Analysis on Policy of Fertilizer Subsidy for Fulfillment of the Farmers' Need: A System Dynamic Approach

by

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Abstract

Fertilizer is one of the important production means in farming activities. The policy to reduce the subsidy through the increase of fertilizer price is confirmed to have a direct impact to increase the cost of farming activities. Farmers are encountered to two inflicting options: sustaining the productivity, with the consequence of having more expensive cost for farming activities, or, reducing the use of fertilizer in order to maintain the production cost with the consequence of decrease in productivity. This research is to analyze the scenarios policy related to reduction of fertilizer subsidy through price increase at the farmer level as well as the government efforts in preventing the drop of farmer's income through the scenario of standard price increase of agricultural commodities. System Dynamic Methodology is capable in modelling the existing policy and accomodating various scenarios related to determination of fertilizer subsidy and the standard of rice agriculture commodities then simulating them in order to see the impacts. Four policy scenarios of fertilizer price per kg are chosen ie: Rp 1,800 per kg; Rp 1,800 per kg with increasing the standard price of agricultural commodities by 10%; Rp 2,200 per kg without increasing the standard price of agricultural commodities; Rp 2,400 per kg with increasing the standard price of agricultural commodities by 15%. Based on the simulation result, it is found that the price determination has the impact on the decrease of farmer's income and the fourth scenario is the best scenario for farmer's income.

Keywords: System Dynamic, Fertilizer, Policy, Scenario, Standard Price

1. Introduction

Indonesia is a country whose majority of its people are farmers. Farming is an important sector in economy and absorbs 44.5% manpower of their overall working-aged population. The agricultural sector also gives significant contribution to *Grossed Domestic Products (GDP)* reaching 14.34% of the total GDP at the total US$ 540.28 billion in the year 2009. It is an undeniable fact that the existence of agriculture sector activities is so far influenced by other economic sectors, such as fertilizer industry as provider for production supporting means of agricultural products.
Fertilizer is one of the important production factors for success of farming activities and its presence contributes 20% to production increase. Experience of Indonesia in reaching the rice self-supporting achievement was largely determined by ability of Government in providing fertilizer to farmers. So far, the need for chemical fertilizer reaches the average of 24,42 million tons per annum.

One of the successes of farming activities is determined by ability in fulfilling the need for fertilizer. Lack of fertilizer will decrease productivity of agricultural products and followed by decrease in level of farmers' income. This is the true fact frequently encountered by farmers beside high price of fertilizer at the farmers' level so that they cannot meet their needs.

From view point of domestic fertilizer industry, we are encountered by our limited ability to produce and by the increase of production cost caused by: *First*, 40% of raw material of fertilizer is natural gas. Fertilizer subsidy applicable at present follows international pattern of natural gas price which always increases deducted by gas price paid by fertilizer producer. The higher the natural gas price is at international market, the bigger amount of subsidy to be provided by Government in order to get a price affordable by farmers. *Second,* is imbalance between increasing demand and production ability of fertilizer industry so far in stagnant status. Non-availability of domestic capital limits the increase of capacity and establishment of new fertilizer factories. And, *third*, is poor management in production and distribution systems of each stake holder in supplying chain causing non-availability and high price of fertilizer.

This research is related to decrease of farmers' income due to non-availability of fertilizer so that its price at the farmer level increases. Analyzing the influential variables as well as studying several scenarios of Government policies in future related to provision and management of fertilizer, it is then expected it can guarantee fulfillment of fertilizer demand at the farmer level at reasonable prices.

Reality of the aforesaid problem constitutes a systemic matter in which price forming variables are mutually related to each other setting up a complex system. Under a *dynamic system methodology*, it is quite possible to set up a model representing the aforesaid matters and putting them into a simulation so that an illustration can be obtained regarding impact behavior of Government policy in future related fulfillment of demand for fertilizer comprehensively.
Since there are so many varieties of agricultural commodities available at farming activities, this research gives more emphasis in agricultural commodities produced in a big amount by farmers in Indonesia in general, namely: paddy, corn and soybean.

2. Methodology

As a whole, there are 5 main stages in this research, namely: identification and data collecting, modelling and model formulation, simulation, verification and validation, model scenario and result analysis.

Identification stage is intended to know general illustration of the existing distribution system of subsidized fertilizer as well as its encountered problems. Data collecting concerns with data related to the variables already been identified previously, such as: type of farmers' plants, area of farm land owned, cost for farming activities and others.

