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Case Study

A Decision Support System to Achieve Self-Sufficiency of Soybean: A Case from Central Java Province, Indonesia

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A B S T R A C T

Soybean self-sufficiency in Central Java Province is a problem that is difficult to realize at this time. As an important commodity, self-sufficiency becomes a serious concern for the government. Supply chain management of soybean is related to the integration of supply, demand, and distribution of soybean. The characteristics of entities involved in the soybean supply chain are complex, dynamic, and probabilistic that make the problem cannot be solved using an analytical model and it becomes too risky for trial and error. A suitable tool is using a simulation model. This paper deals with developing a Decision Support System (DSS) using a simulation model that will assist the government in adopting policies in order to achieve self-sufficiency of soybean and the improvement of farmer's welfare. DSS will help decision-makers to try various scenarios of policy in an easy way. The method was started with developing model components, then decision components and next creating user interfaces. The simulation and system modeling is created by using Powersim software with the intent to obtain the simulation and single document interface (SDI) of the supply chain model. The result shows that land expansion policy is a top priority for realizing food self-sufficiency while increasing productivity and reducing costs of agricultural activities are the main priorities for improving the welfare of farmers.

INTRODUCTION

Food security is one of the decisive factors in the national stability of a country. In Indonesia, one of food security issues is regarded to soybean. Soybean is an important commodity because it is a functional food and raw material of some favourite menu and nutritional products for Indonesians. When this commodity is scarce and its price is too high, it becomes serious problem in the economy. The domestic production of soybean tends to decrease and much lower than its consumption rate. Based on forecasting, the lack of domestic production of soybean to its consumption is about 1.54 million tons in 2020 [1]. The lacks are covered by importing soybean that increases in average of 0.93 ton per year [2].

That condition will threaten the national food security. Food security has four main elements, i.e., availability, stability, utilization, and access [3]. When lack of the supply cannot be covered with import for some reasons, there will be scarcity of the commodity and it will impact vastly in national sectors due to the important of the commodity.

So, it is necessary to find a way to achieve self-sufficiency. Self-sufficiency is typically measured as the ratio between total food consumed compared with domestic production [4]. Food self-sufficiency and growth of welfare of farmers are targets that must be realised to create food security. Government as stakeholder have the responsibility to achieve the plan. Entities involved in supply, demand, and distribution of soybeans are complex, dynamic, and probabilistic [5]-[8]. This condition requires a scientific management approach to solve the problem.

The local soybean production has not been able to meet the demand because the production rate is less than the population growth rate [5][6]. In the production side, land productivity is not optimal, and land use is not maximized. Farmers are preferred to plant others rather than soybean, because soybean considered as an agricultural commodity that does not provide many benefits for farmers, compared to rice, for example. Instability of the soybean's price also become one of the factors that make the farmers switch to plant another commodity, and still a priority number three after rice and corn [5].

Soybean production, as the determinant of supply, is influenced by crop area and land productivity. Land productivity is influenced by irrigation, temperature, seed productivity, fertiliser productivity, and impact of yield losses [5]. The government

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policy regarding land expansion and soybean farmer's welfare are two factors that influence the land area for soybean. Moreover, soybean demand is by the amount of population growth and soybean consumption. The amount of production, price, and cost of the agricultural activity are factors that affect the farmer's welfare. This real phenomenon is very complex, dynamic, and problematic, causing the complexity of the relationship between variables. Because of the complexity in the supply chain system so that it cannot be expressed in a mathematical function, so that the mathematical model will be very difficult to solve the dynamic and stochastic soybean problem [1][2][4][5]. This difficulty encourages the need for simulation models to solve problems that exist in real systems. The simulation model has the advantage of being able to solve problems that exist in real systems that are stochastic which cannot be represented by a mathematical model and search for answers analytically and heuristically. The simulation model can predict system performance under various operating conditions desired by decision makers. Thus, these difficulties led to the need for simulation models to solve the problems in the real system.

The importance of decision-making processes and response choices in strategic decision-making approach is for obtaining the effective outcomes [9]. The simulation model is one of the tools that could assist the effort to conduct experiments to avoid losses. There are three parts to the simulation core namely the basic model, model with system dynamics (SD) technique, and program for normative analysis. SD technique involves the business process, program the scenario, formulation and study of simulation results and selection of solutions [10].

The issue of agriculture supply chain requires policy solutions in various aspects; and problems that cannot be translated into mathematical models as well all the systems that require quantitative solutions and more specific instructive work [11]. The problem that exists in the agricultural supply chain with a scientific approach and implementation can provide intelligent and personalised decision support for its SCM [12]. Decision Support System in the supply chain of agricultural commodities is needed due to the complexity of the relationships between the entities involved [13]. Decision-based model of decision support system will significantly assist government work as a decision maker.

The decision-making process is a cognitive process that results in the selection of a series of actions involving several alternative scenarios [14]. Every decision-making process will produce the final choice based on the best performance indicator results. Management information system (MIS) that supporting a business or organisational decision assessment requires simulations based on DSS [15]. The simulation model is a tool to simulate a system to understand the decision process and/or understand the learning process. The advantage of the simulation as part of the decision support system is that problems in real systems will be easily defined in the causal loop diagram with easy to analyse both quantitative and qualitative in computer programs [15]. Simulation has advantages that include the ability to model complex systems effectively and efficiently to obtain realistic assessments that consider the uncertainties and dynamics inherent in the system [16].

Software assistance is required to perform a simulation of a model. The modelling software can see the behaviour of the model in a fast time. Currently, there are various types of software for simulation. Software designed to make dynamic system model simulations, including Vensim, Stella, Powersim, Goldsim [17][18].

A decision support system is an interactive computer-based system or subsystem and suitable computer-based technology to help improve the effectiveness of decision makers to use the data, technology of communication, document knowledge and/or models so that the decision maker can identify, solve the problem, and make a complete the decision process task [19][20]. The different characteristics of the systems will impact to the DSS categorisation for example for personal or group decision maker. By the application type, DSS can be divided into two kinds namely desktop and web application [18]. DSS components can be specified briefly as follow [21]:

1. Data component. Data used in the data component can be internal or external data. Data component usually consist of DBMS (Database Management System). Data component has three kinds of data. First data are managed by DBMS and the second and third types of data are the internal data and the external data that stored in the data system. DBMS stores the internal data used by the decision and simulation component. The internal data represent all data necessary to describe the internal procedures. The external data are information coming in real time from the system
2. Model component. The model component includes a simulation model, a mathematical model, and a set of optimisation algorithms suitable to analyse the effects of choices on the system performances.
3. Interface component. The interface module is responsible for the communication and interaction of the system. This component is essential because of related the quantity and quality of the available data, and model accuracy depends on this interface.
4. Decision component. The decision component consists of the operational decision class and the tactical decision class. Also, these classes also include a performance index that must reflect to make decisions.

Research in agriculture and ecology has been studied in many previous studies. A discussion about the fundamentals of system dynamics methodology; a causal-loop model and diagram; and model validation has been conducted in [15]. A design of an agricultural products supply chain has been proposed by [11] to assist decision support system which conforms to actual condition and solves of the problems in the supply, demand, production, process and circulation sectors in the current agricultural product supply chain.

Previous research that discussed soybean supply chain to realize soybean self-sufficiency by dynamic system methods has been conducted by [5], [7], [8] and [22]. The relevance between this study and those previous researches are in considering these factors, those are supply, demand, distribution and government policy. Research carried out by Hasan et al. [5] developed a simulation of a dynamic system model for the supply chain of national soybean commodities by involving supply and demand subsystems. In Hasan et al. [5], factors considered are supply, demand, and government policy, without distribution.

A supply chain flow of local soybean commodities has been developed by Kristanti and Guritno [7] to determine the productivity of soybean inventories in each distribution chain and measure price elasticity by involving the distribution subsystem. In [7], factors considered are only demand and distribution.

Research developed by Tastra et al. [8] aims to develop a dynamic system simulation model to realize soybean self-sufficiency. The output produced is the area expansion program, the rate of increase in productivity, reduction in post-harvest yields, controlling the rate of increase in population and controlling the rate of increase in consumption. In Tastra et al. [8], factors considered are supply, demand, distribution and government policy, but only considering 1 aspect of distribution that is price with the total aspects of 10.

