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Centralized cold chain system for fish price stability in Lamongan Jawa Timur

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***Abstract*—the high potential of marine fisheries in Indonesia, especially in Lamongan, East Java, is not followed by the stability of fish prices. The price of marine fish tends to fluctuate because of the uncertainty of fish catches from fishermen. This study designed a cold chain system model that aims to maintain the stability of fish supply to the market so that the stability of fish prices gets better. This study uses a dynamic system approach to design 2 fish distribution models, namely models for existing conditions and models for centralized cold storage. Various conditions for increasing supply, increasing demand, cold storage capacity are parameters to be simulated. The results of this study indicate that the cold chain system built in this model can significantly reduce the variance in average fish prices.**

***Keywords*—Cold chain, price, fish, supply, demand**

I. INTRODUCTION

Indonesia is the country with the largest number of islands in the world, with an island number of 17,504 islands, has the longest coastline to the second in the world which is 81,000 km and has a sea and coast up to 75%. With this geographical condition, the potential of the marine and fisheries sector is very significant in economic growth and fulfillment of food needs for Indonesia[1]. According to data from the Food Agriculture organization[2], Indonesia is the number two largest marine capture fishery producer in the world after China, with annual catches reaching 6.7 million tons[3].

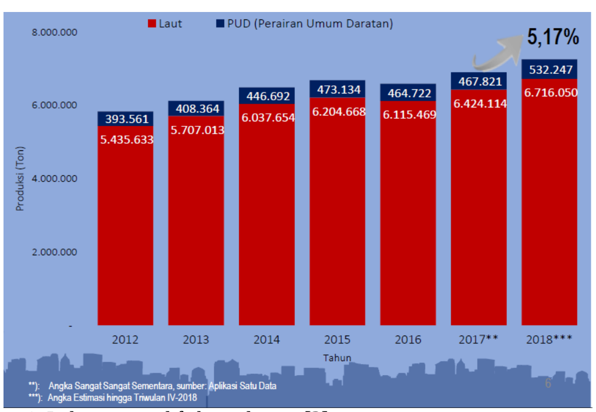

Figure 1. Indonesia total fish production[3]

Lamongan is one of the fisheries producing regions in Indonesia. The geographical location bordering the Java Sea, with a land area of 1,812.8 km, a coastline of 47 km and an area of seawater of 902.4 square kilometers. The potential of marine capture fisheries reaches 75 thousand tons/year which can supply 18.7 percent of the fish demand in East Java and become the highest supplier of capture fisheries in East Java (BPS, 2018). Fish obtained from Lamongan waters are then distributed by land using open truck transportation and transported in drums or fiber boxes to be distributed to several cities in East Java, namely Jombang, Surabaya and Malang.

Climate changes such as rising seawater temperatures, changes in weather patterns, local climate and high sea waves have a significant impact on changes in capture fisheries results. Climate change affects the fisheries sector in various countries in the world. Changes in catch composition, declining fisherman productivity and low catches have occurred in America, Japan, Canada, China, Chile, Thailand, Indonesia [4].

The impact of climate change on capture fisheries production in Indonesia has been investigated by Perdana (2016) in capture fisheries in Semarang City, Central Java. Fishermen feel a decrease in the amount of catch production. This is due to strong winds, high rainfall, high sea waves which have resulted in fishermen having difficulty getting consistent catches, resulting in the stability of the supply and demand of marine fish in Semarang. Very high catch fluctuations also occur in other Indonesian waters, such as Fish Auction Center/PPI Brondong-Lamongan, where the highest peak of fish catch reaches 310 thousand tons in June and almost none in January-February (Amri, 2008).

