,649)
	12	162,750,000	21,700,000	5,500	800	6,000,000	10,500,000	184,450,000	772,264,706	956,714,706	(645,637,283)
2015	1	157,500,000	21,000,000	7,500	700	5,250,000	11,000,000	178,500,000	258,767,773	437,267,773	(308,510,460)
	2	157,500,000	21,000,000	7,500	750	5,625,000	11,000,000	178,500,000	496,386,256	674,886,256	(364,914,949)
	3	157,500,000	21,000,000	7,500	750	5,625,000	11,000,000	178,500,000	1,240,965,640	1,419,465,640	(613,540,241)
	4	157,500,000	21,000,000	7,500	700	5,250,000	11,000,000	178,500,000	6,258,945,498	6,437,445,498	2,911,408,351
	5	157,500,000	21,000,000	7,500	500	3,750,000	11,000,000	178,500,000	12,331,279,621	12,509,779,621	12,463,237,583
	6	157,500,000	21,000,000	7,500	450	3,375,000	11,000,000	178,500,000	12,075,000,000	12,253,500,000	15,970,818,168
	7	157,500,000	21,000,000	7,500	450	3,375,000	11,000,000	178,500,000	12,075,000,000	12,253,500,000	17,557,935,031
	8	157,500,000	21,000,000	7,500	450	3,375,000	11,000,000	178,500,000	12,075,000,000	12,253,500,000	14,453,785,874
	9	157,500,000	21,000,000	7,500	600	4,500,000	11,000,000	178,500,000	6,710,545,024	6,889,045,024	3,128,822,836
	10	157,500,000	21,000,000	7,500	600	4,500,000	11,000,000	178,500,000	4,165,165,877	4,343,665,877	(514,566,473)
	11	157,500,000	21,000,000	7,500	800	6,000,000	11,000,000	178,500,000	507,582,938	686,082,938	(444,305,319)
	12	157,500,000	21,000,000	7,500	800	6,000,000	11,000,000	178,500,000	507,582,938	686,082,938	(483,290,172)

Appendix 3. Tuna Fishery Data Summary on *Sendang Biru* Village from 2005 to 2015

Year	Production (kg)	Effort	CPUE (kg)	Number of Ship		Local Boat Profit		KUD Mina Tani Revenue		Retribution		Profit per Boat	
				Local	Foreign								
2005	9,068,472	6,714	11,968	150	130	Rp	79,279,734,371	Rp	77,848,686,251	Rp	3,127,849,001	Rp	528,531,562
2006	9,860,535	7,201	12,097	152	163	Rp	73,286,601,560	Rp	84,518,871,429	Rp	3,058,070,987	Rp	482,148,694
2007	9,366,315	6,788	12,119	156	146	Rp	88,037,755,908	Rp	93,663,150,000	Rp	3,632,575,670	Rp	564,344,589
2008	9,342,715	8,160	9,897	187	182	Rp	78,943,855,945	Rp	93,581,827,314	Rp	3,560,178,213	Rp	422,159,657
2009	11,567,967	9,188	10,989	208	202	Rp	123,414,787,756	Rp	141,004,128,044	Rp	5,364,287,480	Rp	593,340,326
2010	12,141,495	9,703	11,050	214	200	Rp	54,327,198,219	Rp	90,977,524,089	Rp	3,527,963,647	Rp	253,865,412
2011	10,499,365	9,561	9,837	218	200	Rp	72,013,151,032	Rp	104,993,650,000	Rp	4,103,625,053	Rp	330,335,555
2012	9,296,529	8,783	9,335	218	172	Rp	56,260,120,160	Rp	92,965,290,000	Rp	3,902,165,227	Rp	258,073,946
2013	10,397,958	8,866	10,582	214	187	Rp	81,206,812,840	Rp	115,968,937,956	Rp	4,638,757,518	Rp	379,471,088
2014	9,972,975	8,680	9,950	210	213	Rp	69,002,792,544	Rp	112,918,117,310	Rp	4,276,354,443	Rp	317,985,219
2015	8,606,925	8,226	9,091	198	199	Rp	63,756,880,231	Rp	108,117,560,634	Rp	4,162,920,674	Rp	303,604,192
Mean	**10,011,023**	**8,352**	**10,629**	**193**	**181**	**Rp**	**76,320,880,961**	**Rp**	**101,505,249,366**	**Rp**	**3,941,340,719**	**Rp**	**403,078,204**

