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Analysis of Soybean Production And Demand to Develop Strategic Policy of Food Self Sufficiency: A System Dynamics Framework

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Abstract

Soybean production and demand gap in Indonesia for decades has triggered dependence on imported soy products. Demand consumption of soy protein-based foods higher with increasing population annually. Various efforts have been made by the government but is still not are able to show maximum results overall. The aim of this study is to find an alternative solution using system dynamics approach. Real conditions captured into a model and then performed a series of scenarios the decision to obtain best results using computer assistance.The results of scenarios showed that soybean production could be produced to meet the needs of soybean demand in Indonesia for 20 years by increasing expansion of land of at least 70% per year, the use of seeds with a minimum production level 2.4 tons / hectare or utilization of the short-lived seeds which able to increase the cropping index at least 2.0, use of biological fertilizers which can increase seed productivity at least 125%.

Keywords : Soybean Production; Demand Gap; System Dynamics

1. Introduction

Availability of food is essential for the stability of a country. The ability to be self-sufficient can save foreign exchange that can be utilized for other strategic purposes. In fact, to date in Indonesia import needs especially in the sectors of food needs are always increasing because the demand exceeds the supply of available food.

This condition occurs because there are gaps in the production and consumption of soy every year. Gaps occur due to the rate of domestic soybean production is unable to meet the pace of soybean demand. Increased demand for soybeans occur due to increasing population, rising incomes,

healthy lifestyle changes and progress in the field of agro-industry and farming sectors. Conditions such as these that ultimately trigger a shortcut to import soybeans to meet the needs of the public soy consumption. in addition, an increase in the volume of imports was also caused by increased demand for import soybean because it has cheaper prices than local soybean[4].

In resolving these issues is certainly required number of steps to obtain the expected solution. However, every action would require a long time and cost as well as the risk of unexpected. For that we need a simulation action before a real action is applied in the real world and in this research, the simulation process will use system dinamics approach because it can provide a more reliable estimate than the statistical models for determining the significant and sensitive forecasting factors [5].

The main purpose of this research is to examine how to analysis and find an alternative solution quickly and as expected for supplying the requirements for the next 20 years. This research also tried to improve previous research by including some additional condition such as soybean import, sales, etc. Outcomes from scenario of model can be used as support material for government decisions and the stakeholders in the development of strategies for implementation of national soybean availability. Thus, stakeholder can utilize the results of these simulations to make strategic decisions.

2. Basic Teory

2.1 About Indonesia Soybean.

Soybean (Glycine max L) is a highly nutritious food commodities as a source of vegetable protein and low cholesterol at an affordable price. Soybeans also an important food commodity after rice and maize. Soy consumption in the form of fresh or in processed form can improve nutrition. Soybean plants can grow well in areas with rainfall around 100-400 mm / month with temperatures between 21-34 degrees C and at a height of not more than 500 m above sea. In Indonesia, many processed soybeans for various foodstuffs, such as tempeh, soy milk, tofu, bean curd, soy sauce, oncom, tauco, soybean cake, ice cream, edible oil, and soy flour. In addition, it is also widely used as an animal feed ingredient[6]. Indonesian soybean easier to grow in wetlands than any other land. Soybean species that grow in Indonesia is yellow soybean and black soybean.

2.2 System Dynamics

System Dynamics is a unique method that can be used to help managers and decision makers in order to find the policies and decisions that benefit and could be implemented well in a certain period of time. System dinamics itself is a methodology for studying and managing complex feedback systems. System dinamics can be used as an analytical tool to evaluate the impact of short-term and long-term policy. The final goal of the simulation model creation is validation of models and scenarios decisions. The purpose of the validation is that the model created can certainly approach the original and credible system. The credibility of the model can be expressed from results of the verification and validation of the model. Credible models can be simulated using computer-assisted predictions to see results quickly.

