UPPLY CHAIN DESIGN OF CHILI COMMODITY TO IMPROVE THE NATIONAL FOOD SECURITY BY SYSTEM DYNAMICS SIMULATION

by Ratna Ekawati

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Abstract

Chili is one of vegetable commodities that have high economic value, because of its role to meet domestic needs, as an export commodity and food industries. This study begins with the identification of the basic model of supply chain and the problem in the chilli industry. Furthermore, the model is analyzed with system dynamics approach and simulation was done to know the behavior of the system in chili industry. The behavior of chili supply chain system will be increased until year 2025, but margin of the price will be increased too. Therefore, improvement scenarios are to decrease a margin value of the price along the chili supply chain. The government must determine the profit value for the chili supply chain. Also, the government must give an intervention for the price standard of marketing along chili supply chain so the price margin between farmer and the end customer will be decreased.

Keywords : chili, the price margin, system dynamics, supply chain, simulation

INTRODUCTION

Chili (Capsicum annuum L) is one of vegetable commodity which has high economic value because its role is big enough to fulfill domestic requirement as export commodity and food industry. Chili is a strategic horticultural commodity, both red chilli and cayenne pepper. Indonesian society is one of the biggest chili enthusiasts in the world. Therefore, chili becomes one of the important products of Indonesian food, even it can affect the rate of inflation.

Chili needs for large cities with a population of one million or more about 800,000 tons / year or 66,000 tons / month. In "hajatan" or religious festivals, chili needs usually increase in 10-20% of normal requirement. Chili productivity rate nationally during the last 5 years about 6 tons / ha. The urban community to meet the monthly needs is required chilli harvested area of about 11,000 ha/month, while in the celebration season of harvested area of chili that is available ranges of 12.100-13.3 ha / month. Also, the needs of chili for rural communities or small towns as well as for processed raw materials (Suwandi, et al.,2016). To meet all the needs of chili is needed supply of chili sufficient. If the supply of chili is less or lower than the demand so the price will increase. Conversely, if the supply of chilli exceeds the need, the price will decrease.

In terms of price, chilli has a characteristic often occur very high price fluctuations. For example, a surge in prices above 100% is very common. Even in January 1996 the price of chilli jumped about 327% compared to the previous month's price. Chili price increases to recur within 2-3 months and then thereafter decrease to 2-3 months. By using the Coefficient of Diversity (KK) as an indicator of stability, the price of chili in 2010 reached 57% and the price of red chili pepper in 2010 reached 35%, much higher than the price of rice and sugar in the region, at 6.6% and 3,7% (Farid and Subekti. 2012). Toward the end of the year until the beginning of the year, the price of chilli spikes high enough to reach more than Rp 100.000 / kg, while at a certain price can fall below Rp 10.000 / kg.

These seasonal price fluctuations occur almost every year. The spike in the price of chili is due to reduced supply, while constant and continuous demand every day, even increasing in certain seasons. Fluctuations in the price of chilli occur due to seasonal production of chili, rain factor, production cost and length of distribution channel (Farid and Subekti 2012). Meanwhile, the price disparity between chilli regions occurred because the center of pepper production is concentrated on Java and the quality of road infrastructure is inadequate (Irawan 2007). The problem of national chili supplies availability is very important to be studied because it concerns national food security.

Food security is one of the decisive factors in the national stability of a country, both in economic, security, politics and social. Food security is a major program in agricultural development at present and in the future. Food security is the condition of the fulfillment of household food which is reflected from the availability of adequate food, both quantity and quality, safe, equitable, and affordable. Measures of food security in terms of self-sufficiency (independence) can be seen from the dependence of national food availability on food production in the country. The concept of self-sufficiency (independence) is scenario as a condition where national food requirement is at least 90% fulfilled from domestic production (Suryana, 2004).

Although food availability is sufficient at the national and regional levels, but if individual access to meet food needs is uneven so food security is still fragile. The aspect of the distribution of foodstuff to rural households that includes the function of place, space and time is also an effort to strengthen food security strategies so it is important to assess supply availability in chili pepper supply chain in the framework of national food security.

Several scientific studies related to this research have been conducted by several researchers. Sahara et al. (2011) examines the effect of quality farmer-chili merchant relationships of Indonesia on supply chains in modern and traditional markets. Hadi and Susetyo (2011) studied the marketing margin of red chili in Jember district. Prabhavathi et al. (2013) examines the supply chain analysis of red peppers in India comparing two types of supply chains. Kurniawan et al. (2014) examines the analysis and measurement of supply chain efficiency of large red chili commodities in Jember District. Ongirwalu et al. (2015) examines the downstream evaluation of the supply chain in the chili commodity logistics system in the traditional market of Pinasungkulan Manado. Tuti, K. et al. (2015) examines the design of a red chili commodity supply chain modeling model in West Java with a structured market orientation using case study method with qualitative modeling approach through identification of value stream mapping. Buntuan (2010) conducted a study on early simulation for food crisis management by using dynamic simulation method to see the parameters affecting food crisis then simulated with dynamic model. Akhmad (2013) conducted a study on food security with data analysis using a dynamic model on rice supply chain.

Supply chain is composed by a number of interacting entities through a distinct interaction pattern according to the structure formed. The more number of entities involved in the supply chain will affect the structure and determine the complexity of a supply chain. These entities interact to achieve a common goal, namely the final consumer. According to Zhou and Benton (2007), a supply chain is an integrated system. As a system, the point of view of the analysis of the supply chain must be comprehensive. The entire system components must be viewed as an integral whole. Inequality in one component will disrupt the system as a whole. Therefore, the purpose of a study or analysis of a supply chain is a proportionate increase overall across entities from upstream to downstream.