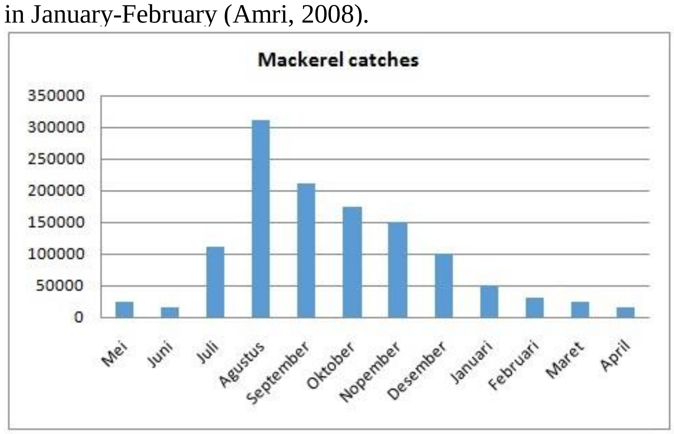

Figure 2. Mackerel catches, Brandong PPI, 2014

The high gap between the peak of the catch and the lowest point of the catch is one form of supply disruption that needs to be addressed because it has an impact on price fluctuations. Supply disruptions often have an impact on low selling power, low product competitive power, reduced market share, low profitability from supply chain actors. Thus, maintaining the availability of resources and supply is important as a supply disruption mitigation effort for food security (Hendrics, 2005).

Storing and distributing perishable products such as marine fish requires different strategies and handling techniques with long-term nonperishable products. Sea fish is a product that is very rapidly declining when not stored in low temperatures. One solution to keep the age of marine fish to be of good quality to customers, and can be stored as a buffer stock for supply stability is by the cold chain system model.

The cold chain is a type of low-temperature supply chain system to maintain perishable product temperature so that product quality is maintained from upstream to downstream/end customer [5].

II. COLD CHAIN FOR FISHERIES PRODUCTS

The cold chain consists of cold storage and refrigerated transportation modes that connect between one cold storage to the next cold storage. The cold chain system in Indonesia is initiated by the government (KKP) by developing a cold chain system scheme in national fish logistics, as shown in the figure below.

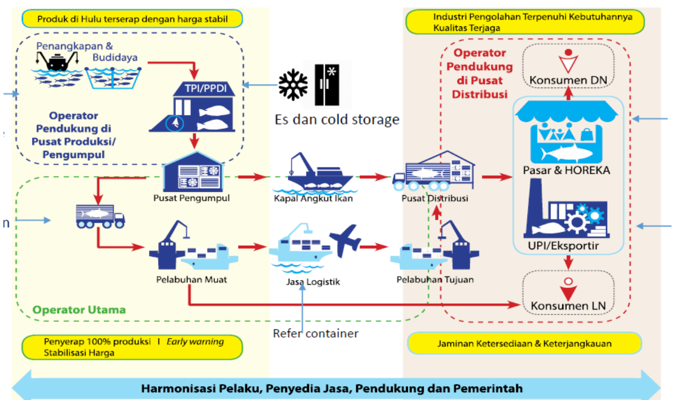

Figure 3. Cold chain facility scheme

A. Existing system identification and proposal

The identification includes supply data of captured marine fish, number of cold storage, marine fish distribution patterns, stock and price formation from upstream (namely fishermen's catches) to downstream (retailers). The existing distribution lines are shown in the figure below (Gumilang, 2014).

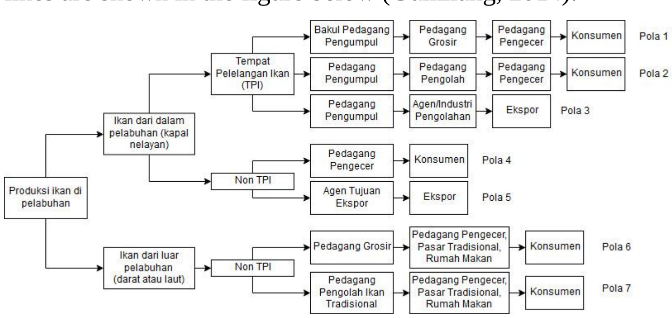

Figure 4. Captured sea fish distribution line

While the distribution pattern **with** a centralized cold chain system is proposed as illustrated in the figure below.