3. Previous Research

Research related to self-sufficiency in soybean in Indonesia ever conducted by previous researchers using a variety of methods including system dynamics approach. Strategy to achieve soybean self-sufficiency in 2015 through implementation of synergic policies[2] found by extended area

program, increase productivity, decrease population, soybean consumption and postharvest losses. Another research[1] concluded that self-sufficiency can be achieved in 2014 by increase the planting area with use of suboptimal land and increasing productivity by improving seeds, fertilizer, farmer education and harvest losses.

4. Research Steps

This research consists of four stages: data collection, analysis of existing condition, design of computer model and perform the process simulation with scenarios.

4.1 Research Information and Data

This study uses secondary data from BPS and the Ministry of Agriculture also related research that has already conducted in areas of Java, Bali, Sumatra, Nusa Tenggara and Sulawesi.

4.2 Analysis of Existing Condition

In an attempt toward self-sufficiency in soybeans, the Indonesian government has conducted various agricultural programs to increase production value since the sixties ago until now. But until now, the fulfillment of soybeans is still not achieved. National soybean production is currently only able to meet 35% of the market, while the rest is filled with soybean imports. Some causes of this condition is the rising of soybean demand due to high population growth, lack of land and production quality problems. Population growth led to the consumption of soy-based foods to be increased and agricultural land decreased because changed into residential land. Of the amount of agricultural land available, the average land for soybean cultivation is only available about 23%, still less with the amount of rice and corn fields. Until now, farmers tend to use wetland than any other land because it does not need additional processed and more efficient. On the other hand, with increasing economic growth in Indonesia, the awareness of a healthy lifestyle is growing. Soybeans as a source of vegetable protein began to be used as the raw material of healthy processed foods, thus causing demand for soybeans growing over time. Soy demand for food raw materials was higher than for other purposes such as animal feed or other. Based on the data SUSENAS 2013, Soy-based foods is dominated by Tempe, Tofu, Soy Sauce, Oncom , Tauco and Soy Fresh.

On the production side, the amount of the national harvest still inadequate and the quality of local soybean yet fully able to compete with imported soybean. Land productivity of soybean currently at 1.4 tonnes / ha. This is caused by the use of uneven quality seeds, fertilizers and the high level of of pest attack. Soybean planting also was done during the times of the year and still a priority number three after rice and maize. Loss of grain during the harvest process traditionally also caused reducing the amount of harvest. Another factor is instability of the price that makes the farmers switch to plant other than soybean. Many factors influencing instability of the price which one of them is competition in price and quality with imported soybeans. Domestic Soybean tend to be expensive caused trick a middleman buy soybeans at low price or existence of high cost transport when farmers try to sell soybeans to wholesalers. Lower selling prices will encourage farmers to use their land for cultivation of other food.

In a systems approach, those condition can be described in the following Causal Loop Diagram below (Fig. 1).
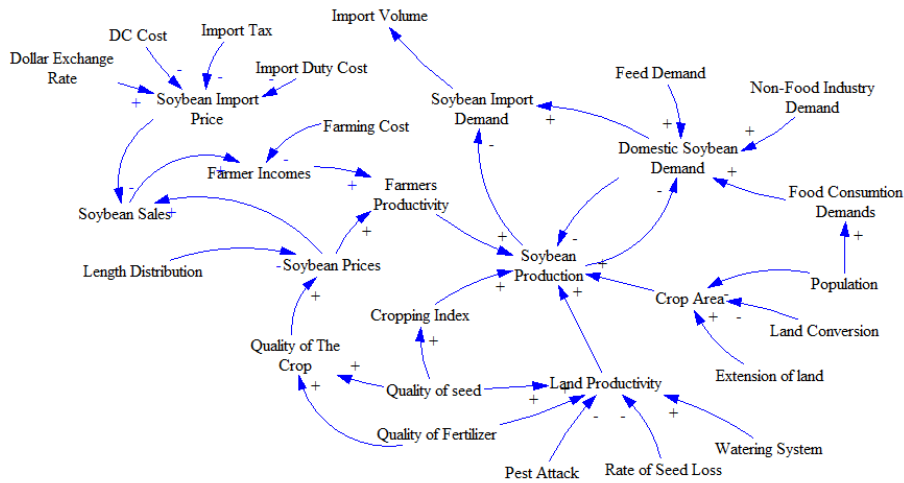
Fig. 1. Causal Loop Diagram for Soybean Production and Demand