Modeling stage is conceptualization of actual system with the help of *Causal Loop Diagram* and *Stock and Flow Diagram* available at simulation software, namely *Veneta Simulation*. Based on variables already been identified, their interaction patterns are set up into Causal Loop Diagram and inter-related variables of cause and effect are classified as material flow or informational flow. If such cause and effect constitutes material flow, the cause and effect variable is more specifically classified into *Flow and Stock*. In this modeling stage, a top-down approach is applied, namely primary model is set up first then broken down into more detailed sub-models.

Further step is Model Formulation pursuant to interaction relation among variables and interaction patterns already been known before, then followed by simulation and its results need to be verified and validated. Verification is intended to verify whether there is any error or not in modeling, whereas validation is conducted in order to compare model structures as well as their behavior to the structure with actual system behavior. Based on models already been verified and validated, models are then simulated with some policy scenarios and their results are analyzed in order to get the best policy scenario behavior.

3. Reality of Fertilizer Distribution System

In order to guarantee fertilizer availability and price affordable for farmers, Government determines subsidized fertilizer as regulated commodity and being controlled in its distribution. Such a policy is applied commencing from annual demand planning by Government at regional and national levels, determination of *Highest Retailed Price* (HRP) every year, amount of budget for subsidized fertilizer up to its distribution system. Effective from the year 2009, Government has applied closed distribution system in which each group of farmers is obliged to prepare *Demand Plan of Farmer Group* (DPFG) to be used as allocation plan for fertilizer requirement.

The problem encountered up to this present time, is that policies applied by Government still have weakness, because Government is not yet capable in guaranteeing fulfillment of fertilizer demand and fertilizer price at farmer level is still exceeding HRP, so as the effect, the farmers suffer more. Control system in fertilizer distribution has not yet been effective, so that non-availability of fertilizer and price above HRP frequently occur when farmers are in need for fertilizer during cultivating season.

Institutional relation and stakeholder of fertilizer distribution till farmer level cover as follows: Fertilizer factory having buffer warehouses in each province supplies distributors' demand at a total pursuant to direction given by Provincial Administration. Similarly, distributor supplies

retailers' demand at sub-district and at village level at a total pursuant to direction of Regency Administration.

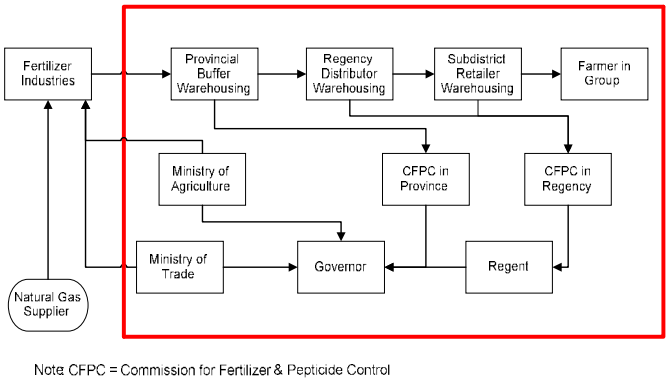


Figure 1 Institutional Interelation in Fertilizer Distribution

Whereas scope of this research stays within red line boundary, namely distribution system of subsidized fertilizer, with stakeholders as follows: fertilizer producers, especially department involved in marketing at provincial and regency levels, distributor, retailers, and farmers as end-consumer. Government acts as regulator and as policy holder in determining and in regulating amount of fertilizer supply, price and distribution system of fertilizer from upstream to downstream.