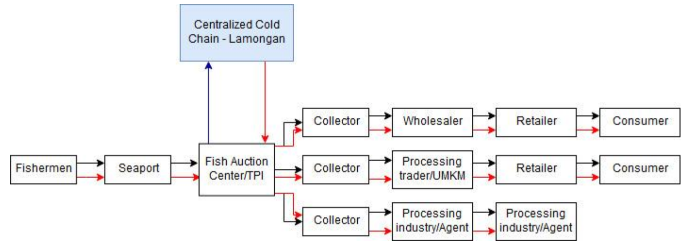

Figure 5. Centralized cold chain system proposal

Legend :
---- = existing distribution
---- = frozen fish distribution from cold storage during a shortage
---- = the captured fish line during oversupply, fish is frozen into cold storage as buffer stock

III. SIMULATION MODEL

A. Conceptual modeling

Conceptual modeling begins with the design of the cold chain system model as illustrated in the figure below.

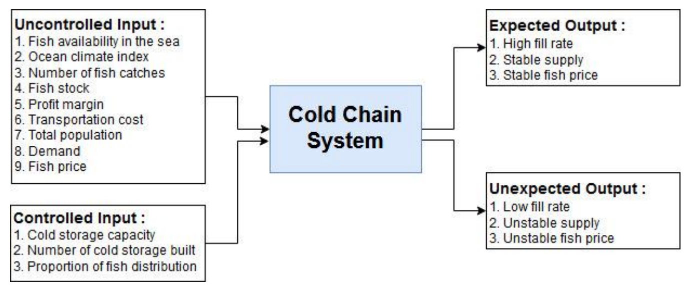

Figure 6. Input-Output Diagram

Using STELLA software, a real system concept model is transformed into computer language with an overview of causal-loop diagram/CLD, subsystem, stock-flow diagrams.