4.4 System Dynamics Model

Based on the causal loop diagram, can be composed of system dynamics models the availability of soybeans into stock flow diagrams and formulation of the function and its parameters. Holistic flow diagram of the model that constructed using Vensim is described as follows (Fig. 2):
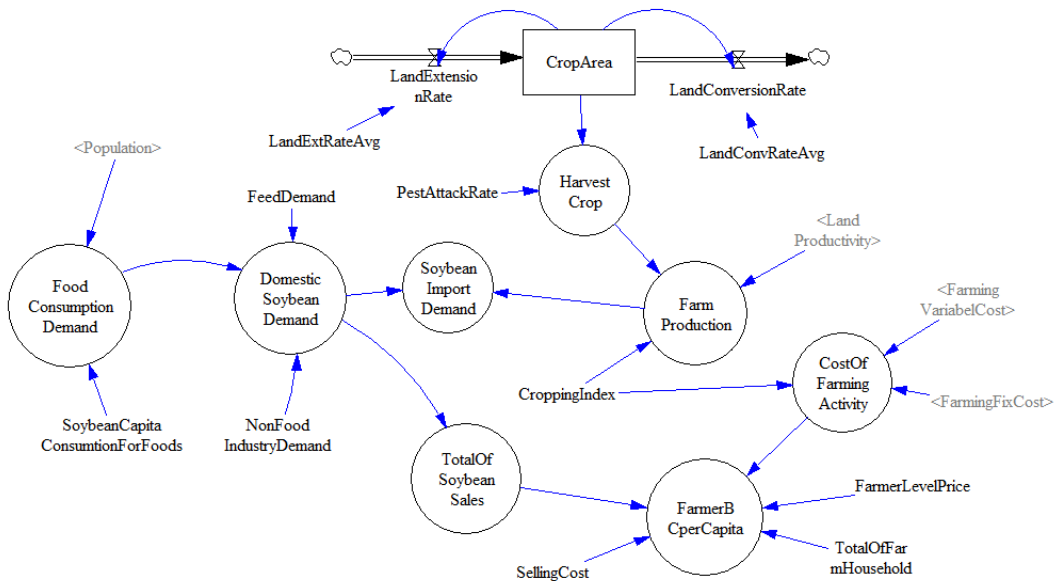

Fig. 2. Stock flow diagram model for soybean self-sufficiency.

The model is composed of four sub-models: demand submodel, production submodel, farming cost submodel and import soybean cost submodel. Overall, the linkages of model variables shown in Table 1.