Appendix 4. Equation for Tuna Fishery Simulation Model

Accumulated_Capital__for_New_Ship(t) = Accumulated_Capital__for_New_Ship(t - dt) + (Income_for_Buying_New_Ship - Expense_for_Buying_New_Ship) * dt
INIT Accumulated_Capital__for_New_Ship = 0
INFLOWS:
Income_for_Buying_New_Ship = Ship_Owner_Profit*Profit_Proportion_for_New_Ship
OUTFLOWS:
Expense_for_Buying_New_Ship = IF (Accumulated_Capital__for_New_Ship*per_unit>=Ship_Price AND Max_Ship_Purchased>0) THEN MIN((Max_Ship_Purchased*Ship_Price),(INT(Accumulated_Capital__for_New_Ship/Ship_Price)*Ship_Price)) ELSE 0
Fish_Trader_Revenues(t) = Fish_Trader_Revenues(t - dt) + (KUD_Revenue__Rate) * dt
INIT Fish_Trader_Revenues = 0
INFLOWS:
KUD_Revenue__Rate = Fish_Trader_Revenue
Local_Ship_Profits(t) = Local_Ship_Profits(t - dt) + (Local_Ship_Profit_Rate) * dt
INIT Local_Ship_Profits = 0
INFLOWS:
Local_Ship_Profit_Rate = Local_Ship_Profit
Number_of_Local_Ship(t) = Number_of_Local_Ship(t - dt) + (New_Ship - Old_Ship_Grounded) * dt
INIT Number_of_Local_Ship = 150
INFLOWS:
New_Ship = IF (Max_Ship_Purchased<=0) THEN 0 ELSE Purchasing
OUTFLOWS:
Old_Ship_Grounded = 0+STEP(Number_of_Local_Ship*Ship_Grounded_Rate,24)
Retribution_Amounts(t) = Retribution_Amounts(t - dt) + (Retribution_Rate) * dt
INIT Retribution_Amounts = 0
INFLOWS:
Retribution_Rate = Retribution_Amount
Stock_of_Migrating_Tuna(t) = Stock_of_Migrating_Tuna(t - dt) + (Emigration - Imigration) * dt
INIT Stock_of_Migrating_Tuna = 0
TRANSIT TIME = varies
INFLOW LIMIT = INF
CAPACITY = INF
INFLOWS:
Emigration = (1-Emigration__Coefficeint)*Stock_of_Tuna_in_Malang
OUTFLOWS:
Imigration = CONVEYOR OUTFLOW
TRANSIT TIME = Transit_Time
Stock_of_Tuna_in_Malang(t) = Stock_of_Tuna_in_Malang(t - dt) + (Growth_Rate + Imigration - Number_of_Catches - Emigration) * dt
INIT Stock_of_Tuna_in_Malang = 25000000
INFLOWS:
Growth_Rate = Stock_of_Tuna_in_Malang*Growth_Coefficient*(1-((Stock_of_Tuna_in_Malang+Stock_of_Migrating_Tuna)/Water_Support_Capability))
Imigration = CONVEYOR OUTFLOW
TRANSIT TIME = Transit_Time
OUTFLOWS:
Number_of_Catches = Effort*CPUE
Emigration = (1-Emigration__Coefficeint)*Stock_of_Tuna_in_Malang
CPUE = Stock_of_Tuna_in_Malang*Fishing_Device_Coefficient

Appendix 4. Equation for Tuna Fishery Simulation Model (con't)