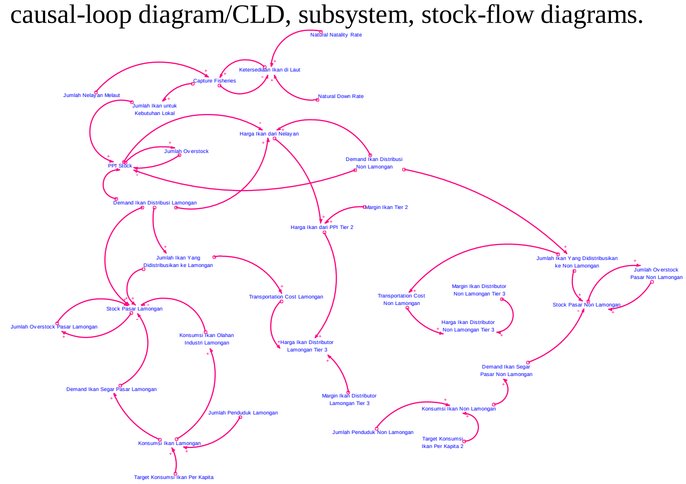

Figure 7. Existing distribution causal-loop diagram/CLD

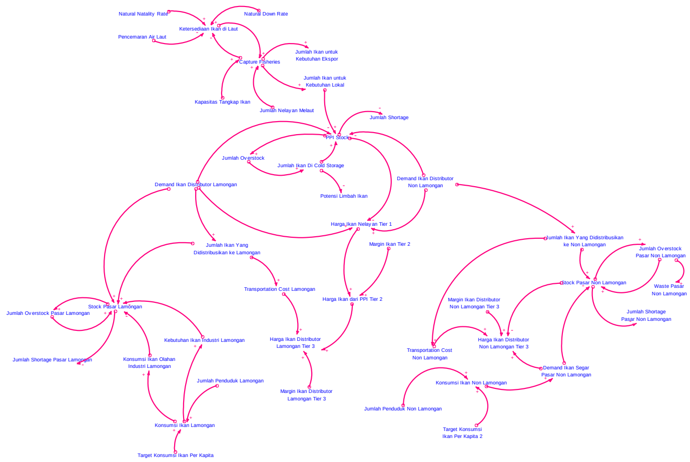

Figure 8. Centralized cold chain system (proposal) causal-loop diagram/CLD

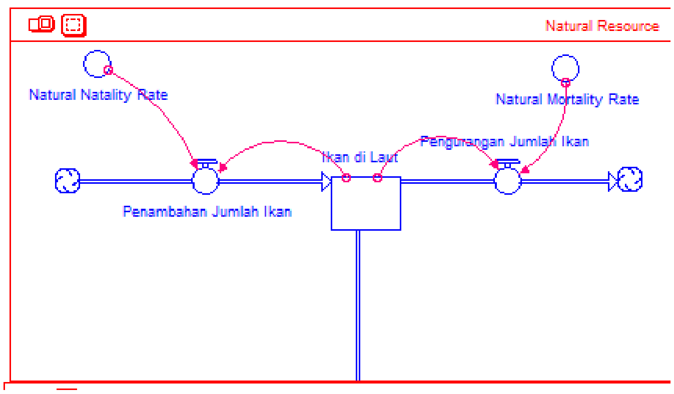

Figure 9. Natural resources subsystem stock-flow diagram

As depicted in figure 9, the rate of fish addition in the sea is influenced by the natural natality rate or natural breeding, while the reduction rate is influenced by the natural mortality rate or natural death of fish. In this subsystem, the author does not include any engineering efforts.

The exploitation subsystem describes the flow of changes from fish stocks in the sea ***to*** catch fish stocks. The rate of increase in the fish catch is influenced by the capacity of fishing vessels and the number of ships that go out to sea. Reduction of captured fish stocks due to exports are not included.

The Lamongan subsystem is the main subsystem of the design of a cold chain system. Lamongan stock-flow subsystem describes the stock-flow that goes into cold storage or that comes out of cold storage. In Lamongan subsystem, PPI fish stocks are influenced by the increased rate of fish catches from the captured fish system, while the reduction in PPI stocks is the fish allocation for Lamongan and nonLamongan (other cities like Malang, Surabaya, Jombang).
PPI stock was also added from Lamongan cold storage, where the rate of fish supply was affected by minimum PPI stock and frozen fish proportion.

Lamongan cold storage is influenced by overstock conditions of nonLamongan demand and Lamongan market. Stock reduction of Lamongan cold storage is from fish that have been damaged or exceed the shelf life period of 1 year.

The excess flow rate of fish entering Lamongan cold storage is determined by the capacity of cold storage and the amount of fish for cold storage, both from Lamongan and nonLamongan supply.

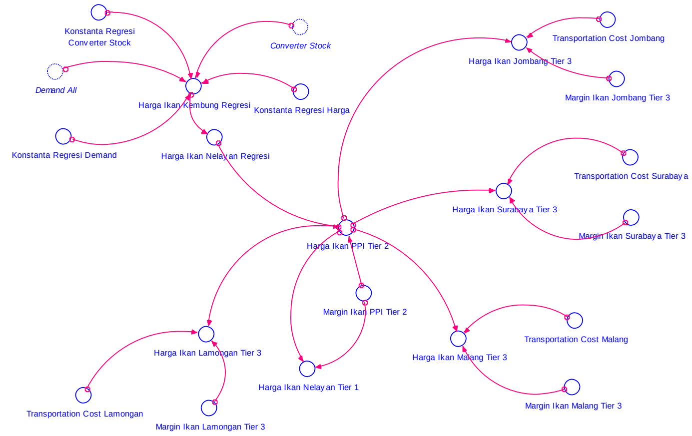

Figure 10. Fish price formation subsystem stock-flow diagram

Price formation in this model is influenced by supply and demand and expressed in multiple regression equations.