In Oktyajati et al. [22], a soybean dynamic model based has been developed with a supply chain perspective of a case study in Central Java Province, Indonesia to support self-sufficiency and to consider supply and demand behavior in the soybean supply chain. In Oktyajati et al. [22], factors considered are supply, demand, distribution and government policy with the total aspects of 13. It shows that research by Oktyajati et al. [22] is the most complex compared to others. Unfortunately, Oktyajati et al. [22] has not consider farmers' welfare that usually become the most vulnerable party in soybean supply chain and has not supported by DSS.

This paper extends Oktyajati et al. [22] study and builds a simulation model that considers the entire entity in the system consisting of supply, consumption, and distribution activities with key performance indicators of achieving self-sufficiency in soybeans and improving farmers' welfare. Thus, it needs an application to help simulate some alternative solutions before deciding the government policy.

This research was using Powersim software. In Powersim software, we need to design a stock flow diagram that connects variables involved in the system. The stock flow diagram describes the structure of the model, while the simulation results in the form of images or graphs illustrates the behaviour of the system. From the results of this study, we can formulate alternative policies that are simulated in a decision support system with the use of the simulation and single document interface (SDI).

METHOD

This research is an advancement model of [22] at the stage of developing policy scenarios and designing a Single Document Interface. The method of developing policy scenarios in the previous research considers two aspects of policy, namely land expansion and productivity improvement policies, with an objective function, namely soybean self-sufficiency. In this study a more in-depth study of the decision variable is in the form of government policy variables that have a response to the response variable so as to achieve the objective function. The objective function expected in this research is soy self-sufficiency and farmer welfare. The next step is formulating the response variable with the interview process and literature study. Based on interviews and literature studies, identification and grouping of types of variables inherent in the system are then made planning of policy scenarios to be taken.

The method approach refers to the method for designing a Decision Support System (DSS). It starts with developing model components, then decision components and next creating user interfaces. Figure 1 describes the methodology of design the decision support system for soybean supply chain. This methodology refers to DSS activity diagram developed by [21]. The figure illustrates the sequence of actions to be taken for the DSS performance.

First step is making a component model. The component model is designed based on real or existing system data of the soybean supply chain system in Central Java. The next step is to make a model construction in Powersim software 10. Construction of the simulation model in Powersim software is done by creating a stock flow diagram for each subsystem. Stock flow diagrams are made based on causal loop diagrams that illustrate the relationships between entities in the system.

After the simulation model is formed the next stage is to verify and validate the model. The simulation model is verified if the simulation model can run properly. The model is declared valid if the model output results represent real conditions. Model validation is done by comparing the simulation outputs of 2006 to 2016 compared with actual data from 2006 to 2016.

The next step is to design the decision component. This stage is the stage of mapping alternative policies. The selection of policies is based on the simulation results whether the results are in accordance with the expected objective function, namely the realization of soy self-sufficiency and also improving farmers' welfare. If the results meet, then the policy becomes the policy proposed by DSS.

Figure 2 depicts the structure of a decision support system. Starting with understanding the system and identify the problem based on the real system, data collection, and propose some simulation scenario. Next step is designing the simulation model and user interface using Powersim software. The output of simulation will be compared to KPI, and decision maker can construct the decision priority base on scenario rank. KPI will be developed base on self-sufficiency consideration and farmer's

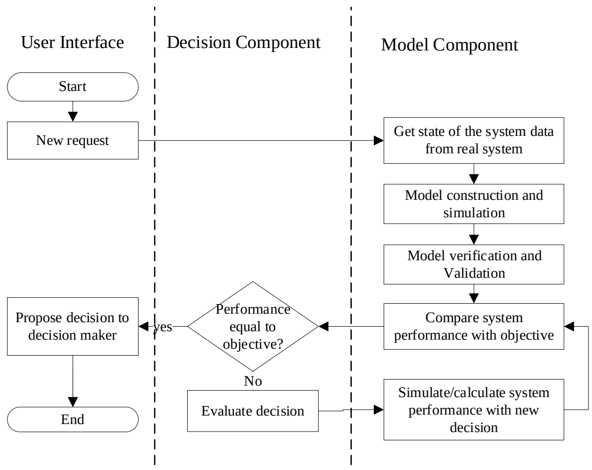

Figure 1. The Methodology of Design the Decision Support System

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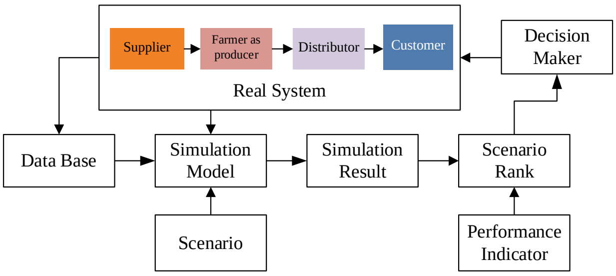

Figure 2. Decision Support System Structure

welfare. Government policy as the input of the system and will impact to the real system.

The last step is creating a user interface. The user interface is designed so that users can easily use the soybean supply chain DSS application. The user interface is created using the presentation mode tools found in Powersim Studio 10 software.

RESULT AND DISCUSSION

As mentioned earlier that this research is an advancement of [22], so we use the strategies, variables, parameters as mentioned in [22], and then we extended some of them appropriately. The importance of the strategy to achieve soybean self-sufficiency and improve the farmer's welfare is mentioned in [22]. The government as a decision maker have an authority to establish policies regarding providing subsidy, facilitation and regulation. The Government will generate the best strategy to increase soybean production, reduce the cost of the farming activity, and increase the production quantity to achieve the goals. This paper discusses:

a. The proposed policy scenario is in the form of a scenario of increasing productivity and land area to achieve soybean self-sufficiency. In this study the proposed scenarios are Subsidies, Technology innovation to reduce yield loss, Technology innovation to reduce seed consumption and workforce productivity improvement, Facilitation to increase seed quality, Increasing crop area and pricing policies and market guarantees.
b. This study also designed a single document interface (SDI) so that government as users can operate easily. This dynamic simulation-based decision support system can be used to review the effect of a new policy before deciding it. With this application, the decision maker can simulate policy scenarios by changing the option in the scenario menu. This assessment can be changed anytime, based on the input value. To estimate demand of soybean, the user can simulate the population estimation based on the projection of birth and death and also soybean's consumption of per capita. The results of the simulation are in the form of results tables, and to make it easier for users to analyse the results that can be displayed in graphical form.

The detailed description of the decision support system components is mentioned in the next sections.

The Model Component: Simulation Module

The first stage in designing the DSS component is by receiving state of the system data from the real system. The decision support system model for soybean supply chain structured on the three sub models namely sub model of supply, demand, and distribution.

a. Subsystem supply
   The supply subsystem involved in the soybean SCM model is the production and cost of farming activities. The components included are crop area and land productivity. Land productivity is dynamic and probabilistic is influenced by impacts of the seed yield loss, the temperature, and the watering treatment. Cost of farming activities consists of fixed cost and variable cost. Fixed costs arise due to the cost of land rent while variable costs occur because of the cost of pesticides, fertilizer costs, seed costs, and labour costs.
b. Subsystem demand
   The demand subsystem model is designed as a tool to simulate soybean demand conditions. The demand for soybeans calculated based on factors of population change and the factor of the soybean consumption per capita. The number of soybean demand is the multiplication of the population with the amount of soybean consumption per capita.
c. Subsystem distribution
   The subsystem of distribution discussed in this research is related to price, level of self-sufficiency and decision of import policy of soybean. Food self-sufficiency can be defined as the fulfilment of food needs, which as far as possible comes from domestic supply. In this model, we will describe the dynamics of policies that must be taken to realize food self-sufficiency, in this case, the availability of soybean supply to meet demand. Import policy occurs when the supply from the production of local farmers is unable to meet demand.

The second stage of designing DSS is creating construction and simulation. The characteristics of the soybean supply chain are complex, dynamic, and probabilistic. Dynamic simulation is suitable to be developed in this model. System dynamics as a part of systems approach has the advantage of being able to define problems in natural language and transformed into a useful graph for qualitative and quantitative analysis in a computer program [15]. A simulation is an imitating operation of processor system in the real world over time. Determination of model structure and parameters is an essential part before creating a dynamic system simulation [15]. Causal loop diagram is one tool to assist in articulating a model structure. Each level and rate element have a causal relationship. The "+" sign mean if direct arrow from cause to consequence has the same direction, and "-" means if the opposite direction exists [23].