This research was conducted to identify the basic system of chili pepper supply chain in achieving national food security, to formulate conceptual system and formulation of chili supply chain model to achieve national food security, and to know the behavior of chili supply chain system for the next 10 years.

RESEARCH METHOD

The design of dynamic system of chili supply chain starts from the analysis of the situation and condition of chili industry in Indonesia, then identifies the basic system of chili supply chain by looking at upstream and downstream sub-system diagrams and causal loop diagram of chili supply chain. Flow diagrams with mathematical equations, simulations and validation tests into supply chain models with economic and social aspects as policy analysis or decision. This research is a combination of explanatory research and causal research that is combination of secondary data analysis and experiment. Exploratory research with secondary data analysis to know the situation and problem of national chili, while causal research with experiment to know the relationship between phenomenon in model.

Data Retrieval

Data onto this research are primary and secondary data. Primary data obtained from the observation and direct interviews for the relevant sources include several farmer groups, merchant, and chili consumers, while secondary data obtained from relevant agencies include the Central Bureau of Statistics, the Department of Trade and the Department of Agriculture.

Solution to problem

Problem solving plot is a general step done in doing research. The problem solving flow is useful for providing information on the beginning of the research to the completion of the research. The following is a problem solving plot as an overview of the research undertaken. Flow chart of research framework can be seen in Figure 1:

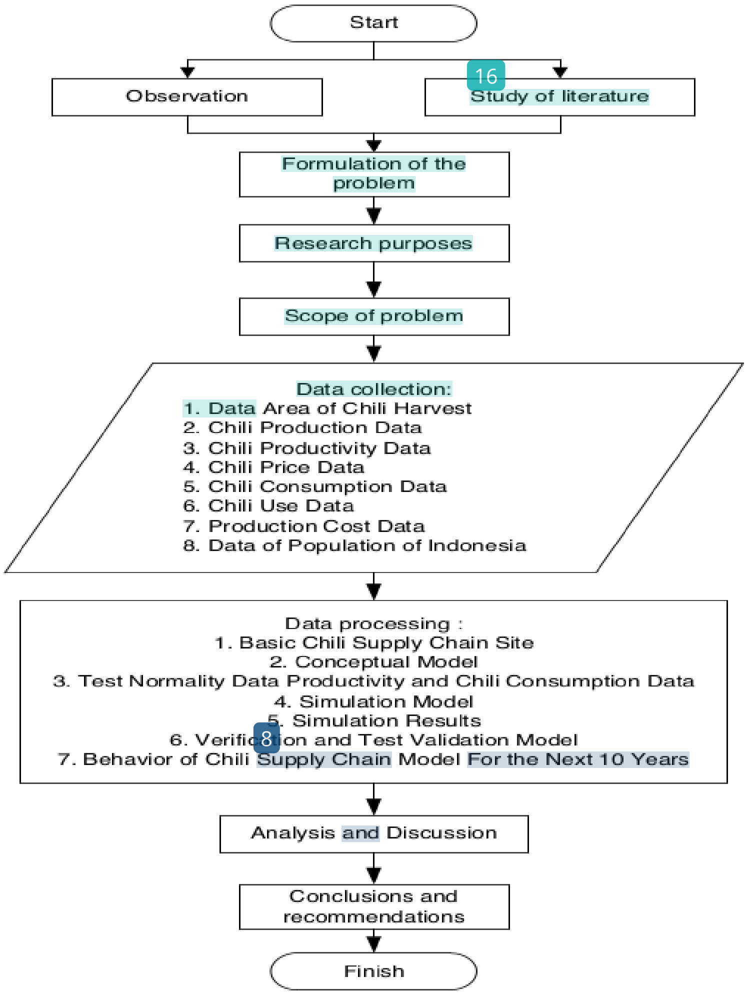

Figure 1. Flow Chart of Research Framework

RESULTS AND DISCUSSION

Basic Chain Supply Chain System

Supply chain as a system can not be separated from the close relationship between components, as well as the supply chain system on horticultural commodities such as chili. Chili availability system is divided into three sub-systems namely sub-system production (manufacturer), sub-system distribution (supplier), and sub-system consumption (consumer). All three of these interconnected systems form a chili supply chain system (Figure 2). The components of the supply chain in more detail as shown in Figure 2.