- Effort = (Number_of_Operating_Foreign_Ship+Number_of_Operating_Local_Ship)*Number_of_Trip
- Fishermen_Revenue = Number_of_Catches*Tuna_Price_from_Fishermen_to_Fish_Trader
- Fishing_Device_Coefficient = 7.20363E-05
- Fish_Trader_Revenue = Number_of_Catches*(Tuna_Price-Tuna_Price_from_Fishermen_to_Fish_Trader)
- Fix_Cost = (Administration_Cost+Maintenance_Cost)*Number_of_Local_Ship
- Fuel_Cost_per_Trip = Fuel_Consumption_per_Trip*Fuel_Price
- Growth_Coefficient = 1.13/12
- Incremental_Operational_Cost_per_Year = 1099720
- Local_Ship_Profit = Local_Ship_Revenue__After_Retribution-Total_Cost
- Local_Ship_Revenue = Fishermen_Revenue*(Number_of_Operating_Local_Ship/(Number_of_Operating_Local_Ship +Number_of_Operating_Foreign_Ship))
- Local_Ship_Revenue__After_Retribution = Local_Ship_Revenue-Retribution_Amount
- Local_Ship__Limit = 230
- Max_Ship_Purchased = Local_Ship__Limit-Number_of_Local_Ship
- Max_Trip = 4
- Number_of_Operating_Foreign_Ship = INT(1.074*Number_of_Local_Ship*Operating_Foreign__Ship_Percentage)
- Number_of_Operating_Local_Ship = INT(Number_of_Local_Ship*Operating_Local_Ship_Percentage)
- Number_of_Trip = Max_Trip*Trip_Seasonality
- Operational_Cost_per_Trip = First_Year_Operational_Cost_per_Trip+(INT((TIME-6)/12)*Incremental_Operational_Cost_per_Year)
- per_unit = 1
- Profit_Margin_Fish_Trader = 40
- Profit_Proportion_for_New_Ship = 0.5
- Purchasing = DELAY(Expense_for_Buying_New_Ship/Ship_Price,24)
- Retribution_Amount = Local_Ship_Revenue*0.03
- Ship_Grounded_Rate = (1/5)/12
- Ship_Owner_Profit = Local_Ship_Profit*0.5
- Ship_Price = 250000000*(1+((0.1/12)*TIME))*Ship_Price_Converter
- Ship_Price_Converter = 1
- Total_Cost = Fix_Cost+Variable_Cost_per_Month
- Transit_Time = 4
- Tuna_Price_from_Fishermen_to_Fish_Trader =
- Variable_Cost_per_Month = (Operational_Cost_per_Trip+Fuel_Cost_per_Trip)*Number_of_Trip*Number_of_Operating_Local_Ship
- Water_Support_Capability = 70000000
- Administration_Cost = GRAPH(TIME)

(0.00, 100000), (1.00, 100000), (2.00, 100000), (3.00, 100000), (4.00, 100000), (5.00, 100000), (6.00, 100000), (7.00, 100000), (8.00, 100000), (9.00, 100000), (10.0, 100000), (11.0, 100000), (12.0, 100000), (13.0, 100000), (14.0, 100000), (15.0, 100000), (16.0, 100000), (17.0, 100000), (18.0, 100000), (19.0, 100000), (20.0, 100000), (21.0, 100000), (22.0, 100000), (23.0, 100000), (24.0, 100000), (25.0, 100000), (26.0, 100000), (27.0, 100000), (28.0, 100000), (29.0, 100000), (30.0, 100000), (31.0, 100000), (32.0, 100000), (33.0, 100000), (34.0, 100000), (35.0, 100000), (36.0, 100000), (37.0, 100000), (38.0, 100000), (39.0, 100000), (40.0, 100000), (41.0, 100000), (42.0, 100000), (43.0, 100000), (44.0, 100000), (45.0, 100000), (46.0, 100000), (47.0, 100000), (48.0, 100000), (49.0, 100000), (50.0, 100000), (51.0, 100000), (52.0, 100000)...