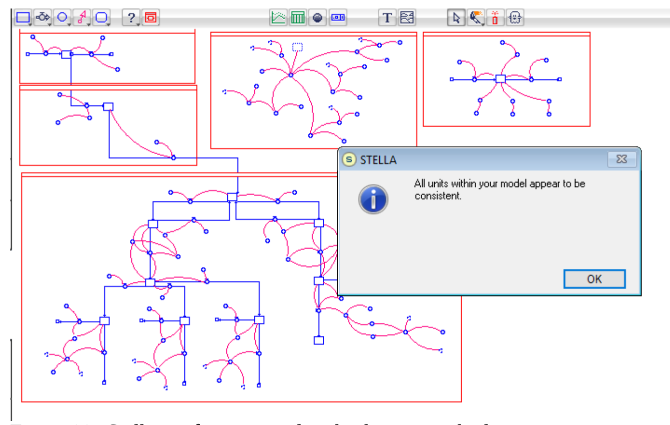

Figure 11. Stella verification result - check units method

Further verification of conceptual modeling using STELLA shows the model consistent and verified.

B. Data collection and model validation

Data collection uses secondary data obtained from the Ministry of Maritime Affairs and Fisheries Indonesia, Department of Marine and Fisheries-Lamongan, PPI Office Brondong, Central Bureau of Statistics/BPS.

Model validation is carried out to testing whether the model can represent or describe the real system. Model validation is done by testing the simulation results with real systems, also called Mean Comparison testing with the following equation :

$$E = \frac{|\bar{S} - \bar{A}|}{\bar{A}}$$

where S = average value of simulation result
A = actual data value

A model is considered valid if it has an E value < 10%

C. Designing Scenarios

The scenario is designed to see the effectiveness of the cold chain on supply and price stability. In existing conditions, without the presence of cold chains, fish supply is high fluctuated, which results in high fluctuations in fish prices.

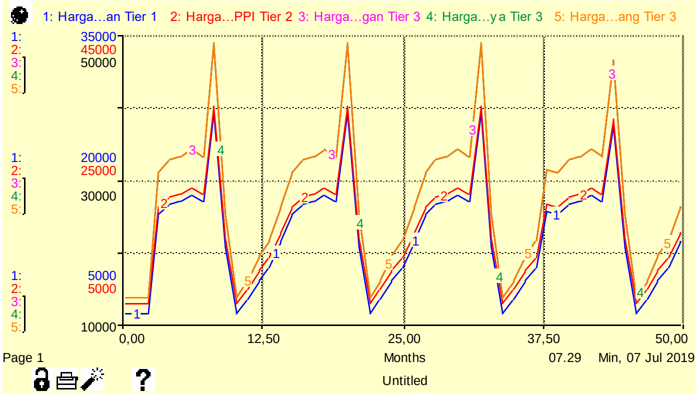

Figure 12. Existing price fluctuations of Mackerel fish without cold chain presence

Centralized cold chain scenarios with 25% supply increase (S1-S7) is a condition where there is only 1 cold storage in Lamongan and is simulated if there is an increase in supply up to 25%.

The scenario with code S1 is the simulation condition when there is no increase in supply or demand, there is cold storage so that it reduces the percentage of damaged fish from 35% (existing) to 5%.

The S2 to S7 scenario is a simulation if there is an increase in demand 15% to 35% and simulated with 100 tons and 1000 tons cold storage capacity, where the existing condition of cold storage capacity in Lamongan is 400,000 tons with consumption target 50 kg/capita/year. Mackarel fish is one of 35 species fish landed at PPI Lamongan.

Details of the simulated input variables in each scenario are shown in the table below.

Scenario Code	S1	S2	S3	S4	S5	S6	S7
Supply Increase	normal	25%	25%	25%	25%	25%	25%
Demand Increase	normal	15%	15%	25%	25%	35%	35%
Cold storage capacity (ton)	100	100	1000	100	1000	1000	100

D. Scenarios Result

Output simulation results for each scenario are shown in the following figure.