The result of the component model is a simulation module in the form of a flow diagram designed in the simulation software. Below figures show a flow diagram for each subsystem [23]. Figure 3 design flow diagram for demand subsystem, Figure 4 and Figure 5 show the flow diagram for subsystem supply for productivity and crop area, and Figure 6 shows subsystem distribution.

The third stage in designing DSS, are comparing performance with the objective. The objective function of this research is the achievement of soybean self-sufficiency and improvement of farmer welfare. Key performance indicators of both objectives

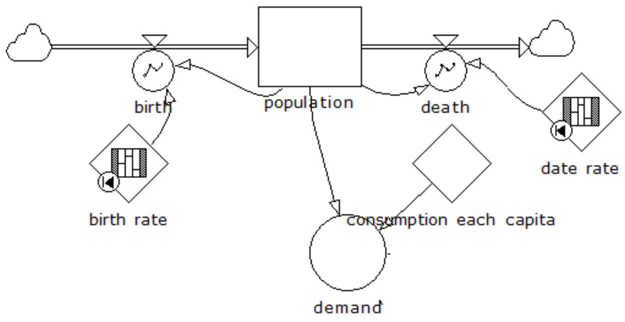

Figure 3. Flow Diagram Demand Subsystem

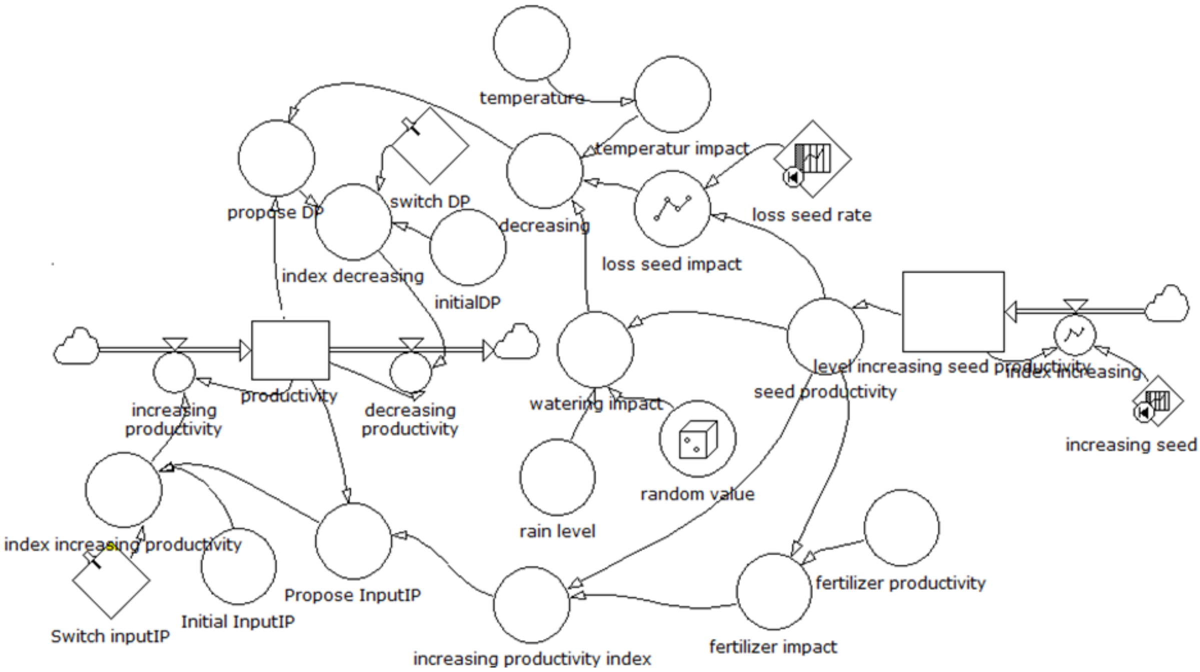

Figure 4. Flow Diagram Subsystem Supply-Productivity

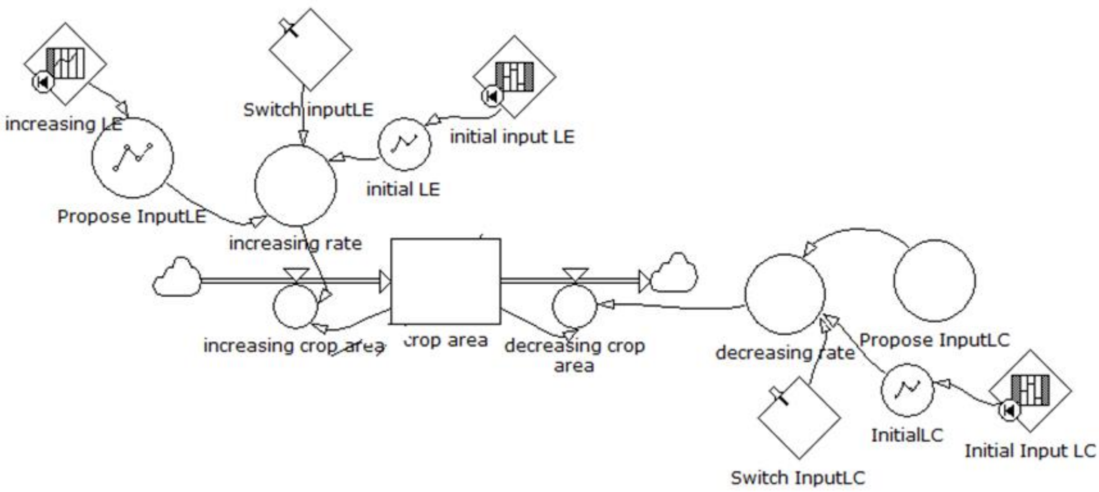

Figure 5. Flow Diagram Subsystem Supply-Crop Area

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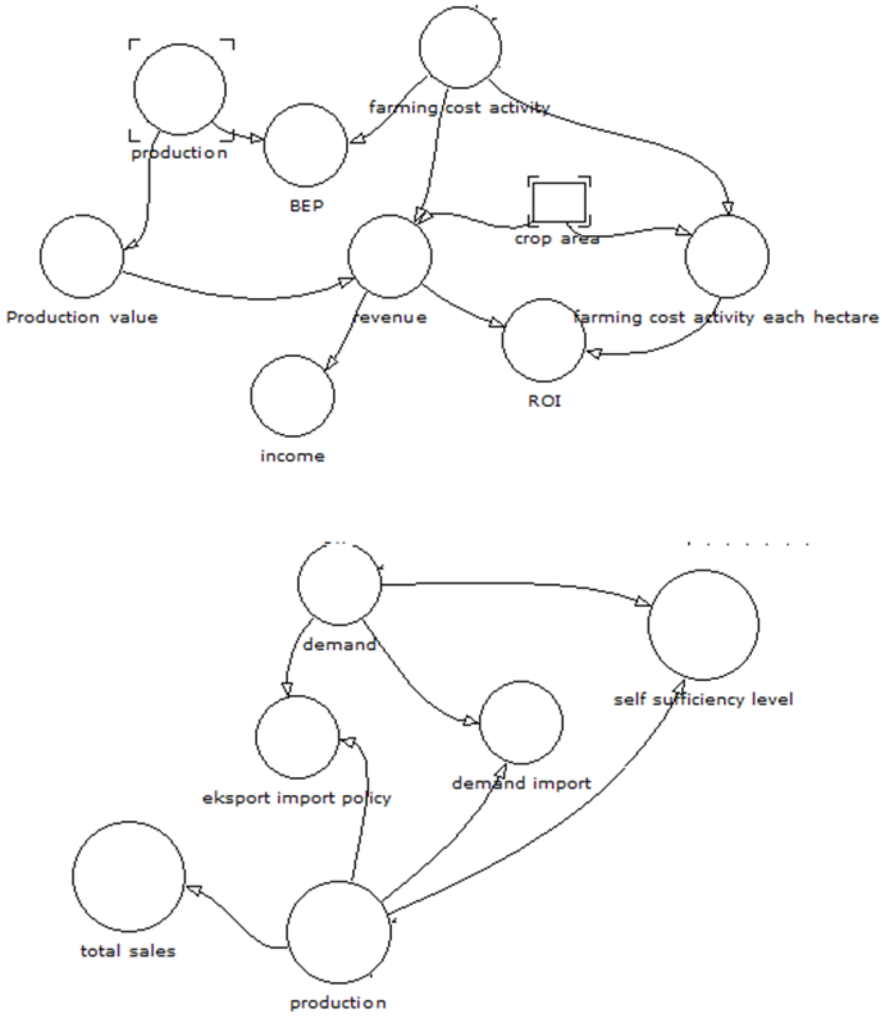

Figure 6. Flow Diagram Distribution Subsystem

are self-sufficiency level and farmer income per capita. Table 1 shows the policy mappings and the decision variables to achieve the objective.