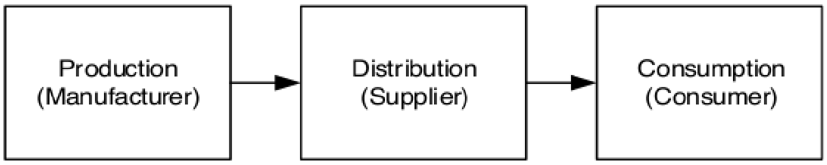

Figure 2. Mapping of Chili Supply Chain Subsystem Elements

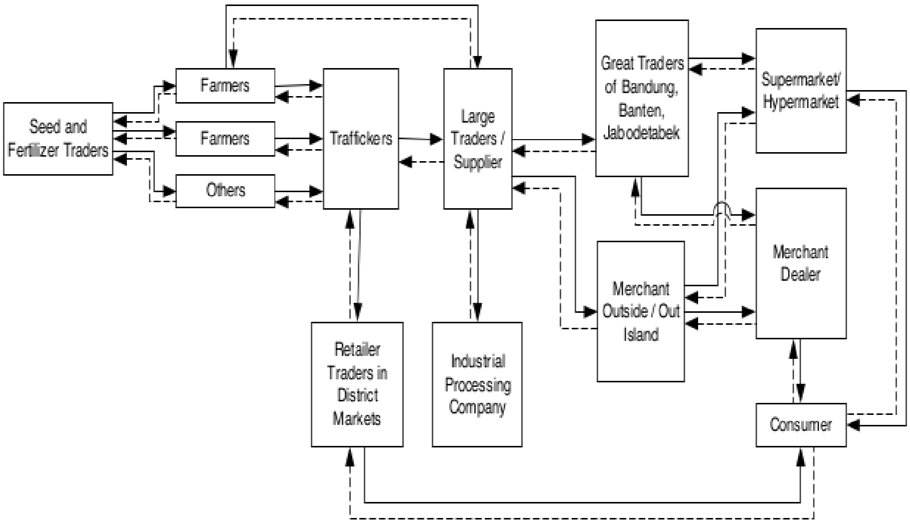

Figure 2. Supply Chain Components in Indonesia

The distribution and marketing system covered by the chili supply chain vary by region of production and market objectives. Chili supply chain is still largely targeted to meet the local, provincial and provincial markets for example: Jakarta, Bogor, Depok, Tangerang, Bekasi (Jabodetabek) markets, Banten markets and Bandung markets. The traders involved in the distribution of chilli are traders, wholesalers or wholesalers including suppliers of processing industries, and retailers, both traditional market retailers and modern markets (supermarkets, hypermarkets and supermarkets).

Collecting traders acts as collectors and buyers of pepper production from farmers. Wholesalers, in addition to acting as buyers of the products of collecting traders and farmers, often also play the role of capital providers (informal finance institutions) for the farmers and collecting traders who are their accomplices. Capital loans to farmers can be in the form of money or nature (seeds, fertilizers, and medicines).

In the supply chain institutional, farmers act as chilli producers, which is responsible for the production process of chili. Collecting traders act as collectors and buyers of pepper production from farmers. Wholesalers act as buyers of the products of collecting merchants and capital providers for the farmers and collecting traders who are their subordinates. Inter-island traders play a role in distributing inter-regional chilli commodities, these actors usually have transport fleets, especially trucks and pickup trucks. Market retailers play a direct selling role to consumers in traditional markets and modern markets (Supermarkets, Hypermarkets and Supermarkets) that sell chillies to consumers directly in central consumption areas.

In addition to knowing the supply chain chili pepper, another thing that is not less important is the marketing margin of chili on every component of the supply chain. The result of Hadi and Susetyo (2011) research on marketing margin analysis of red pepper in Jember District shows that during planting season I and II in 2011 amounted to IDR 37.250/ Kg. This margin is above the price of red pepper at the producer level of only IDR 20,750/kg. Indeed, between the margin value should be much smaller than the price at the producer level. The margin value consists of Share price received by farmers amounting to 35.78% of the price paid by the end consumer and amounted to 64.22% is the share of marketing margin. The total marketing margin of 27.40% is the marketing cost incurred by the four marketing agencies involved and then 36.82% is the advantage of the four marketing agencies involved.

The description of the injustice of marketing share of red chilli in as indicated above indicates that the marketing process of chili has excess demand or undersupply chilli products. Therefore, the government tries to intervene in the market through imported chili actions from India, China and Vietnam. Nevertheless, the price of the product has not been any signs of decline even tends to increase until close to IDR 100.000/kg and even outside the region can reach above IDR 100.000/kg to IDR 150.000/kg. What a very irrational price. This means that the price of red chili is high at the consumer level and very low at the farm level, so the high price is only enjoyed by the traders involved in the marketing process.

If the price of the sky is higher than the value of its marketing margin, it may still be accepted by economic logic. Viewed from the profit ratio aspect that the highest average ratio experienced by retailers and the lowest received by traders between regions (districts). This means that the level of fairness in receiving profits is very unfair compared to the proportion of costs incurred by each marketing agency. Supposedly the highest ratio experienced by traders between regions / districts with the highest marketing expenditure of each product Kg, not by retailers whose marketing costs on average only IDR 838 / kg. Symptoms of the high price of red chili due to bad weather so that production plummeted that led to a limited supply. However, the government has taken import actions from India, China, and Vietnam, but product prices remain expensive.

Conceptual Model Supply Chain of Chilli

1. Problem Definition

The dynamic model illustrates the interactions between elements that make up the chili supply chain system. The problem of chilli availability is a fairly complex system problem involving various components, variables in which interact and integrated. The availability of chili nationally can be viewed as a system dynamics problem that changes over time and is influenced by factors that are also dynamic. The purpose of modeling the availability of chili is to look at the pattern of chili availability in the future to improve national food security with a variety of scenario development alternatives that are in line with real conditions.

The developed system dynamics model is limited to matters relating to the supply, supply and demand of chili. This model is made based on the identification of problems poured into the causal loop, formulated in stock and flow diagrams and simulated using Powersim software.

2. Identification of Key Variable

In determining the level of national chili availability, researchers need to know the factors that affect the supply of chili. Based on the observation and literature study it is known that the national chilli availability level is the difference between the production and consumption of chili. Chili production is influenced by variables such as planting area, productivity, farmer household income, cultivated area, conversion of land, conversion and extensification of cultivated area. Constants are required as inputs to the model in addition to these variables, making it easier to modify the model in case of changes in accordance with the actual conditions. These constants include the percentage of additional planting costs, the area of planting area (extensification) per year, and the percentage of land conversion (conversion) per year.

Chili consumption is influenced by variables such as chili production, household consumption, industrial consumption, aging for seeds and scattered. Chili consumption is strongly influenced by people's behavior in consuming chili. Level of pepper needs can be seen from the dynamics of population development that is very influential on the demand for chili for consumption. The dynamics of this population model will produce output in the form of future population forecasts. The dynamics of population development are formed through the interaction between the variables of the population of Indonesia with the variables rate of population growth and the rate of death of the population that form a relationship. The greater the rate of population growth per year the greater the annual population, the greater the rate of death of the population, the less the annual population. The consumption pattern is based on population dynamics and the average requirement of chili for consumption is converted in kg/capita/year. Required variable (constant) level of chilli consumption which input average chili consumption in accordance with real conditions to know the consumption needs of chili. Chili consumption level variables will further impact the positive effect on the amount of chili consumption. The greater the level of chili consumption per capita, the greater the amount of chili needed for consumption.