Table 1. Variable of Simulation Model

Variabel Name	Function of Time	Variabel Name	Function of Time
Crop Area BM (CA)	Land Extension Rate BM-Land Conversion Rate BM	Cost of Farming Activity BM (CFA)	Farming FixCost BM+(Farming VariabelCost BM*Cropping Index BM)
Land Extension Rate BM (LER)	Crop Area BM*Land Ext Rate Avg BM	Farming FixCost BM (FFC)	Cost of Rent Land BM
Land Conversion Rate BM (LCR)	Crop Area BM*Land Conv Rate Avg BM	Cost of Rent Land BM (CRL)	(Percentage of RentLand BM*Crop Area BM)*RentLand Chargers BM
Harvest Crop BM (HC)	Crop Area BM-(Pest Attack rate BM*Crop Area BM)	Farming Variabel Cost BM (FVC)	Seed Cost BM+Pest Control Cost BM+Fertilizer Cost BM+Farm Labor Cost BM
Farm Production BM (FP)	Harvest Crop BM*Land Productivity BM*Cropping Index BM	Farm Labor Cost BM (FLC)	Crop Area BM*HOK Labor Fee BM*HOK Labor Each Hectar BM
Amount of WetLand BM (AW)	Percentage of WL BM*Crop Area BM	Fertilizer Cost BM (FC)	Cost of K Fertilizer BM+Cost of N Fertilizer BM+Cost of P Fertilizer BM
Amout of DryLand BM (AD)	Percentage of DL BM*Crop Area BM	Pest Control Cost BM (PCC)	Pesticide Cost BM+Herbicide Cost BM
Amount of TidalLand BM (AT)	Percentage of TL BM*Crop Area BM	Seed Cost BM (SC)	Crop Area BM*Price of Seed BM*Seed Need each Hectar BM
Land Productivity BM (LP)	land productivity increase BM-land productivity decrease BM	Pesticide Cost BM (PC)	Crop Area BM*Cost of Pesticide each Hectare BM
land productivity increase BM (LPI)	Seed Productivity BM+Impact of Fertilizer BM	Herbicide Cost BM (HC)	Amout of DryLand BM*DL Herbicide Need each Hectare BM*Price of Herbicide BM
land productivity decrease BM (LPD)	(impact of lost seed BM)+Impact of Temperature BM+Impact of Watering BM	Cost of N Fertilizer BM (CNF)	((Amount of WetLand BM*WL Urea need each Hectare BM)+(Amout of DryLand BM*DL Urea Need each Hectare BM)+(Amount of TidalLand BM*TL Urea Need each Hectare BM))*Price of Urea BM
Impact of Fertilizer BM (IF)	Seed Productivity BM*Fertilizer Productivity BM	Cost of P Fertilizer BM (CPF)	((Amount of WetLand BM*WL SP3 need each Hectare BM)+(Amout of DryLand BM*DL SP3 need each Hectare BM)+(Amount of TidalLand BM*TL SP3 need aech Hectare BM))*Price of SP3 BM
impact of lost seed BM (ILS)	Lost Seed rate BM*Seed Productivity BM	Cost of K Fertilizer BM (CKF)	((Amount of WetLand BM*WL KCL need each Hectare BM)+(Amout of DryLand BM*DL KCL need each Hectare BM)+(Amount of TidalLand BM*TL KCL need each Hectare BM))*Price of KCL BM
Impact of Watering BM (IW)	IF THEN ELSE(Level of Rainfall BM<100 , (Seed Productivity BM*RANDOM NORMAL(0.18, 0.6 , 0.4 , 0.2 , 0)) , IF THEN ELSE(Level of Rainfall BM>400, (Seed Productivity BM*RANDOM NORMAL(0.18, 0.6 , 0.4 , 0.2 , 0)) , 0))	Soybean Import Demand BM (SID)	ABS(Lack Demand BM)
Impact of Temperature BM (IT)	IF THEN ELSE(Temperature BM<21 , 0.04 , IF THEN ELSE(Temperature BM>34, 0.04 , 0))	Distribution Cost BM (DC)	DC each Ton BM*Dollar Exchange Rate*Soybean Import Demand BM
Lack Demand BM (LD)	Farm Production BM-Domestic Soybean Demand BM	Import Cost BM (IC)	(Import Duty BM+Income Tax BM+Distribution Cost BM)
Domestic Soybean Demand BM (DSD)	(NonFood Industry Demand BM+Food Consumption Demand BM+Feed Demand BM)	Income Tax BM (ITX)	Import Value Rp BM*Income Tax Rate BM
Food Consumption Demand BM (FCD)	Population BM*Soybean Capita Consumtion for Foods BM	Import Duty BM (ID)	Import Duty Rate BM*Import Value Rp BM
Population BM (P)	Growth Rate BM	Import Value Rp BM (IV)	((World Soybean Bushel Price BM*Dollar Exchange Rate)/27)*Soybean Import Demand BM
Growth Rate BM (GR)	Population BM*(Population Growth avg BM/100)	Import Soybean Net Price BM (ISNP)	(Import Value Rp BM-Import Cost BM)/Soybean Import Demand BM
Total of soybean Sales BM (TSS)	Percentage of Total Sales BM*Domestic Soybean Demand BM	Soybean Price at Importir Level BM (SPIL)	Import Soybean Net Price BM+Importir Profit Margin Avg Rp BM
Farmer B/C per capita BM (FPC)	((Total of soybean Sales BM*Farmer Level Price BM)-Cost of Farming Activity BM-Selling Cost BM)/Total of Farm Household	Import Soybean Market Price BM (ISMP)	Soybean Price at Importir Level BM+Import Soybean Margin Distribution BM