Decision Component

The conceptual framework in decision component is simulating the government policy scenario that supports food self-sufficiency and farmer's welfare. The policy will be translated into the decision variable as input in the simulation. Each decision variable will have an impact on the response variable in the system and result of the simulation will be a status variable. The simulation runs with several policy scenarios. Each result from the scenario compared to the objective function and then evaluate and rank the result. The best scenario will be proposed to the decision maker as the best policy. Table 1 shows policy mapping and decision variable that will be simulated to find the best policy to be purposed to government as a decision maker.

Model Verification and Validation

The verification of the simulation program was conducted by writing and debugging and checking the logicality of the relationships between variables and unit consistency in the model. The model is running in the Powersim Studio software, the results are obtained that the model can be run properly and there is no warning sign in the form of "?" or "#" on variables or relationships between variables in the model. This shows that the relationship between variables in the logical model and the units used in each variable in the model has been consistent, so it can be decided that the model built is a consistent model.

Validation of a model is done to ensure the ability of a model to represent a real system. Validation tests were performed using performance validation techniques. Performance validation is conducted by performing a statistical test to see the deviation between the simulation output for period 2006 till 2016 and the actual historical data of the year 2006 till 2016. The statistical test used is the mean absolute percentage error (MAPE) test model is declared valid if the deviation that occurs between the output of the simulation model and the real system output can be received statistically. The accuracy criteria of the model with the MAPE test are MAPE less than 5% means very appropriate, MAPE is between 5% -10% means valid, MAPE more than 10% mean not valid. The next is the calculation of mean absolute percentage error between actual self-sufficiency level with self-sufficiency level output from simulation. The MAPE value for self-sufficiency level performance worth 8.01% means the model is valid. Table 2 shows detail calculation of Mean Absolute Percentage Error (MAPE).

Table 1. Policy Mapping and Decision Variable

Government Policy	Decision Variable	Response Variable	Objective Function
Subsidies of agricultural production facilities	Increasing subsidy of fertiliser, seed and pesticide 1% per year	Reducing cost	Farmer welfare
Technology innovation to reduce yield loss	Reducing yield loss by 4% per year	Increasing productivity	Farmer welfare and self-sufficiency
Technology innovation to reduce seed consumption and workforce productivity improvement	Reduce seed consumption from 50Kgs per hectare become 45% per year, and workforce productivity improve 30%	Reducing cost	Farmer welfare
Facilitation to increase seed quality	Increase seed productivity 35%	Increasing productivity	Farmer welfare and self-sufficiency
Increasing crop area	Increase 3.62% per year	Increasing crop area	Self-sufficiency
pricing policy and market guarantees	Increase price 1% per year	Increasing revenue	Farmer welfare

Table 2. Mean Absolute Percentage Error (MAPE)

Year	Actual data of self-sufficiency level	Simulation Result of self-sufficiency level	$\frac{\lvert X_m - X_d \rvert}{X_d}$
2006	41.09	41.06	0.00082
2007	38.05	38.66	0.01600
2008	51.29	54.68	0.06597
2009	53.30	54.94	0.03084
2010	57.94	58.03	0.00157
2011	34.31	43.15	0.25776
2012	46.19	52.85	0.14422
2013	29.86	39.10	0.30955
2014	37.43	38.32	0.02379
2015	38.43	37.55	0.02287
2016	32.97	33.23	0.00795
		$\sum \frac{\lvert X_m - X_d \rvert}{X_d}$	**0.88135**
		MAPE	**8.01%**

The Interface Component

The user interface provided in the Powersim software is with presentation mode. Presentation Mode can be described as a "browser simulation", where users are allowed to browse and play via simulations in the manner specified by the model maker. Presentation mode itself is a Single-Document Interface (SDI) where Project Window, Details Window, and all other oriented simulations that aid development have been removed. There is only one toolbar available, the Presentation Toolbar. Figure 7 shows the homepage application that consists of several menus. Menu of this application are home, data, result, and scenario.

Figure 8 shows the data menu that will show several data required in the simulation model. Data menu will be divided into three part namely data demand, data supply and cost of the farming activity. The user has to input consumption per capita per year, data input for population column is data number of populations at the time of simulation started. Birth rate and death rate are data input

Figure 6. Flow Diagram Distribution Subsystem

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projection of birth rate and death rate during the simulation period. Figure 9 shows the scenario of simulation. In this model, scenario to improve self-sufficiency level and improvement of farmer welfare will be divided into three areas namely improvement of productivity, improvement of the crop, and cost reduction.

This application can predict self-sufficiency achievement and improvement of farmer's welfare base on some scenario setting. Figure 10 until Figure 15 shows simulation result consists of self-sufficiency level, Return on Investment (ROI), farmer income per capita, cost of the farming activity, and soybean price. The result are based on scenario of subsidies, technology innovation to reduce yield loss, technology innovation to reduce seed consumption and workforce productivity improvement, facilitation to increase seed quality, increasing crop area and pricing policies and market guarantees. This simulation result on the base for input value and scenario selected. User can change the simulation database on scenario required. The user only selects which scenario will be activated.

Figure 10 shows the results of implementing the six policies together. Table 3 provides detailed predictions of demand, production and self-sufficiency levels on a simulation basis. Figure 11 shows result of comparation production and demand. Based on simulation prediction, soybean self-sufficiency can be achieved in 2031 by implementing overall policy.

Figure 13 is a menu of simulation results to predict Farmer income per capita. Farmer income per capita is one of the key performance indicators to measure the level of welfare of farmers. Simulation results show that the policy scenario of Subsidies, Technology innovation to reduce yield loss, Technology innovation to reduce seed consumption and workforce productivity improvement, Facilitation to increase seed quality, Increasing crop area and pricing policies and market guarantees can increase soybean farmers' income per capita in Central Java Province. Table 4 provides detailed of simulation result of Return on Investment and farmer income per capita.

Figure 14 shows the menu of the Result for Calculating Cost of Farming Activity. This menu will facilitate the government to estimate the cost of agricultural activities for the next time. The costs of agricultural activities include the costs of fertilizers, pesticides, seeds, labour and rent cost. Figure 15 shows the menu of the Result to predict soybean price. This menu will facilitate the government to estimate the cost of agricultural activities for the next time.