In addition, the relationship between production and consumption of chili will affect the supply chain dynamics. In terms of supply or distribution there is a supply chain component which is described by several variables such as producer price, collectors, small traders, wholesalers, retailers, consumer prices, and income from RTs. The relationships among these variables will simulate how the effect of price changes on the producer level on prices in each other supply chain components.

3. Reference Model

Reference models related to the design of the chain's dynamic supply chain model for the agricultural commodity supply chain model, Akhmad Mahbubi et.al (2013), entitled "The Dynamic Model of Sustainable Rice Supply Chain in National Food Security Efforts".

4. Development of Causal Loop Diagram

Causal simulation model is the basis of making the main model simulation. Causal simulation model is built based on the relationship between variables in the model (Japar et al., 2013) The Causal Loop Diagram relation explains the causal relationship between variables with each other. The relationships between these variables form a long chain of causal loops that will provide feedback on other variables. Causal Loop diagram explains about the causal relationship of supply availability level of chili influenced by the level of production, distribution (supply) and level of consumption.

Causal Loop The diagram above illustrates the relationship between production, distribution and consumption of chili. A causal relationship with a positive sign (+) indicates if the dependent variable increases then the independent variable will increase. Similarly, the causal relationship with the negative sign (-) indicates if the dependent variable increases then the independent variable will decrease.

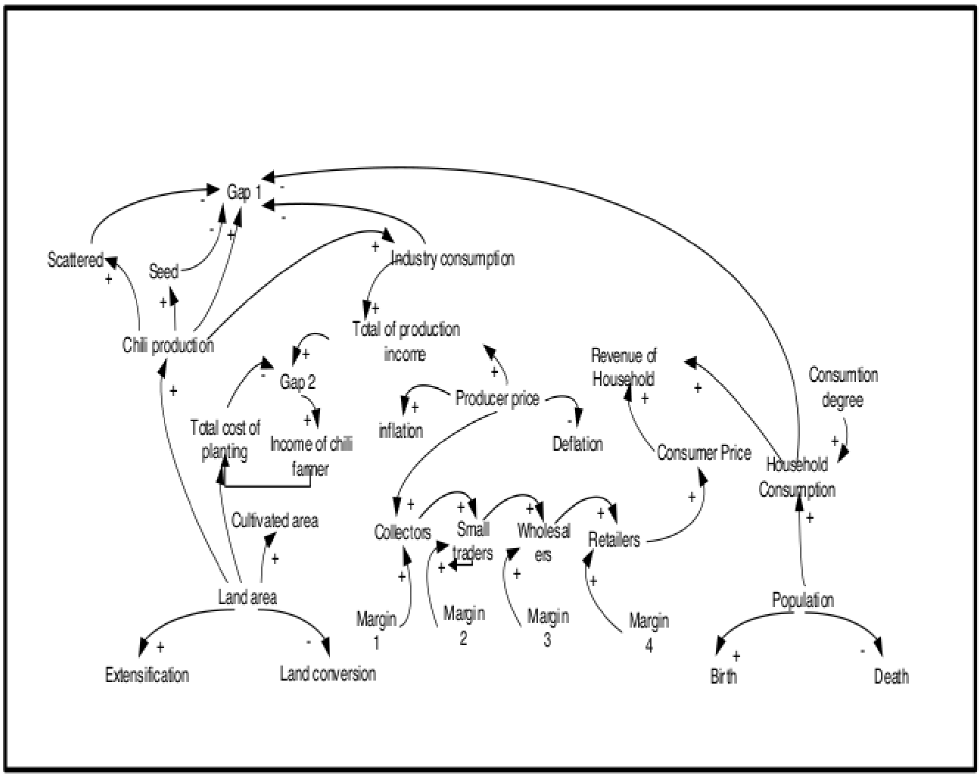

Figure 3. Causal Loop Diagram of Chili's supply chain in Indonesia

Test Data Normality

Normality test is a test of data to see whether the residual value is normally distributed or not (Ghozali, 2011). Normally distributed data will minimize the likelihood of bias occurring. In this study, to know the normal distribution of data using Kolmogorov-Smirnov Test manual calculation. This data distribution is required for equation on Stock Flow Diagram.

The following is the distribution of average productivity data of chilli ton / ha in 2006-2015 with manual calculation :

Formulation of hypothes

H0: $\mu = \mu 0$ means the sample data comes from the normal distribution

H1: $\mu \neq \mu 0$ means the sample data does not come from the normal distribution

Significansi $\alpha = 0{,}05$

Calculation of the area of the curve z : $Z = \frac{x - \bar{x}}{s}$ .... (1)

Test Statistic : $D = |F_n(x) - F_0(x)|$ .... (2)

Critical area : Reject H_1 if $D < D_\alpha$

Accept H_1 if $D > D_\alpha$

Table 1. Calculation of Normal Distribution of Chili Productivity

Thn	X	Freq	Cumul	$F_n(x)$	Z	F(x)	D
2006	5.796	1	1	0.100	-0.65	0.0985	0.0015
2007	5.525	1	2	0.200	-1.01	0.0869	0.1131
2008	5.452	1	3	0.300	-1.11	0.0778	0.2222
2009	5.854	1	4	0.400	-0.57	0.2776	0.1224
2010	5.617	1	5	0.500	-0.89	0.6808	0.1808
2011	6.199	1	6	0.600	-0.11	0.516	0.0840
2012	6.838	1	7	0.700	0.75	0.5948	0.1052
2013	6.905	1	8	0.800	0.84	0.5557	0.2443
2014	7.101	1	9	0.900	1.11	0.6772	0.2228
2015	7.496	1	10	1.000	1.64	0.6293	0.3707
Rata-rata	6.278						
St. Deviasi (s)	0.743						

D is the calculated value kolmogorov smirnov one sample.