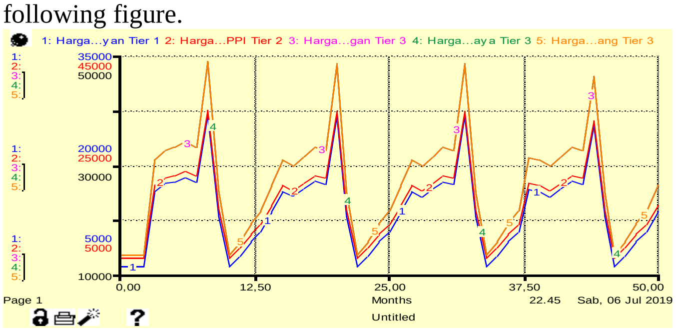

Figure 13. Scenario 1/S1 output result for fish price

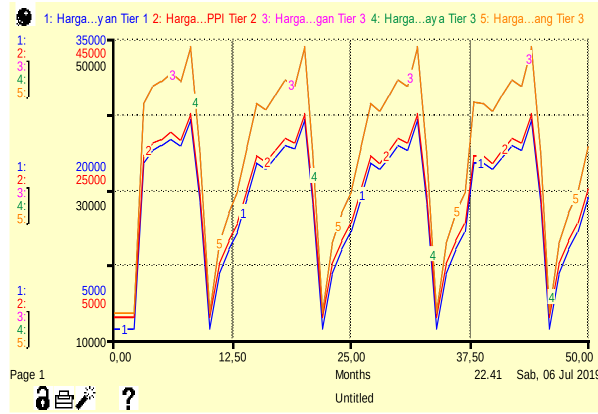

Figure 14. Scenario 2/S2 output result for fish price

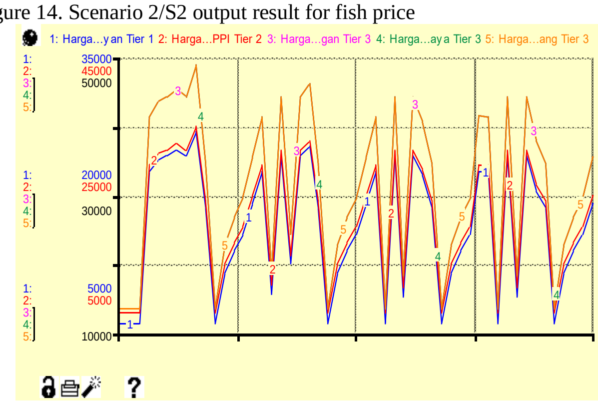

Figure 15. Scenario 3/S3 output result for fish price

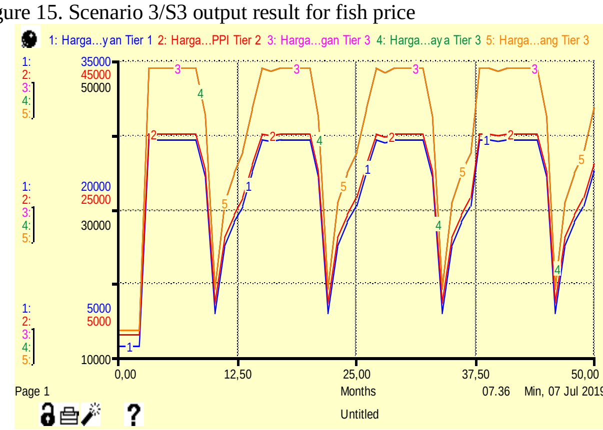

Figure 16. Scenario 4/S4 output result for fish price

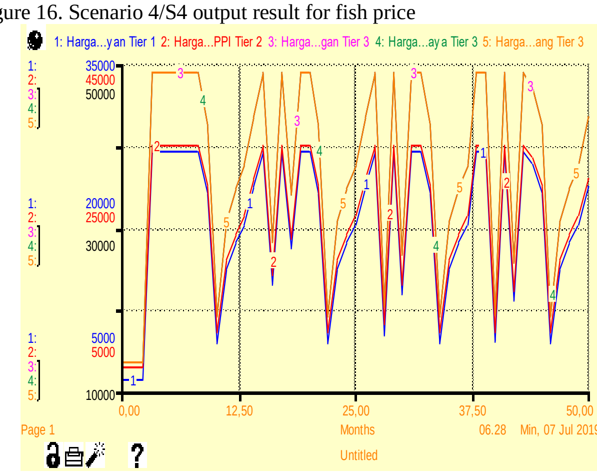

Figure 17. Scenario 5/S5 output result for fish price

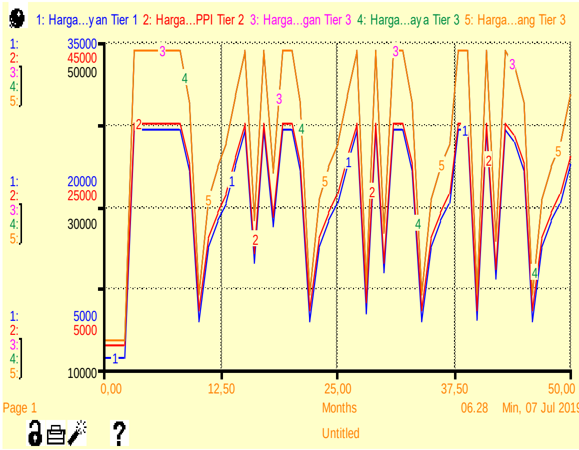

Figure 18. Scenario 6/S6 output result for fish price

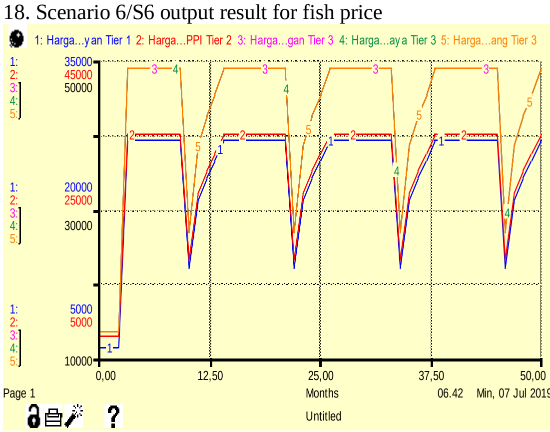

Figure 19. Scenario 7/S7 output result for fish price

In numeric wise, below are the fish price for each scenarios :

	In Rupiah/Kg			
	Existing	**S1**	**S2**	**S3**
Average	19055.46	18800.38	25081.88	23783.32
Std. Deviation	7348.21	7094.57	7895.40	8253.56

	In Rupiah/Kg			
	S4	**S5**	**S6**	**S7**
Average	29808.18	28717.34	31975.84	32495.53
Std. Deviation	7172.36	7374.28	5081.49	4996.55

The best scenario in this group determines to look at which S1-S7 scenario has a smaller variance than the existing value of 7348. In this group, there are 5 scenarios with an average standard deviation that is smaller than the existing value, namely the S1 scenario, S4, S6 and, S7. To decide on which conditions the cold chain system scenario can provide the best price stability, an average difference test of the existing conditions and the S7 scenario is performed.

IV. Result and Discussion

To see the impact of the cold chain on the stability of Mackerel prices, the indicator used is the variance or standard deviation value. Variance(s) which is smaller than the existing variance is considered as the best scenario. Based on tabulated results, the best scenario is S7 with the smallest variance (Rp.4,996) than the existing (Rp.7,348).

Scenarios S1, S2, S3, S4, S5, S6, and S7 are a group of scenarios with the condition that there is an increase in the supply of up to 25% and increase demand by 15%, 25%, 35% with cold storage capacities of 100 tons and 1000 tons.

Simulation results and statistical tests show that the scenario S7 differs significantly from the existing variance. The standard deviation value of fish prices in scenario S7 decreases to 32% of the exciting conditions.

This work only looks at one commodity, so further work can be developed to see the effectiveness of cold chains for multi-product scenarios.

Acknowledgment

The author would like to acknowledge the support from Section Head of Port Operation PPN Brondong, Lamongan and Department Head of Fishery Competitiveness Products-DKP Lamongan.

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