This decision support system based - dynamics model can help decision maker in planning policies. This application result shows that base on implementation of scenario of productivity improvement, crop area improvement, technology improvement and subsidy of fertilizer and pesticide, self-sufficiency level can achieved in the year 2031. This scenario also can improve

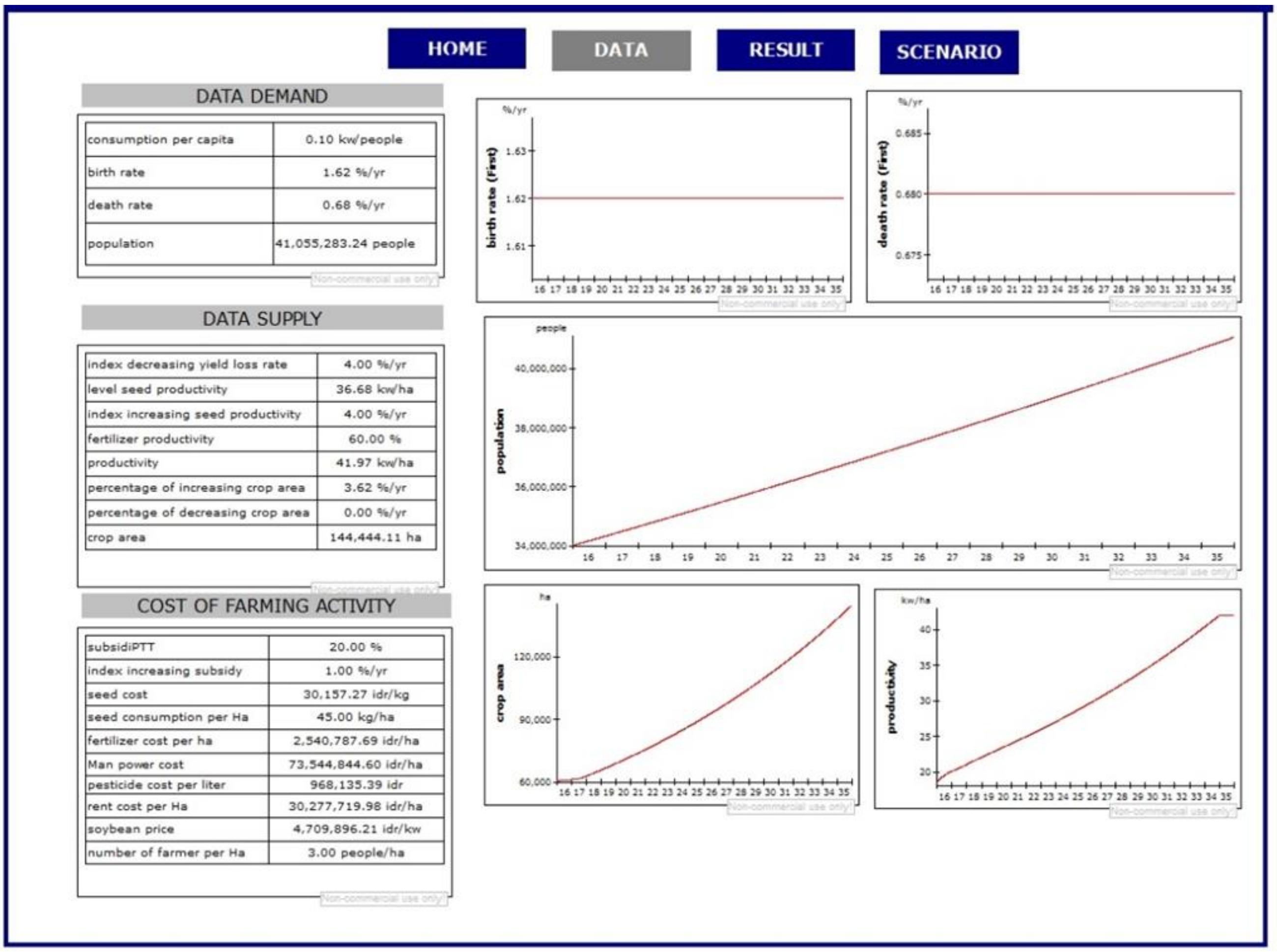


Figure 8. Menu of Data Input

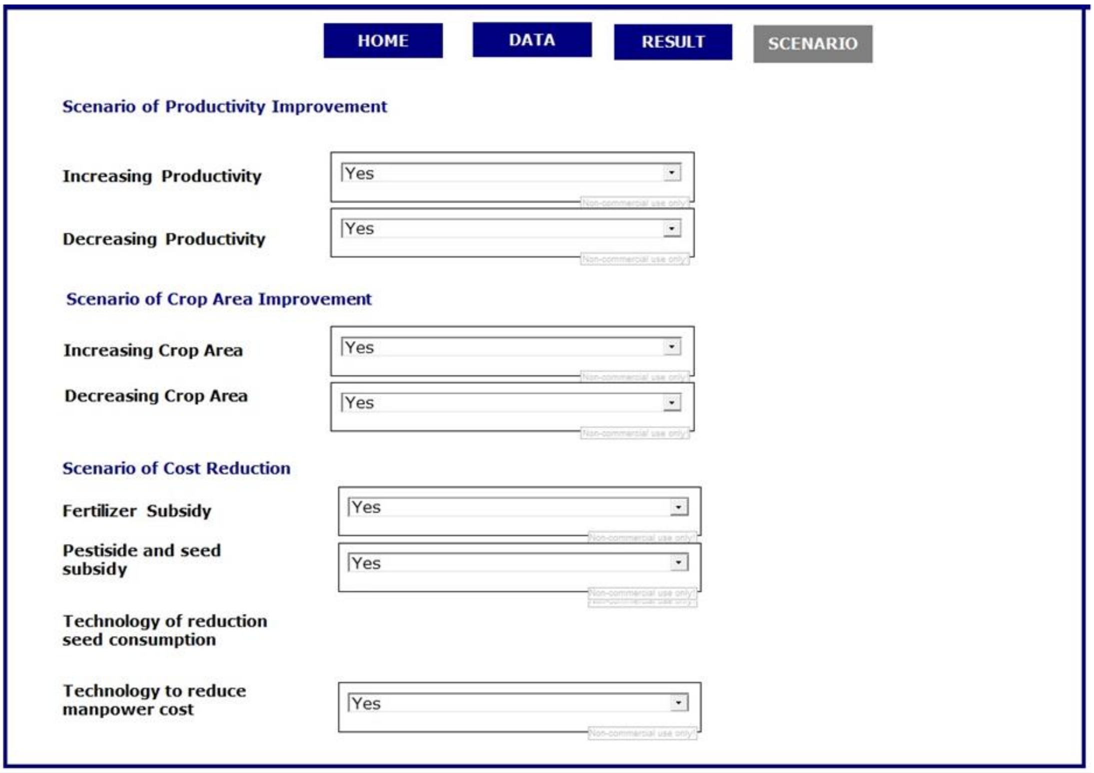
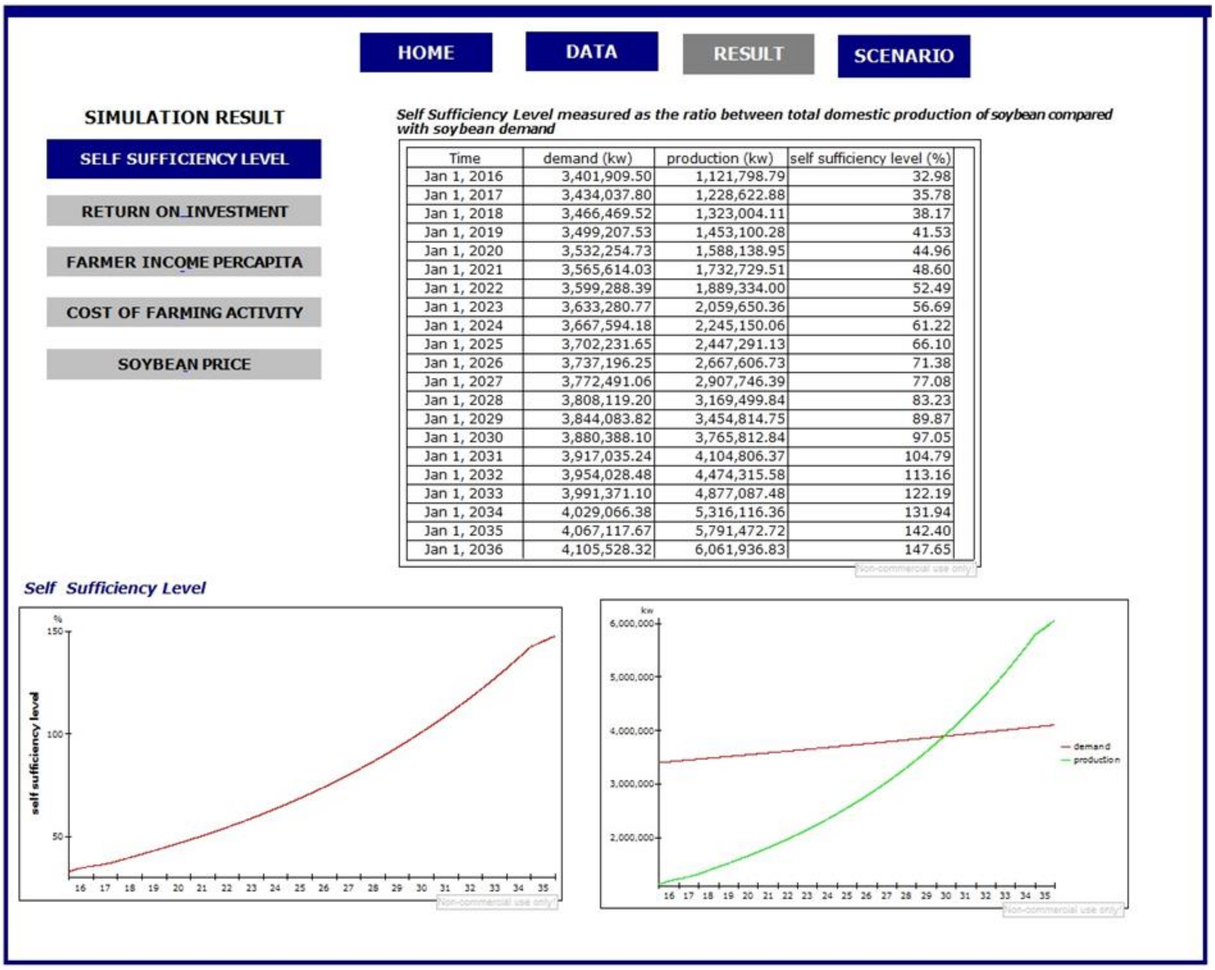