- **Buffer Warehouse:** is a fertilizer storage managed by marketing department of fertilizer producer at provincial level and is responsible for fertilizer distribution and marketing pursuant to requirement plan.
- **Distributor:** is an individual company or a corporation appointed by producer to carry out purchase, storage, distribution, and sales of subsidized fertilizer at large scale in area of its responsibility. Data on referential price at distributor level for the year 2009 was Rp 1,150.00 in conformity with that as suggested by Government. Distributor purchased fertilizer from producer at the price of Rp 1,07.00 per kilogram, so that the *fee* obtained was Rp 80.00 per kilogram or about 6% to 7% of HRP of fertilizer.
- **Retailers:** are individuals, farmer groups, and corporation having a seat at Sub-District and appointed by distributor with main activity to carry out sales of subsidized fertilizer at area of their responsibility directly only to farmers or to farmer groups. Retailers buy fertilizer from distributor at the price of Rp 1,150.00 per kilogram, so that *marketing margin (fee)* suggested by Government is Rp 50.00 per kilogram or about 4% of HRP determined by Government.
- **Farmers:** are individuals carrying out farming activities and need to get a special attention, because they are very vulnerable and sensitive to policies related to fertilizer. The presence of small scaled farmers in Indonesia reaches 72% with land ownership of only 13% of whole farm lands in Indonesia. The farming activities of small scaled farmers mostly concern with 3 commodities: paddy, corn and soybeans planted intermittently pursuant to cultivating season in a year.
- **Government:** is institution having authority to regulate and control fertilizer distribution covering determination of HRP, plan of fertilizer requirement, and distribution system of subsidized fertilizer. Control and distribution at regional level are delegated by Regent to *Commission for Fertilizer and Pesticide Control* (CFPC).

4. Initial Model Designing

Model conceptualization of fertilizer distribution is initiated by setting up *Input-Output Diagram* useful to describe and classify systematically input/output variables of subsidized fertilizer distribution system. Based on such diagram, variables able to be used as policy scenario on fertilizer and also variables able to be used as success indicator can be determined. The input variables consist of: (i) *Controlled Variable*, namely magnitude in system whose value can be set up through regulation; and (ii) *Uncontrolled Variable,* namely magnitude in system that cannot be intervened by policy. Similarly, Output Variables are classified into 2 categories: *wanted or expected output* and *unwanted output* or more popularly known as *'negative externality'*. Environment constitutes Government policies related to fertilizer.

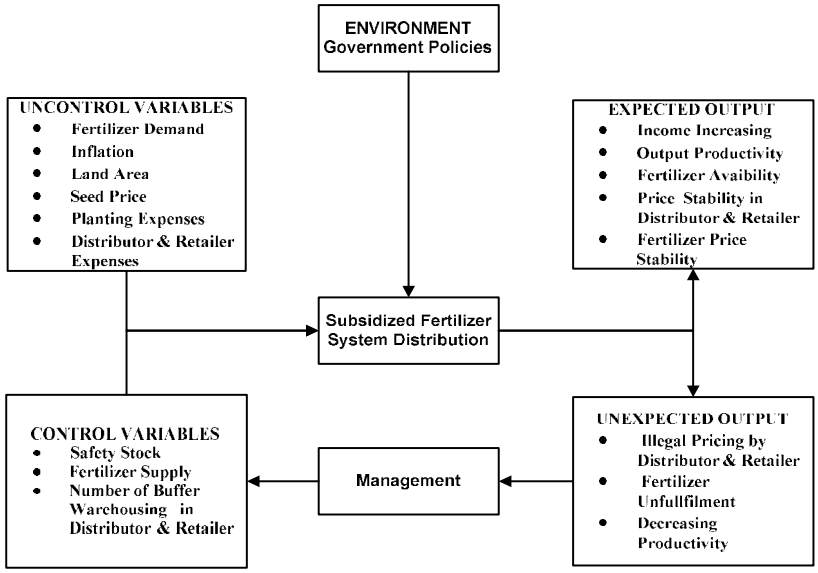


Figure 2 Input-output Diagram on Fertilizer Distribution System

The next step in setting up initial model is illustration of cause-effect diagram among variables already been chosen at input-output diagram. Amount of Government subsidy for fertilizer has impact on price of fertilizer at farmer level. The bigger the subsidy is, the cheaper the price of the fertilizer is, so that the relation between these two variables of subsidized fertilizer and fertilizer price will be negative. Positive relation is available at variable of fertilizer production and at the increase of fertilizer stocks. On the contrary, if there is any decrease in production, fertilizer stock will also decrease.