- Emigration__Coefficeint = GRAPH(MOD(TIME,12))

(0.00, 0.5), (1.00, 0.6), (2.00, 0.7), (3.00, 0.8), (4.00, 0.9), (5.00, 1.00), (6.00, 1.00), (7.00, 0.9), (8.00, 0.8), (9.00, 0.7), (10.0, 0.6), (11.0, 0.5)

Appendix 4. Equation for Tuna Fishery Simulation Model (con't)

First_Year_Operational_Cost_per_Trip = GRAPH(MOD(TIME,12))
(0.00, 5.5e+006), (1.00, 5.6e+006), (2.00, 5.6e+006), (3.00, 5.5e+006), (4.00, 5.1e+006), (5.00, 4.9e+006), (6.00, 4.9e+006), (7.00, 4.9e+006), (8.00, 5.3e+006), (9.00, 5.3e+006), (10.0, 5.7e+006), (11.0, 5.7e+006)

Fuel_Consumption_per_Trip = GRAPH(MOD(TIME,12))
(0.00, 700), (1.00, 750), (2.00, 750), (3.00, 700), (4.00, 500), (5.00, 450), (6.00, 450), (7.00, 450), (8.00, 600), (9.00, 600), (10.0, 800), (11.0, 800)

Fuel_Price = GRAPH(TIME)
(0.00, 2100), (1.00, 2100), (2.00, 2100), (3.00, 2100), (4.00, 2100), (5.00, 2100), (6.00, 2100), (7.00, 2100), (8.00, 2100), (9.00, 2100), (10.0, 2100), (11.0, 2100), (12.0, 4300), (13.0, 4300), (14.0, 4300), (15.0, 4300), (16.0, 4300), (17.0, 4300), (18.0, 4300), (19.0, 4300), (20.0, 4300), (21.0, 4300), (22.0, 4300), (23.0, 4300), (24.0, 5500), (25.0, 5500), (26.0, 5500), (27.0, 5500), (28.0, 5500), (29.0, 5500), (30.0, 5500), (31.0, 5500), (32.0, 5500), (33.0, 5500), (34.0, 5500), (35.0, 5500), (36.0, 4300), (37.0, 4300), (38.0, 4300), (39.0, 4300), (40.0, 4300), (41.0, 4300), (42.0, 4300), (43.0, 4300), (44.0, 4300), (45.0, 4300), (46.0, 4300), (47.0, 4300), (48.0, 4500), (49.0, 4500), (50.0, 4500), (51.0, 4500), (52.0, 4500)...

Maintenance_Cost = GRAPH(TIME)
(0.00, 750000), (1.00, 750000), (2.00, 750000), (3.00, 750000), (4.00, 750000), (5.00, 750000), (6.00, 750000), (7.00, 750000), (8.00, 750000), (9.00, 750000), (10.0, 750000), (11.0, 750000), (12.0, 800000), (13.0, 800000), (14.0, 800000), (15.0, 800000), (16.0, 800000), (17.0, 800000), (18.0, 800000), (19.0, 800000), (20.0, 800000), (21.0, 800000), (22.0, 800000), (23.0, 800000), (24.0, 800000), (25.0, 800000), (26.0, 800000), (27.0, 800000), (28.0, 800000), (29.0, 800000), (30.0, 800000), (31.0, 800000), (32.0, 800000), (33.0, 800000), (34.0, 800000), (35.0, 800000), (36.0, 800000), (37.0, 800000), (38.0, 800000), (39.0, 800000), (40.0, 800000), (41.0, 800000), (42.0, 800000), (43.0, 800000), (44.0, 800000), (45.0, 800000), (46.0, 800000), (47.0, 800000), (48.0, 850000), (49.0, 850000), (50.0, 850000), (51.0, 850000), (52.0, 850000)...