Figure 9. Menu of Scenario for Government Policy Input



Time	demand (kw)	production (kw)	self sufficiency level (%)
Jan 1, 2016	3,401,909.50	1,121,798.79	32.98
Jan 1, 2017	3,434,037.80	1,228,622.88	35.78
Jan 1, 2018	3,466,469.52	1,323,004.11	38.17
Jan 1, 2019	3,499,207.53	1,453,100.28	41.53
Jan 1, 2020	3,532,254.73	1,588,138.95	44.96
Jan 1, 2021	3,565,614.03	1,732,729.51	48.60
Jan 1, 2022	3,599,288.39	1,889,334.00	52.49
Jan 1, 2023	3,633,280.77	2,059,650.36	56.69
Jan 1, 2024	3,667,594.18	2,245,150.06	61.22
Jan 1, 2025	3,702,231.65	2,447,291.13	66.10
Jan 1, 2026	3,737,196.25	2,667,606.73	71.38
Jan 1, 2027	3,772,491.06	2,907,746.39	77.08
Jan 1, 2028	3,808,119.20	3,169,499.84	83.23
Jan 1, 2029	3,844,083.82	3,454,814.75	89.87
Jan 1, 2030	3,880,388.10	3,765,812.84	97.05
Jan 1, 2031	3,917,035.24	4,104,806.37	104.79
Jan 1, 2032	3,954,028.48	4,474,315.58	113.16
Jan 1, 2033	3,991,371.10	4,877,087.48	122.19
Jan 1, 2034	4,029,066.38	5,316,116.36	131.94
Jan 1, 2035	4,067,117.67	5,791,472.72	142.40
Jan 1, 2036	4,105,528.32	6,061,936.83	147.65

Figure10. Menu of Result for Self-sufficiency Level

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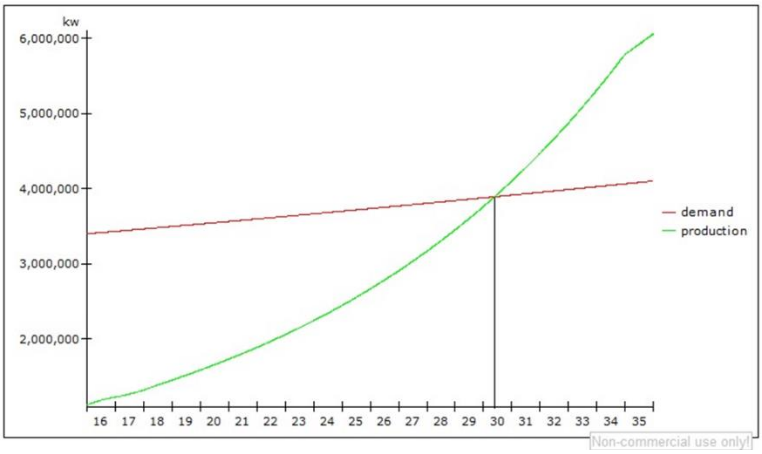