Dα is the critical value for one sample kolmogorov smirnov test, obtained from kolmogorov smirnov table one sample.

$F_n(x)$ Is the cumulative opportunity value derived from the comparison of the data by the number of whole data.

$F_0(x)$ Is the cumulative opportunity value obtained from the z curve

Example Calculation:

$$Z = \frac{X-\bar{x}}{s} = \frac{5.796-6.278}{0.743} = -0.65$$

$F_0(x)$ ketika Z = -0.65 adalah 0.0985

$$F_n(x) = \frac{1}{10} = 0{,}1$$

$$D = \left|F_n(x) - F_0(x)\right| = |0{,}1 - 0{,}0985| = 0{,}0015$$

$D_\alpha = 0{,}371$

From the calculation, it can be seen that D count has a value of 0.371, while D table has a value of 0.409. Therefore, D <Dα = 0.371 <0.409. This means that H1 is rejected, so the existing sample data comes from the normal distribution.

Based on the result of manual calculation with excel software, it can be seen that productivity data of chilli is normal distribution. Therefore, for chili production formula can use Normal function by involving chili productivity mean and standard of chili productivity deviation on Stock Flow Diagram. Similarly, the consumption level of chili kg / capita / yr was tested for normality and the results were normally distributed.

5. Development of Stock Flow Diagram

Based on the result of causal loop diagram which has been designed before, hence can be done development of stock flow diagram of dynamic model of chili supply chain in Indonesia. In stock flow diagrams that have been made to explain the grooves get the value of gap 1 between the level of production and consumption levels that indicate the availability of chili in aggregate every year that fulfillment is done without import. In addition to this model there is a gap 2 that shows the difference between the production income and the cost of planting chili as well as showing the change in price of chili pepper from each component in chili supply chain. The following is a stock flow diagram of Chain Supply Chain in Indonesia :

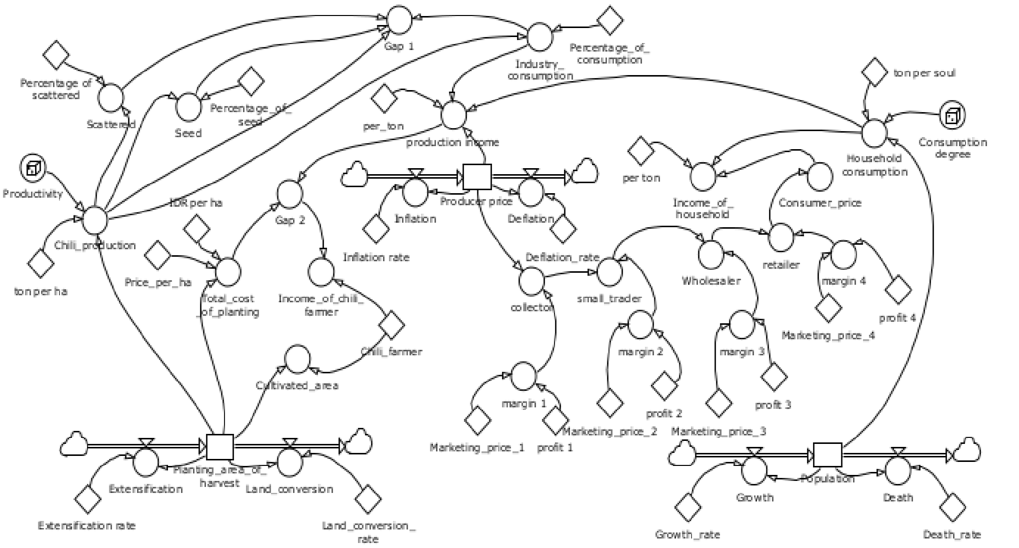

Figure 4. Stock Flow Diagram Chili supply chain in Indonesia

6. Simulation Results

The simulation result of the system shows the value generated from the calculation by using Powersim 10. The dynamic model of chili pepper supply chain in Indonesia will be shown simulation results from three sub chains of supply chain of chili, namely production sub-system (harvested area, pepper production and farmer income), sub Distribution systems (supply chain dynamics) and consumption sub-systems (RT and Industry consumption). The number of periods in exsisting system simulations is 10 years from 2006-2015. The following is the result of calculation of harvested area, chili production, producer price and consumption level of chili :

Table 2. Calculation Result of Dynamic Model Chain Supply Chain Model

Year	Harvested area (ha)	Chili production (ton)	Producer price (IDR)	Consumtion degree (IDR/capita/year)
2006	204,747.00	1,321,016.60	10,906.61	2.98
2007	210,560.70	1,024,557.77	11,874.09	3.22
2008	216,539.48	1,317,066.09	12,927.40	2.74
2009	222,688.03	1,296,559.57	14,074.14	3.13
2010	229,011.16	1,333,067.44	15,322.60	3.22
2011	235,513.83	1,423,697.33	16,681.81	3.35
2012	242,201.14	1,495,542.46	18,161.59	3.14
2013	249,078.34	1,518,698.54	19,772.63	3.08
2014	256,150.81	1,864,936.81	21,526.59	3.00
2015	263,424.10	1,866,774.53		2.93

From the simulation result shows that harvest area, chilli production, producer price and chilli consumption level tend to increase every year. This indicates that chili is one of the commodities that Indonesians are interested in and have good prospects for the future. Here is a graph of the existing simulation results.