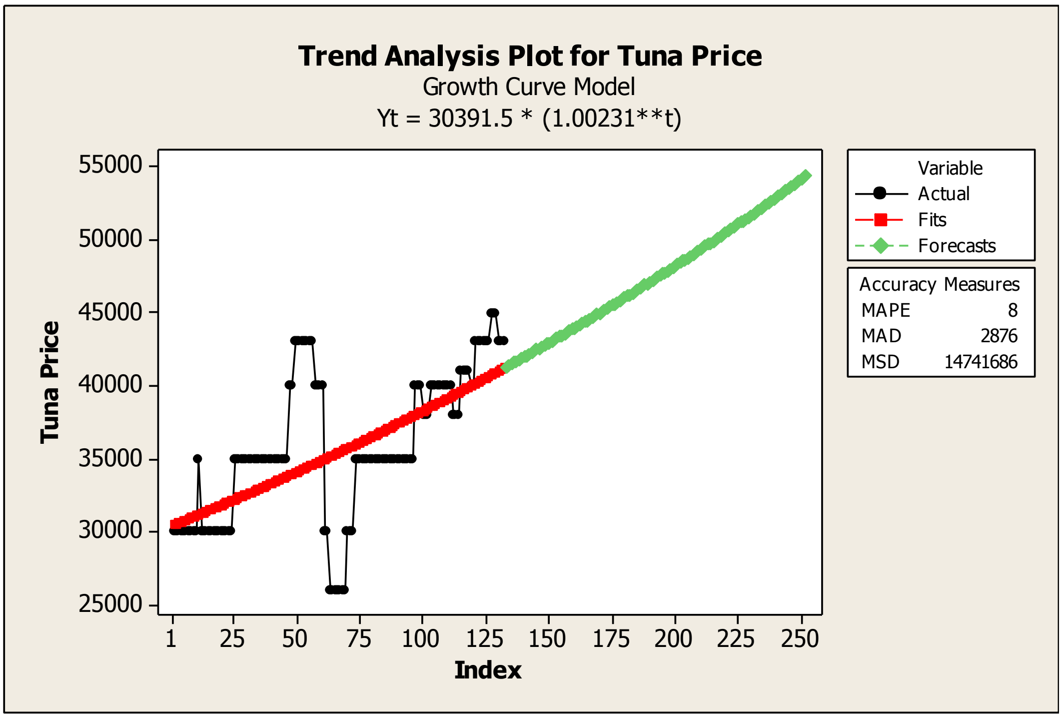
Operating_Foreign__Ship_Percentage = GRAPH(MOD(TIME,12))
(0.00, 0.0295), (1.00, 0.0649), (2.00, 0.108), (3.00, 0.417), (4.00, 0.892), (5.00, 1.00), (6.00, 1.00), (7.00, 0.968), (8.00, 0.746), (9.00, 0.36), (10.0, 0.127), (11.0, 0.0394)

Operating_Local_Ship_Percentage = GRAPH(MOD(TIME,12))
(0.00, 0.105), (1.00, 0.136), (2.00, 0.243), (3.00, 0.634), (4.00, 0.991), (5.00, 0.997), (6.00, 1.00), (7.00, 0.998), (8.00, 0.77), (9.00, 0.451), (10.0, 0.275), (11.0, 0.169)

Trip_Seasonality = GRAPH(MOD(TIME,12))
(0.00, 0.5), (1.00, 0.5), (2.00, 0.75), (3.00, 0.75), (4.00, 1.00), (5.00, 1.00), (6.00, 1.00), (7.00, 1.00), (8.00, 0.75), (9.00, 0.75), (10.0, 0.5), (11.0, 0.5)

Tuna_Price = GRAPH(TIME)
(0.00, 30000), (1.00, 30000), (2.00, 30000), (3.00, 30000), (4.00, 35000), (5.00, 35000), (6.00, 30000), (7.00, 30000), (8.00, 30000), (9.00, 30000), (10.0, 35000), (11.0, 30000), (12.0, 30000), (13.0, 30000), (14.0, 30000), (15.0, 30000), (16.0, 30000), (17.0, 30000), (18.0, 30000), (19.0, 30000), (20.0, 30000), (21.0, 30000), (22.0, 30000), (23.0, 30000), (24.0, 35000), (25.0, 35000), (26.0, 35000), (27.0, 35000), (28.0, 35000), (29.0, 35000), (30.0, 35000), (31.0, 35000), (32.0, 35000), (33.0, 35000), (34.0, 35000), (35.0, 35000), (36.0, 35000), (37.0, 35000), (38.0, 35000), (39.0, 35000), (40.0, 35000), (41.0, 35000), (42.0, 35000), (43.0, 35000), (44.0, 35000), (45.0, 35000), (46.0, 40000), (47.0, 40000), (48.0, 43000), (49.0, 43000), (50.0, 43000), (51.0, 43000), (52.0, 43000)...