Figure 11. Simulation Result of Demand and Production

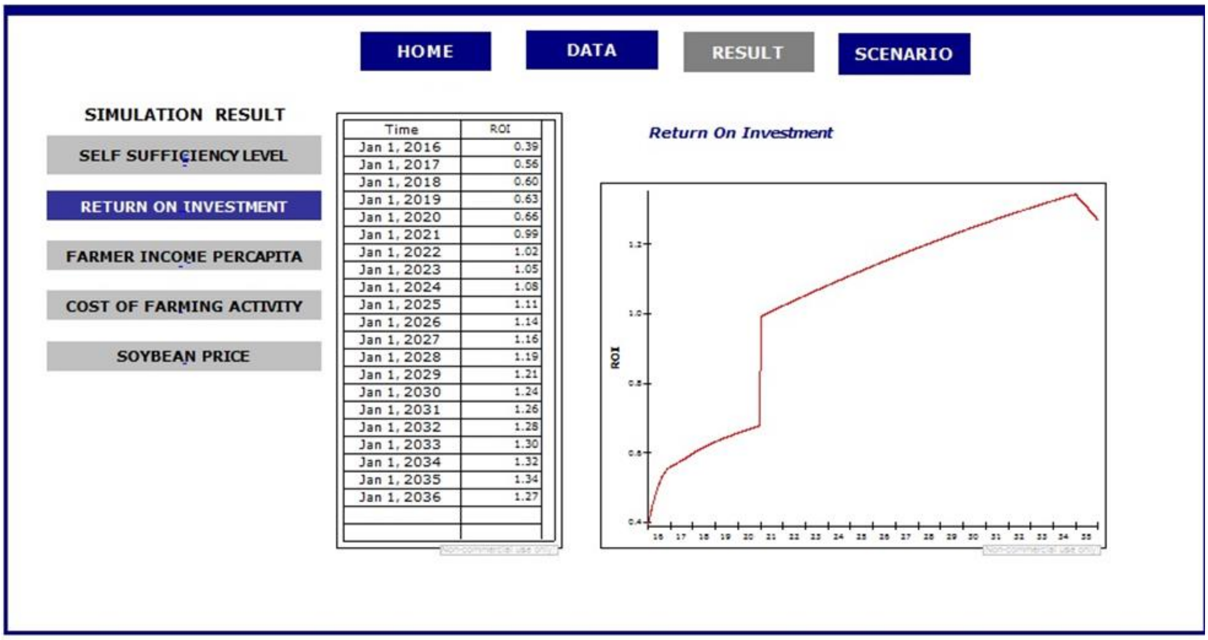


Figure 12. Menu of Result for Return on Investment Farming

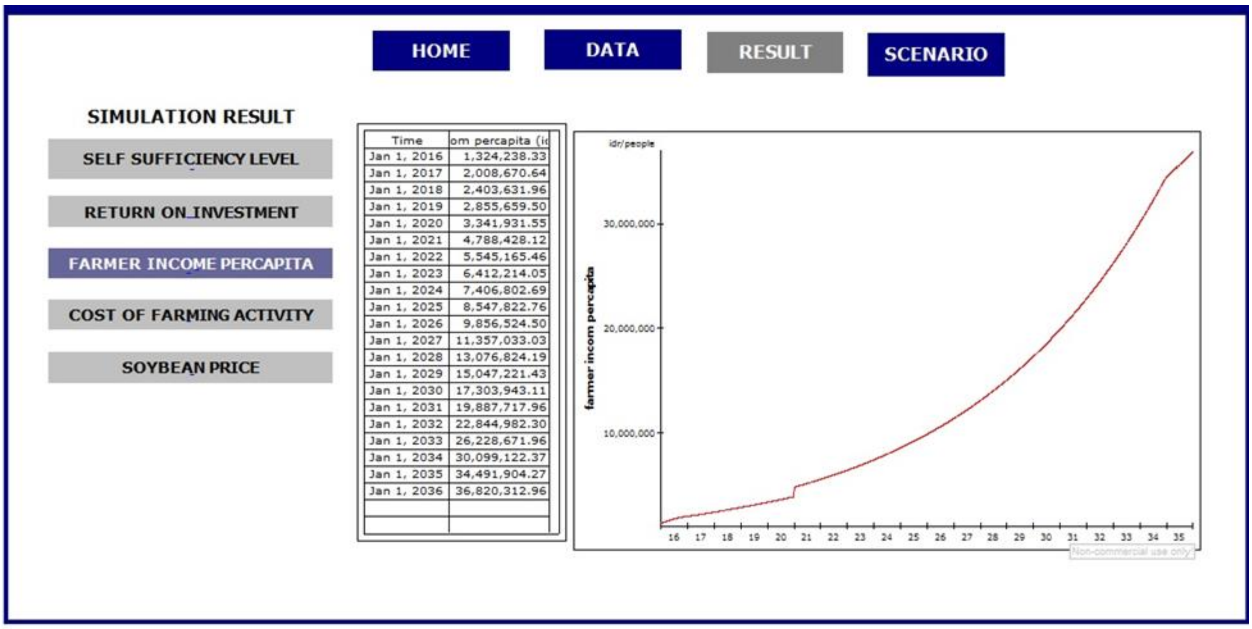
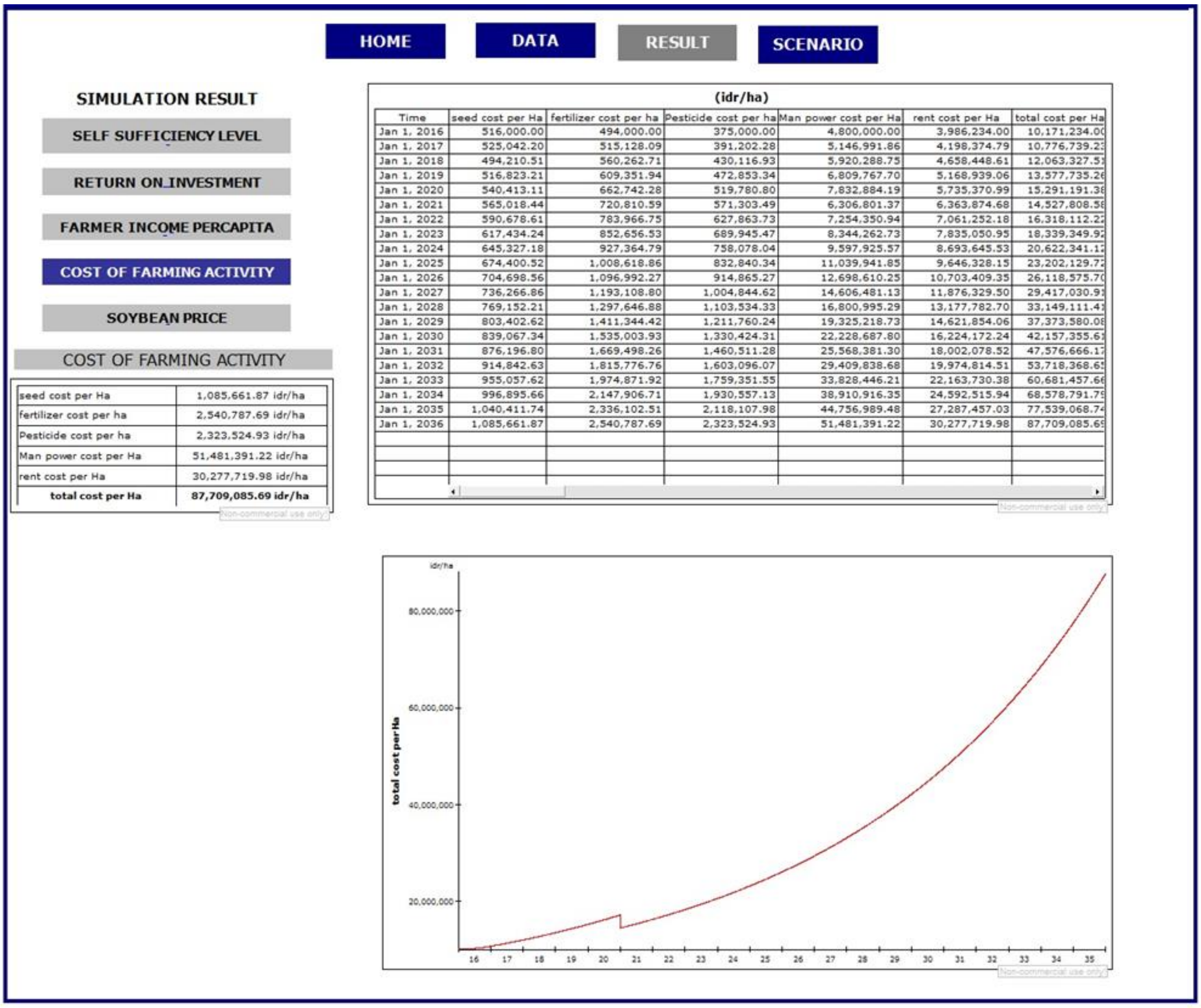


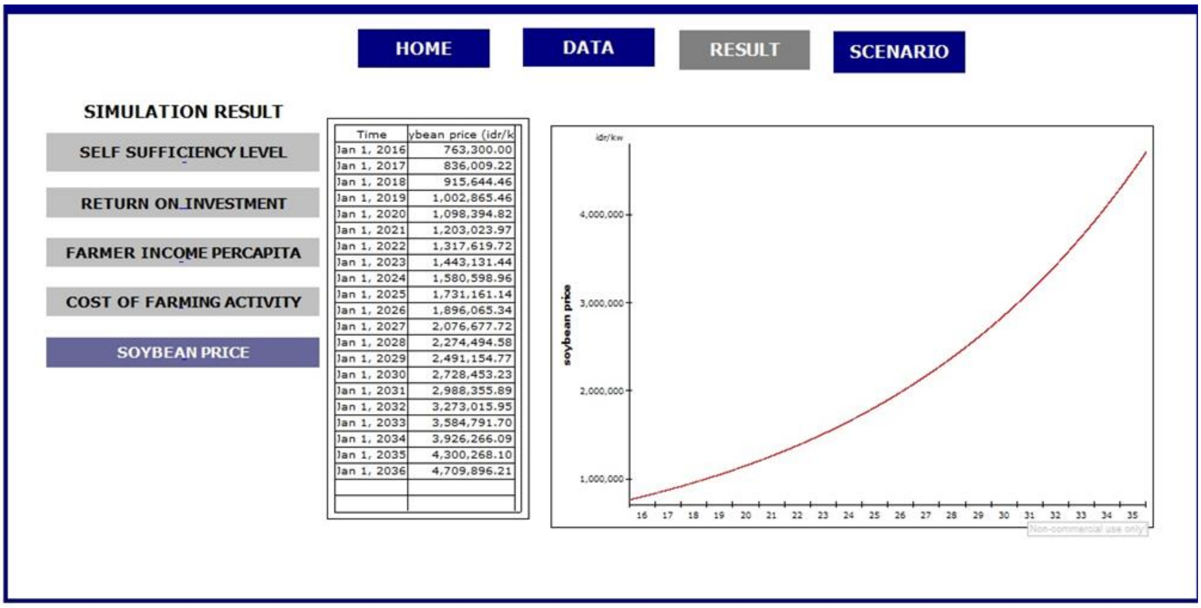
Figure13. Menu of Result for Farmer Income per Capita



seed cost per Ha	1,085,661.87 idr/ha
fertilizer cost per ha	2,540,787.69 idr/ha
Pesticide cost per ha	2,323,524.93 idr/ha
Man power cost per Ha	51,481,391.22 idr/ha
rent cost per Ha	30,277,719.98 idr/ha
total cost per Ha	**87,709,085.69 idr/ha**