Verification and Validation Model

At this stage validation test of the simulation results have been done to determine whether the different models significantly or not with the real system. Validation in dynamic system modeling can be done in several ways including direct structure tests without model processing, structural behavior test model (model oriented behavior test) with model process, and comparison of model behavior with real system or quantitative behavior pattern comparison (Daalen and Thissen, 2001), i.e. by the test of the mean absolute percentage error is one of the relative measures involving percentage errors. This test can be used to determine the suitability of forecasted data data with actual data.

$$MAPE = \frac{1}{n}\sum \frac{[Xm - Xd]}{Xd} \times 100\%$$

Description
Xm = Data of simulation result
Xd = Data actual
N = Period / number of data

Criteria for model accuracy with MAPE test (Lomauro and Bakshi, 1985 in Soemantri, 2005) is:
MAPE < 5% : Very Precise
5% < MAPE < 10% : Precise
MAPE > 10% : Not Precise

Here is a table of validation calculation of harvested area, chili production, producer price and chili consumption level on actual / actual system with simulation result :

Table 3. Validation of Exsisting and Actual Results of Planting of Chili

Year	Simulation (Xm)	Actual (Xd)	[Xm-Xd]	[Xm-Xd]/Xd	Percentage (%)
2006	204,747.00	204,747.00	0.00	0.00	0.00
2007	210,560.70	204,048.00	6,512.70	0.03	3.19
2008	216,539.48	211,566.00	4,973.48	0.02	2.35
2009	222,688.03	233,904.00	11,215.97	0.05	4.80
2010	229,011.16	237,105.00	8,093.84	0.03	3.41
2011	235,513.83	239,770.00	4,256.17	0.02	1.78
2012	242,201.14	242,366.00	164.86	0.00	0.07
2013	249,078.34	249,232.00	153.66	0.00	0.06
2014	256,150.81	263,616.00	7,465.19	0.03	2.83
2015	263,424.10	255,716.00	7,708.10	0.03	3.01
				Σ	**21.50**
				MAPE	**2.15**

Example Calculation:

[Xm-Xd] = [263424 − 255716]= 7708.10

$$\frac{[Xm-Xd]}{Xd} = \frac{7708.10}{255716} = 0.03$$

Percent % = 0.03 x 100%
= 3 %

$$MAPE = \frac{1}{n}\sum \frac{[Xm - Xd]}{Xd} \times 100\%$$

$$= \frac{1}{10} \times 21.50 \times 100\% = 2.15\ \%$$

From result of calculation of validation test known that MAPE for planting area is 2.15%. Based on the criteria of model accuracy with MAPE test, it is found that MAPE planting area of chili <5% means that the model is very precise or very describes the real condition (valid). Other validation results can be seen in table 4:

Table 4. Existing and Actual Simulation validation results

No.	Validation item	MAPE (%)	Conclusion
1	Produksi cabai	7.00	Model tepat (valid)
2	Produsen cabai	5.83	Model tepat (valid)
3	Konsumsi cabai	6.17	Model tepat (valid)

Behavior of Chilli Supply Chain System for the Next 10 Years

Modeling the dynamics of chili availability system, model design, simulation and analysis is done by referring to the objectives and scenarios in each model. Some policy scenarios to be used in behavioral analysis. The chili supply chain system for the next 10 years is as follows :

Scenarios without Policy Change

This scenario is assumed as a simulation result without any policy changes such as government intervention to see system behavior over the next 10 years and determine the point of improvement whether in the production sub-sub-system, consumption sub-system or distribution sub-system (supplier).

1. Sub System Production

The production sub-system is related to matters affecting the production of chili, ie planting or harvest area, production, cultivated area and household income of chili farmers. Below is a projection result on chilli production sub system for 10 years ahead.

From the simulation result, the value of chili harvest area and cultivated area increase every year, while chilli production fluctuated or fluctuated during the next 10 years. The highest production occurred in 2024, which was 2,356,992 tons and the lowest was 2014 at 1,451,654 tons. Fluctuations in chili production is due to changes in the productivity of chili due to climate and crop failure due to pests or other natural factors. In terms of income RT chili farmers value increases every year where in 2025 income of RT chili farmers with an area of 0.1 ha of land is IDR 47,007,430 per year. This indicates that there will be an increase in the welfare of chili farmers and show the prospect of better chili farming business.

Table 5. Results of Projection Simulation on Chilli Production Sub-System Year 2016 - 2025

Year	Harvested area (Ha)	Production (Ton)	Wide arable (Ha per HH farmers)	Revenue HH farmers (IDR/Year)
2016	270,904	1,451,654	0.17	19,640,038
2017	278,596	2,202,969	0.17	25,899,711
2018	286,507	1,682,557	0.17	25,881,278
2019	294,642	1,935,561	0.18	27,130,671
2020	303,008	2,107,352	0.18	33,176,116
2021	311,612	2,256,178	0.19	37,067,854
2022	320,460	1,898,228	0.20	35,908,167
2023	329,559	2,257,579	0.20	44,635,923
2024	338,917	2,356,992	0.21	47,350,626
2025	348,540	2,002,323	0.21	47,007,430

(Note: HH= house hold)

2. Sub System Consumtion

The consumption sub-system is related to the things that affect the consumption of chilli, ie consumption of RT, industrial consumption, scattered and seeds. Here is a of projection result on chili consumption sub system for 10 years ahead.

Table 6. Results of Projection Simulation on Chilli Consumption Sub-System Year 2016 - 2025

Year	Utilization(Ton)			
	HH Consumption	Industry consumption	scattered	Bibit
2016	828,371	435,496	76,647	10,452
2017	869,852	660,891	116,317	15,861
2018	900,266	504,767	88,839	12,114
2019	772,176	580,668	102,198	13,936
2020	887,218	632,206	111,268	15,173
2021	882,449	676,853	119,126	16,244
2022	817,998	569,468	100,226	13,667
2023	906,825	677,274	119,200	16,255
2024	836,414	707,097	124,449	16,970
2025	806,787	600,697	105,723	14,417

Note: HH =household

From the simulation results obtained the value of the use of chili for the consumption of RT, scattered and the seeds of the value tends to be stable for the next 10 years for the highest RT consumption occurred in 2023 of 906.825 tons and the lowest in 2019 of 772.176 tons, while for industrial consumption fluctuated with the trend increases every year.