Appendix 5. Forcasted Tuna Price from 2016 to 2025



Period	Forecast
1	41,330
2	41,426
3	41,521
4	41,618
5	41,714
6	41,810
7	41,907
8	42,004
9	42,101
10	42,199
11	42,296
12	42,394
13	42,492
14	42,591
15	42,689

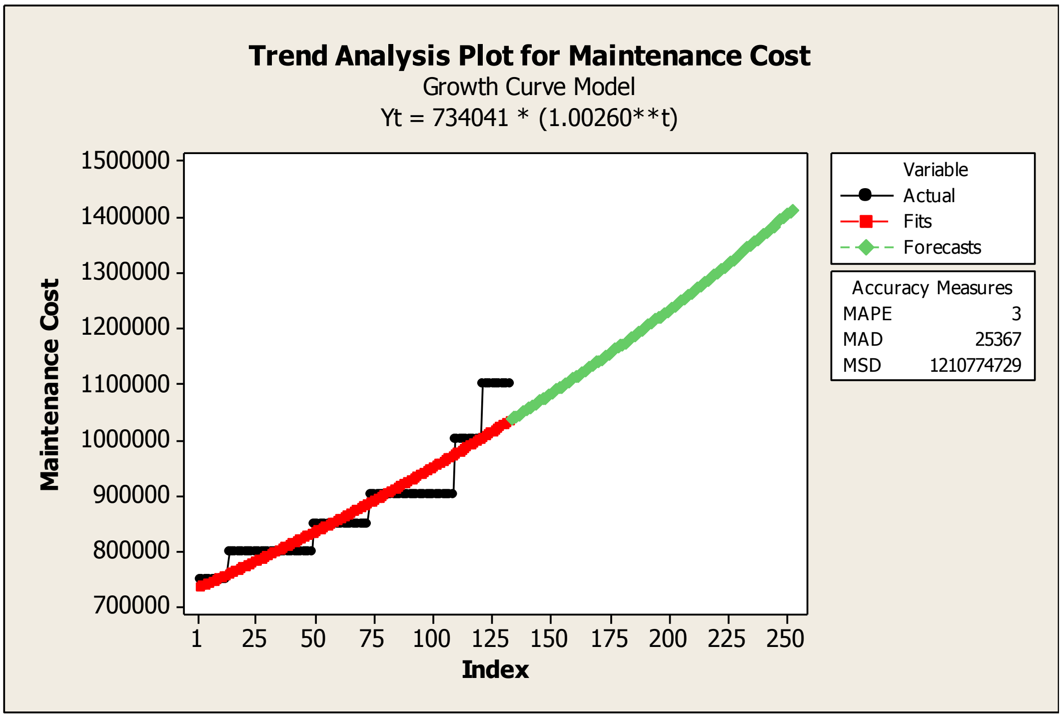
Period	Forecast
21	43,285
22	43,386
23	43,486
24	43,587
25	43,687
26	43,789
27	43,890
28	43,991
29	44,093
30	44,195
31	44,298
32	44,400
33	44,503
34	44,606
35	44,709

Period	Forecast
...	...
82	49,840
83	49,955
84	50,071
85	50,187
86	50,303
87	50,419
88	50,536
89	50,653
90	50,770
91	50,888
92	51,005
93	51,123
94	51,242
95	51,360

Period	Forecast
101	52,077
102	52,198
103	52,319
104	52,440
105	52,561
106	52,683
107	52,805
108	52,927
109	53,049
110	53,172
111	53,295
112	53,419
113	53,542
114	53,666
115	53,790

16	42,788	36	44,813	96	51,479	116	53,915
17	42,887	37	44,916	97	51,598	117	54,040
18	42,986	38	45,020	98	51,718	118	54,165
19	43,086	39	45,124	99	51,837	119	54,290
20	43,185	...	...	100	51,957	120	54,416