Time	seed cost per Ha	fertilizer cost per ha	Pesticide cost per ha	Man power cost per Ha	rent cost per Ha	total cost per Ha
Jan 1, 2016	516,000.00	494,000.00	375,000.00	4,800,000.00	3,986,234.00	10,171,234.0
Jan 1, 2017	525,042.20	515,128.09	391,202.28	5,146,991.86	4,198,374.79	10,776,739.2
Jan 1, 2018	494,210.51	560,262.71	430,116.93	5,920,288.75	4,658,448.61	12,063,327.5
Jan 1, 2019	516,823.21	609,351.94	472,853.34	6,809,767.70	5,168,939.06	13,577,735.2
Jan 1, 2020	540,413.11	662,742.28	519,780.80	7,832,884.19	5,735,370.99	15,291,191.3
Jan 1, 2021	565,018.44	720,810.59	571,303.49	6,306,801.37	6,363,874.68	14,527,808.5
Jan 1, 2022	590,678.61	783,966.75	627,863.73	7,254,350.94	7,061,252.18	16,318,112.2
Jan 1, 2023	617,434.24	852,656.53	689,945.47	8,344,262.73	7,835,050.95	18,339,349.9
Jan 1, 2024	645,327.18	927,364.79	758,078.04	9,597,925.57	8,693,645.53	20,622,341.1
Jan 1, 2025	674,400.52	1,008,618.86	832,840.34	11,039,941.85	9,646,328.15	23,202,129.7
Jan 1, 2026	704,698.56	1,096,992.27	914,865.27	12,698,610.25	10,703,409.35	26,118,575.7
Jan 1, 2027	736,266.86	1,193,108.80	1,004,844.62	14,606,481.13	11,876,329.50	29,417,030.9
Jan 1, 2028	769,152.21	1,297,646.88	1,103,534.33	16,800,995.29	13,177,782.70	33,149,111.4
Jan 1, 2029	803,402.62	1,411,344.42	1,211,760.24	19,325,218.73	14,621,854.06	37,373,580.0
Jan 1, 2030	839,067.34	1,535,003.93	1,330,424.31	22,228,687.80	16,224,172.24	42,157,355.6
Jan 1, 2031	876,196.80	1,669,498.26	1,460,511.28	25,568,381.30	18,002,078.52	47,576,666.1
Jan 1, 2032	914,842.63	1,815,776.76	1,603,096.07	29,409,838.68	19,974,814.51	53,718,368.6
Jan 1, 2033	955,057.62	1,974,871.92	1,759,351.55	33,828,446.21	22,163,730.38	60,681,457.6
Jan 1, 2034	996,895.66	2,147,906.71	1,930,557.13	38,910,916.35	24,592,515.94	68,578,791.7
Jan 1, 2035	1,040,411.74	2,336,102.51	2,118,107.98	44,756,989.48	27,287,457.03	77,539,068.7
Jan 1, 2036	1,085,661.87	2,540,787.69	2,323,524.93	51,481,391.22	30,277,719.98	87,709,085.6

Figure 14. Menu of Result for Calculating Cost of Farming



Time	ybean price (idr/k
Jan 1, 2016	763,300.00
Jan 1, 2017	836,009.22
Jan 1, 2018	915,644.46
Jan 1, 2019	1,002,865.46
Jan 1, 2020	1,098,394.82
Jan 1, 2021	1,203,023.97
Jan 1, 2022	1,317,619.72
Jan 1, 2023	1,443,131.44
Jan 1, 2024	1,580,598.96
Jan 1, 2025	1,731,161.14
Jan 1, 2026	1,896,065.34
Jan 1, 2027	2,076,677.72
Jan 1, 2028	2,274,494.58
Jan 1, 2029	2,491,154.77
Jan 1, 2030	2,728,453.23
Jan 1, 2031	2,988,355.89
Jan 1, 2032	3,273,015.95
Jan 1, 2033	3,584,791.70
Jan 1, 2034	3,926,266.09
Jan 1, 2035	4,300,268.10
Jan 1, 2036	4,709,896.21

Figure 15. Menu of Result To Predict Soybean Price

farmer's income per capita and Return on Investment for the next 20 year.

Managerial implications that can be carried out by the government as the policy maker have been proposed based on the simulation results. The strategy proposed through the developed model is proven to be able to realize soybean self-sufficiency and improve farmers' welfare. This is proven by being able to achieve

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Table 3. Simulation Result of Demand, Production, Self-sufficiency Level

Time	Demand (kw)	Production (kw)	Self Sufficiency Level (%)
01-Jan-16	3,401,909.50	1,121,798.79	32.98
01-Jan-17	3,434,037.80	1,228,622.88	35.78
01-Jan-18	3,466,469.52	1,323,004.11	38.17
01-Jan-19	3,499,207.53	1,453,100.28	41.53
01-Jan-20	3,532,254.73	1,588,138.95	44.96
01-Jan-21	3,565,614.03	1,732,729.51	48.6
01-Jan-22	3,599,288.39	1,889,334.00	52.49
01-Jan-23	3,633,280.77	2,059,650.36	56.69
01-Jan-24	3,667,594.18	2,245,150.06	61.22
01-Jan-25	3,702,231.65	2,447,291.13	66.1
01-Jan-26	3,737,196.25	2,667,606.73	71.38
01-Jan-27	3,772,491.06	2,907,746.39	77.08
01-Jan-28	3,808,119.20	3,169,499.84	83.23
01-Jan-29	3,844,083.82	3,454,814.75	89.87
01-Jan-30	3,880,388.10	3,765,812.84	97.05
01-Jan-31	3,917,035.24	4,104,806.37	104.79
01-Jan-32	3,954,028.48	4,474,315.58	113.16
01-Jan-33	3,991,371.10	4,877,087.48	122.19
01-Jan-34	4,029,066.38	5,316,116.36	131.94
01-Jan-35	4,067,117.67	5,791,472.72	142.4
01-Jan-36	4,105,528.32	6,061,936.83	147.65

Table 4. Simulation Result of Return on Investment and Farmer Income per Capita

Time	ROI	Farmer Income Per Capita
01-Jan-16	0.39	1,324,238.33
01-Jan-17	0.56	2,008,670.64
01-Jan-18	0.60	2,403,631.96
01-Jan-19	0.63	2,855,659.50
01-Jan-20	0.66	3,341,931.55
01-Jan-21	0.99	4,788,428.12
01-Jan-22	1.02	5,545,165.46
01-Jan-23	1.05	6,412,214.05
01-Jan-24	1.08	7,406,802.69
01-Jan-25	1.11	8,547,822.76
01-Jan-26	1.14	9,856,524.50
01-Jan-27	1.16	11,357,033.03
01-Jan-28	1.19	13,076,824.19
01-Jan-29	1.21	15,047,221.43
01-Jan-30	1.24	17,303,943.11
01-Jan-31	1.26	19,887,717.96
01-Jan-32	1.28	22,844,982.30
01-Jan-33	1.30	26,228,671.96
01-Jan-34	1.32	30,099,122.37
01-Jan-35	1.34	34,491,904.27
01-Jan-36	1.27	36,820,312.96

a level of soybean self-sufficiency in excess of 100% and an increase in farmers' per capita income and Return on Investment (ROI). Policies taken to achieve food self-sufficiency and improve farmers' welfare are the provision of subsidies, technology innovation to reduce yield loss, technology innovation to reduce seed consumption and workforce productivity improvement, facilitation to increase seed quality, increasing crop areas and pricing policies and market guarantees.

In this study a simulation model was developed that considers together the entire entity in the system that consist of supply, consumption, and distribution. This study has developed an application as decision support to simulate several policy alternatives. The proposed policy are land expansion policy is a top priority for realising food self-sufficiency. Increased productivity and reduced costs of agricultural activities are the main priorities for improving the welfare of farmers.

CONCLUSION

Self-sufficiency in soybeans and improving the welfare of farmers become a critical agenda for the government. These objectives can be achieved if the government as the decision maker establishes new policies that lead to increased production, decreased agricultural costs and increased value of agricultural products. Determination of policies must be based on a priority scale that has the most significant impact on achieving objectives.

This study has developed an application as a decision support system that can simulate several policy alternatives related to increasing land area, increasing productivity and reducing the costs of agricultural activities. The decision maker can use this application to simulate the impact of policy alternatives before being applied as a new policy. Hence, the government can take a decision more appropriately. Based on the results of the application, the land expansion policy is the top priority for realising food self-sufficiency, while increasing productivity and reduced costs of agricultural activities are the main priorities for improving the welfare of farmers. Further research can be conducted to develop a web application environment with the simulation module of Powersim format that hosted in the server and with a specific database.

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