3. Comparison of Chili Production and Consumption

Based on the simulation results show that the production rate of chilli is greater than the total use of chili in Indonesia. The following is the result of projected comparison of production and use of chili for the next 10 years.

Table 7. Results of Production and Chili Use Projection Simulation Year 2016 - 2025

Year	Production (Ton)	Utilization(Ton)				
		Consumption HH	Industry Consumption	Scattered	Seed	Total
2016	1,451,654	828,371	435,496	76,647	10,452	1,350,966
2017	2,202,969	869,852	660,891	116,317	15,861	1,662,921
2018	1,682,557	900,266	504,767	88,839	12,114	1,505,987
2019	1,935,561	772,176	580,668	102,198	13,936	1,468,978
2020	2,107,352	887,218	632,206	111,268	15,173	1,645,865
2021	2,256,178	882,449	676,853	119,126	16,244	1,694,673
2022	1,898,228	817,998	569,468	100,226	13,667	1,501,360
2023	2,257,579	906,825	677,274	119,200	16,255	1,719,554
2024	2,356,992	836,414	707,097	124,449	16,970	1,684,931
2025	2,002,323	806,787	600,697	105,723	14,417	1,527,623

The simulation results of the production and use of chili using powersim software show the value that varies from year to year. Overall the production of chilli is always above the total use of chili so it can be said that during the next 10 years there will be no shortage of pepper stock and food security for chili commodity is reached and if managed properly then the government does not need to import chili. Therefore, the government must maintain stability in the sub-system of production and consumption sub-system.

4. Sub System Distribution (Supply)

The distribution sub-system deals with matters affecting the distribution of chilies from producers to consumers. In the sub-distribution system the components involved consist of producers / chili farmers, collectors / wholesalers, small traders, wholesalers, and retailers. The focus of this sub-system on supply chain is the price margin from upstream to downstream of chili pepper supply chain.

From the simulation result, the price of chilli turns up from year to year both side of producer and consumer. However, the price margin between producer price and consumer price is also higher. If left then it will cause harm both side of the manufacturer and the consumer side. Here is a table and graph of simulation results in chilli distribution sub-system for the next 10 years.

To see the price differences in each component of the chili supply chain the following table 9 and price comparison charts on the chili supply chain components are presented.

Table 8. Projected Simulation Results Average Chili Price Year 2016 - 2025

Year	Harga Cabai (IDR/Kg)		Price margin (IDR/Kg)
	Produsen (farmer)	Consumer	
2016	25,515	71,321	45,805
2017	27,778	77,647	49,869
2018	30,243	84,535	54,292
2019	32,925	92,034	59,108
2020	35,846	100,198	64,352
2021	39,026	109,086	70,060
2022	42,487	118,762	76,275
2023	46,256	129,297	83,041
2024	50,360	140,767	90,407
2025	54,827	153,254	98,427

Table 9. Price Comparison Simulation Results on Chili Supply Chain Components in Indonesia 2016-2025

Year	Chili Price (IDR/Kg)				
	Producers (farmers)	Collectors	Small traders	wholesalers	retailers
2016	25,515	38,426	53,796	64,555	71,321
2017	27,778	41,834	58,568	70,282	77,647
2018	30,243	45,545	63,763	76,516	84,535
2019	32,925	49,585	69,420	83,303	92,034
2020	35,846	53,984	75,577	90,693	100,198
2021	39,026	58,773	82,282	98,738	109,086
2022	42,487	63,986	89,581	107,497	118,762
2023	46,256	69,662	97,527	117,032	129,297
2024	50,360	75,841	106,178	127,414	140,767
2025	54,827	82,569	115,597	138,716	153,254

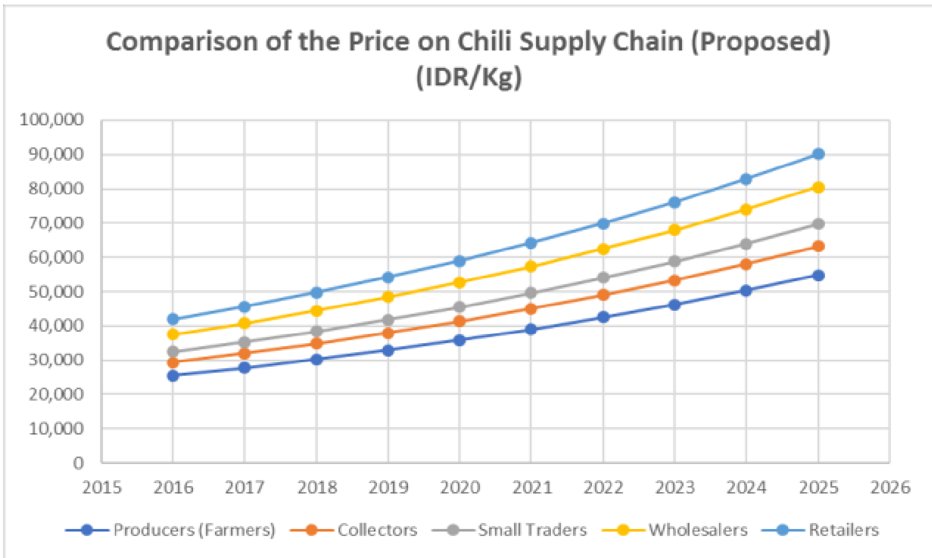

Figure 5. Projection Graph of Price Comparison on Chili Supply Chain

From the simulation results, it can be seen that the problem of chilli supply in Indonesia is found in supply chain sub-sector, that is price margin between producer and consumer price every year will increase or widen as shown in figure 8. Therefore, improvement scenario made to reduce margin price in every component of chili supply chain.