	BM		
Selling Cost BM (SLC)	Transportation Cost BM	Import Soybean Margin Distribution BM (ISMD)	Length of Import Suply Chain Distribution BM*Import Margin Distribution Avg BM
Domestic Soybean Market Price BM (DSMP)	Farmer Level Price BM+(Length of Distribution Level BM*Distribution Sale Margin Avg BM)		

4.5 Model Simulations

Model simulations carried out to obtain the results and the behavior of the system during the period of the simulation. Simulations done by entering the input parameter value and changes the structure of the model if necessary. The simulation period used for the model was from year 2015 to 2035. To get the soybean self-sufficiency goals in the next 20 years then conducted the following scenario: (1) Scenario of productivity improvement in the existing conditions of land.; (2) Scenario of combination of productivity improvement with the expansion of planting area.; (3) Scenario of stabilization soybean prices to increasing farmer productivity through the implementation of policies related to import soybeans.

4.5.1 Result of Model Simulation

The simulation process is done using software Vensim. The data used came from the Central Bureau of Statistics, Ministry of Agriculture and other relevant government agencies.

4.5.2.1   Scenario of productivity improvement in the existing conditions of land.
As well as other food crops, soybean productivity is influenced by factors of seed. For maximum growth, the seed is affected by the fertility of the soil and sufficient water. Whereas the final results are affected by the level of damage caused by pests and loss of seed at harvest. Assumption of this scenario is no land conversion, farmers use wetland and rate of pest attack at 5-8%. Planting area used is 640.85 thousand hectares. From various combinations of scenarios obtained the best results in the use of the type of seeds with an average productivity of at least 2.5 tonnes / ha (example: gamasugen) and biological fertilizer with an average productivity increase of at least 125% (example:Bio P2000Z) that shown in Fig 3.
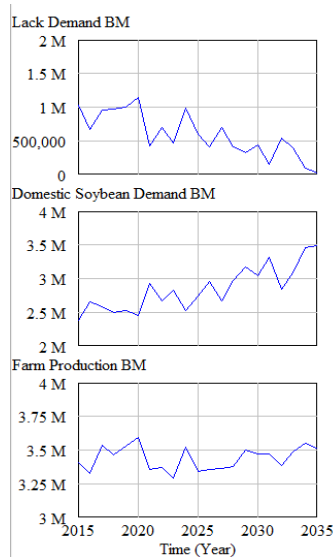

Fig. 3. Prediction of the ability of self-sufficiency with superseed and biofertilizer

Another alternative is the use of seeds that have a short growing season so that it can perform soybean planting at least twice a year (Fig 4).
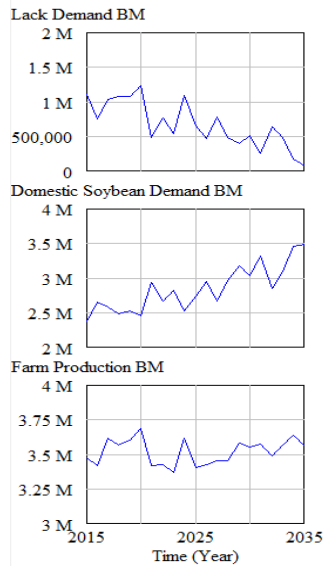

Fig. 4. Prediction of the ability of self-sufficiency by productivity improvement.