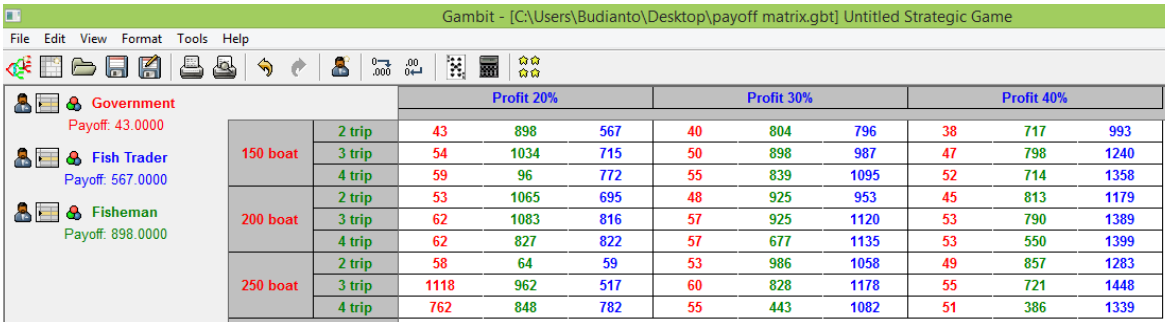
Appendix 6. Forcasted Maintenance Cost from 2016 to 2025



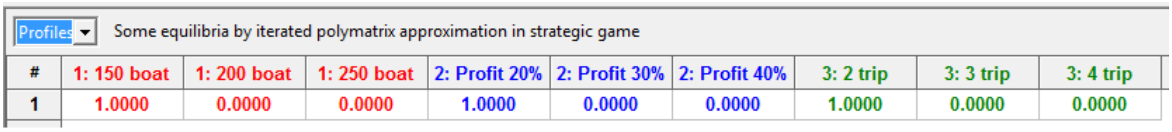
Period	Forecast	Period	Forecast	Period	Forecast	Period	Forecast
1	1.04E+06	21	1.09E+06	...	...	101	1.34E+06
2	1.04E+06	22	1.09E+06	82	1.28E+06	102	1.35E+06
3	1.04E+06	23	1.10E+06	83	1.28E+06	103	1.35E+06
4	1.04E+06	24	1.10E+06	84	1.29E+06	104	1.35E+06
5	1.05E+06	25	1.10E+06	85	1.29E+06	105	1.36E+06
6	1.05E+06	26	1.11E+06	86	1.29E+06	106	1.36E+06
7	1.05E+06	27	1.11E+06	87	1.30E+06	107	1.36E+06
8	1.06E+06	28	1.11E+06	88	1.30E+06	108	1.37E+06
9	1.06E+06	29	1.11E+06	89	1.30E+06	109	1.37E+06

10	1.06E+06	30	1.12E+06	90	1.31E+06	110	1.38E+06
11	1.06E+06	31	1.12E+06	91	1.31E+06	111	1.38E+06
12	1.07E+06	32	1.12E+06	92	1.31E+06	112	1.38E+06
13	1.07E+06	33	1.13E+06	93	1.32E+06	113	1.39E+06
14	1.07E+06	34	1.13E+06	94	1.32E+06	114	1.39E+06
15	1.07E+06	35	1.13E+06	95	1.32E+06	115	1.39E+06
16	1.08E+06	36	1.14E+06	96	1.33E+06	116	1.40E+06
17	1.08E+06	37	1.14E+06	97	1.33E+06	117	1.40E+06
18	1.08E+06	38	1.14E+06	98	1.33E+06	118	1.40E+06
19	1.09E+06	39	1.14E+06	99	1.34E+06	119	1.41E+06
20	1.09E+06	...	...	100	1.34E+06	120	1.41E+06

Appendix 7. Determining Nash Equilibrium Point using Gambit Software



		Profit 20%			Profit 30%			Profit 40%		
150 boat	2 trip	43	898	567	40	804	796	38	717	993
	3 trip	54	1034	715	50	898	987	47	798	1240
	4 trip	59	96	772	55	839	1095	52	714	1358
200 boat	2 trip	53	1065	695	48	925	953	45	813	1179
	3 trip	62	1083	816	57	925	1120	53	790	1389
	4 trip	62	827	822	57	677	1135	53	550	1399
250 boat	2 trip	58	64	59	53	986	1058	49	857	1283
	3 trip	1118	962	517	60	828	1178	55	721	1448
	4 trip	762	848	782	55	443	1082	51	386	1339



#	1: 150 boat	1: 200 boat	1: 250 boat	2: Profit 20%	2: Profit 30%	2: Profit 40%	3: 2 trip	3: 3 trip	3: 4 trip
1	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000