Marketing Margin Decrease Scenario on Supply Chain Components

The decreasing scenario of marketing margin in chili supply chain is done as an effort to minimize marketing margin between components in chili supply chain. Margin marketing is the difference between the purchase price and the selling price, the value of this margin is composed of components of marketing costs and profit per kg. Marketing costs are composed of transportation costs, packaging costs and storage costs.

In the calculation of the marketing margin value, it is assumed that for the collecting volume category, the purchase of chili from farmers is 3000 Kg / Month, small traders 60,000 Kg / Month, wholesalers 600,000 Kg / Month and retailers 150 Kg / Month. And the county is to meet the local needs of large traders with a percentage of 65% for the market within the province and 35% for markets outside the province. The following is the basis for determining the decrease of price margin on chili pepper supply chain. Table 10 contains the value change of the percentage of profit and marketing costs of existing and proposed.

Table 10. Percentage of Marketing Price and Profit for Existing and Proposed

	Existing		Proposed	
	% Marketing price	**% Profit**	**% Marketing price**	**% Profit**
Collectors	13.76	36.84	5.58	10.0%
Small Traders	18.24	21.76	5.23	5.0%
Wholesaler	14.86	5.14	13.17	2.5%
Retailers	1.6	8.88	1.90	10.0%

Simulation results of the decreasing of marketing margin on chili supply chain component can be seen in Table 11 and Figure 7 for the next 10 years.

Table 11. Results of Price Comparison Simulation on Chili Supply Chain Components Proposed in Indonesia Year 2016 - 2025

Year	Chili Price (IDR/Kg)				
	Producers (Farmers)	Collectors	Small Traders	Wholesalers	Retailers
2016	25,515	29,414	32,423	37,503	41,966
2017	27,778	32,023	35,299	40,830	45,689
2018	30,243	34,864	38,430	44,452	49,742
2019	32,925	37,956	41,839	48,395	54,154
2020	35,846	41,323	45,550	52,688	58,958
2021	39,026	44,989	49,591	57,362	64,188
2022	42,487	48,980	53,990	62,450	69,882
2023	46,256	53,324	58,779	67,990	76,081
2024	50,360	58,054	63,993	74,021	82,830
2025	54,827	63,204	69,670	80,587	90,177

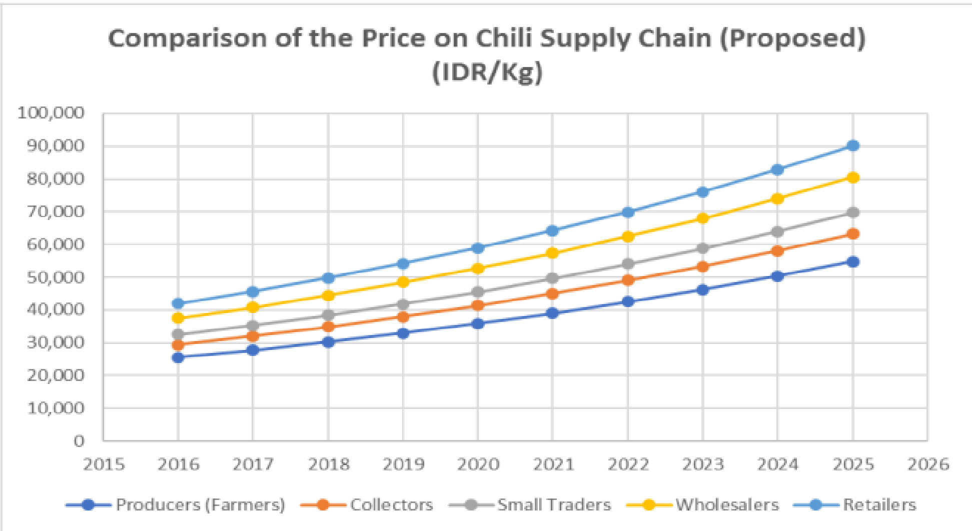

Figure 6. Projected Graph of the Price of Chain of Supply Chain of Supply Chain

From the simulation results obtained margin marketing is smaller and evenly distributed along the chili supply chain components. The price margin between producer and consumer is still relatively high, this is because supply chain is not efficient yet and further study on marketing cost calculation on each component involved in chili supply chain system must be done.

CONCLUSION

The dynamic system model of chili supply chain is appropriate and acceptable so that the result of this research can be summarized as follows. **First**, the national chili system consists of several subsystems, including distribution or supply, production, and consumption. Each subsystem consists of elements or elements that are more specific and influenced by the development of time so that the national neglect system is dynamic. The national neglect system is cross-sectoral because it encompasses various related institutions, such as chili consumption subsystem related to population problem, whereas production subsystem is related to land area and agriculture cultivation. **Second**, the result of chili production subsystem is influenced by variables such as planting area, conversion of land, conversion, extensification, productivity and income of chili farmers. The distribution subsystem, the supply of chili depends on the price margin on the chili supply chain components composed of components of marketing and profit costs. Chili consumption is influenced by the behavior of people in consuming chillies on the consumption subsystem. Submodel consumption needs can be seen dynamics of the development of the population that is very influential on the demand for chili for consumption. **Third**, the result of scenario without policy change then chili food security will be sustainable with the value of production above the level of use of chili so that for the next 10 years food security for chili is still safe. However, the value of the price margin is higher so the improvement scenario is done to minimize the marketing margin value.

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