4.5.2.2   Scenario of combination of productivity improvement with the expansion of planting area. This scenario conducted by trying to involve the expansion of planting area in order to increase production. With the use of quality seeds as the previous scenario, the best results obtained to use the expansion of planting area of at least 70% every year. As shown in Figure 5, the first year of self-sufficiency simulating the conditions are still not met, but in subsequent years the condition will increase according to the amount of available land.
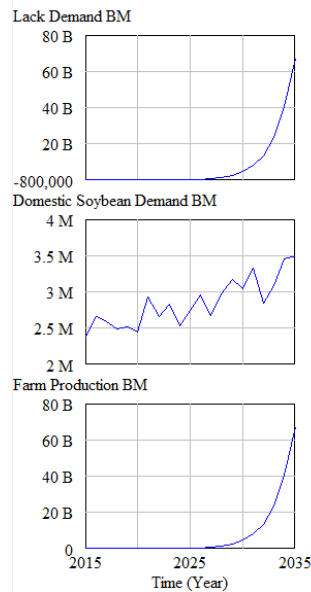

Fig. 5. Prediction of the ability of self-sufficiency with land expansion

4.5.2.3 Scenario of stabilization soybean prices to increasing farmer productivity through the implementation of policies related to import soybeans.

Besides the availability of land, availability of farmers who want to cultivate soybeans is important. farmers was not willing to plant soybeans if they can not profit from the farm. farmers will suffer losses if the community prefers soybean imports because it has a cheaper price. The establishment of the purchase price the government does not help if the price of soybean imports are still cheaper than the price of local soybean. To overcome these problems it is necessary to keep the price of imported soybeans remain under control. Base on simulation, the percentage of the cost of imports to be charged at least relative to the fixed price of government (HPP) with reference to Eq. (1).

$$C = 1 - (Gc * T) / V \qquad (1)$$

Where :

C = percentage of the cost of imports
Gc = HPP of Soybean
T = Import Volume
V = Import Value in Rupee

5. Conclusions

Based on simulation results, to improve national soybean production to meet the needs for the next 20 years, the government needs to take action as follows:

1. Increase the planting area at least 70% every year to obtain sufficient land to increase the amount of production.
2. Doing provision of quality seeds production with high productivity level of at least 2.4 tons / hectare, biological fertilizer that can increase seed productivity at least 125%.
3. Controlling the price of imported soybeans by providing high import costs corresponding to (Eq 1) in order to keep price stability so that the soybean farmers remain productive.

References

1. Surachman, Arif.et al. Soybean Self sufficiency Achievement in 2014 With System Dynamics Approach. Agency for Agricultural Research and Development. Ministry of Agriculture of Indonesia 2012.
2. Tastra, I., Ginting, E., & Fatah, G. S. Towards Soybean Self-Sufficiency Through Application Synergistic Policies. IPTEK Tanaman Pangan 2012; 7:1.
3. Pusdatin. Bulletin of Food Consumption. 2014; 4:3.
4. Atman. Strategy to Increase Soybean Production in Indonesia. Tambua Scientific Journals 2009, 8:39-45.
5. Lyneis, James M. System dynamics for market forecasting and structural analysis, (2000).
6. Fatah, Abdul.,Satna, Andi. Soybean Cultivation Technology on Wetland. Institute for Agricultural Technology (BPTP) South Sulawesi; 2012.
7. Adillah, Rizma. Analysis Of National Soybean Production And Consumtion. Bogor Agricultural University Graduate School 2014.
8. Barlas, Y. Model Validation in System Dynamics. International System Dynamic Conference; 2004.