Appendix 8. Surplus Payoff Distribution Calculation using Shapley Value

$$
v(c) = \begin{cases} 32 & ;\text{ if } c = \{\text{Fisherman}\} \\ 8 & ;\text{ if } c = \{\text{Local Government}\} \\ 0 & ;\text{ if } c = \{\text{Fish Trader}\} \\ 40 & ;\text{ if } c = \{\text{Fisherman, Local Government}\} \\ 32 & ;\text{ if } c = \{\text{Fisherman, Fish Trader}\} \\ 8 & ;\text{ if } c = \{\text{Local Government, Fish Trader}\} \\ 40 & ;\text{ if } c = \{\text{Fisherman, Local Government, Fish Trader}\} \end{cases}
$$

$\boldsymbol{\pi}$	$\boldsymbol{\delta_{\pi}^{G}}$
(Fisherman, Local Government, Fish Trader)	(32, 8, 0)
(Fisherman, Fish Trader, Local Government)	(32, 8, 0)
(Local Government, Fisherman, Fish Trader)	(32, 8, 0)
(Local Government, Fish Trader, Fisherman)	(32, 8, 0)
(Fish Trader, Fisherman, Local Government)	(32, 8, 0)
(Fish Trader, Local Government, Fisherman)	(32, 8, 0)
Average	**(32, 8, 0)**

Conclusion:

Surplus value for fisherman, local government, and fish trader respectively are; 32 billion rupiah, 8 billion rupiah and 0 billion rupiah. Fish tradder get no additional payoff value because it has no power to change the equilibrium point.

Appendix 9. Determining Coalition Equilibrium using Gambit Software

Gambit - [C:\Users\Budianto\Desktop\payoff matrix coalition.gbt] Untitled Strategic Game (unsaved changes)

File Edit View Format Tools Help

Government — Payoff: 53.0000

Fish Trader — Payoff: 1300.7584

Fisheman — Payoff: 830.0321

		Profit 20%			Profit 30%			Profit 40%		
150 boat	2 trip	43	898	567	40	804	796	38	717	993
	3 trip	54	1034	715	50	898	987	47	798	1240
	4 trip	59	96	772	55	839	1095	52	714	1358
200 boat	2 trip	53	1065	695	48	925	953	45	813	1179
	3 trip	62	1083	816	57	925	1120	57	892	1283
	4 trip	62	827	822	57	677	1135	53	550	1399
250 boat	2 trip	58	64	59	53	986	1058	49	860	1283
	3 trip	1118	962	517	60	828	1178	55	721	1448
	4 trip	762	848	782	55	443	1082	51	386	1339

Profiles 2 — Some equilibria by solving polynomial systems in strategic game

#	1: 150 boat	1: 200 boat	1: 250 boat	2: Profit 20%	2: Profit 30%	2: Profit 40%	3: 2 trip	3: 3 trip	3: 4 trip
1	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	1.0000	0.0000
2	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000
3	0.0000	0.6376	0.3624	0.0000	0.0000	1.0000	0.3333	0.6667	0.0000

AUTHOR'S BIODATA

The author, Budianto, was born in Medan on March 3rd, 1996. Being the middle child from three siblings, the author went to TK Methodist-3, Medan (1999-2002) for kindergarden and continued to SD Methodist-3, Medan (2002-2008) for elementary school. The author then continued to SMP Methodist-3, where he sits for junior high school (2008-2011), senior high school in SMA Sutomo-1 Medan (2011-2013) and passed as a student in Industrial Engineering Department of Institut Teknologi Sepuluh Nopember (ITS) Surabaya.

As a college student, the author had actively engaged in several communities and interests. The author worked as Human Relation Committee on PIFOT (Public Figure on Talk) 2014 and other similar activities. The author was also a laboratory assistant in Quantitative Modelling and Industrial Policy Analysis Laboratory (Q-Lab) of Industrial Engineering Department where he helped the faculty member and external party in applying the core competence of the laboratory into various type of research activities. The author can be contact via email budianto13@mhs.ie.its.ac.id or budiantoc96@gmail.com.