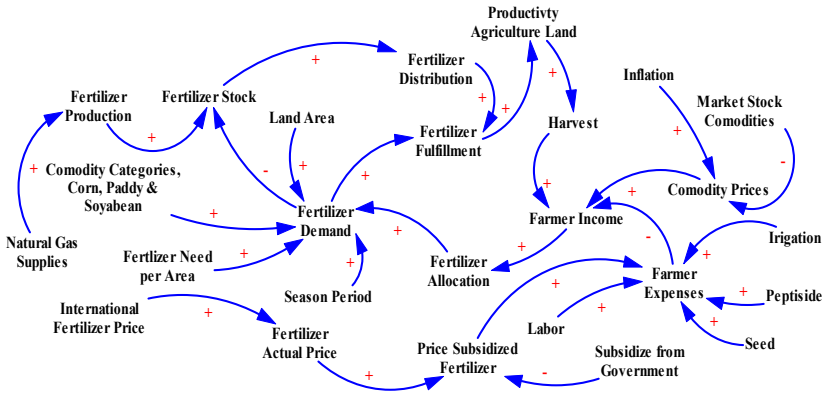


Figure 3 Cause-effect Diagram

In order to make model formulation easy in next step, the cause effect relation is classified into *informational and material flow relations.* Special for material flow relation, its variables are identified as Stock and Flow. Considering that developed model of subsidized fertilizer distribution involves many variables, the models are grouped into several sub-model depending on stakeholders involved in subsidized fertilizer distribution, covering as follows: demand for subsidized fertilizer, buffer warehouse, distributor, and retailers, farmers sub-models. Here they are:

- **Subsidized Fertilizer Demand Sub-model** illustrates demand of farmers, farmer groups, retailers and also distributor for subsidized fertilizer to producer represented by buffer warehouse. Demand for fertilizer has fluctuated patterns, depending on cultivating season and commodities planted.

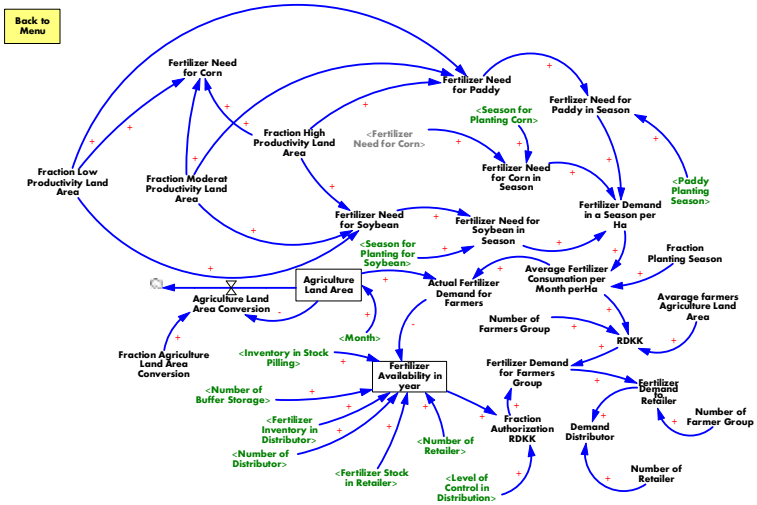


Figure4 Fertilizer Demand Sub-model

- **Buffer Warehouse Sub-model** illustrates fertilizer procuring activities at provincial buffer warehouse. The buffer warehouse gets fertilizer from producer which is then distributed to distributors in regencies as subsidized fertilizer distributors within one province.

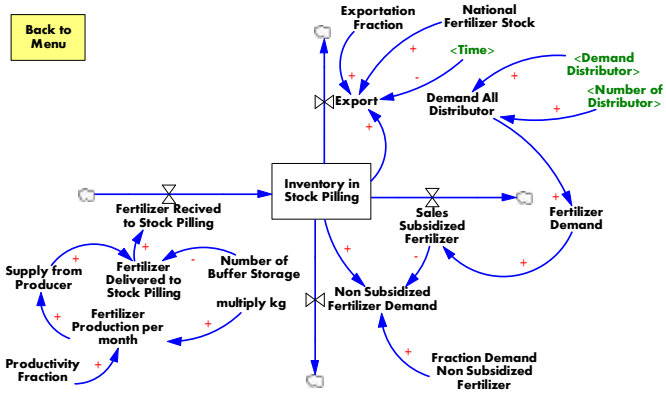


Figure 5 Buffer Warehouse Sub-model

- **Distributor Sub-model** illustrates fertilizer distributing activities by distributor to retailers. In this distribution chain, it is possible to have price increase at distributor level, because supply from buffer warehouse cannot fulfill distributor's demand. So, fertilizer sales to retailers will be smaller compared to farmers' demand. Consequently there will be a non-availability of fertilizer and its price will increase exceeding HRP as suggested by Government.

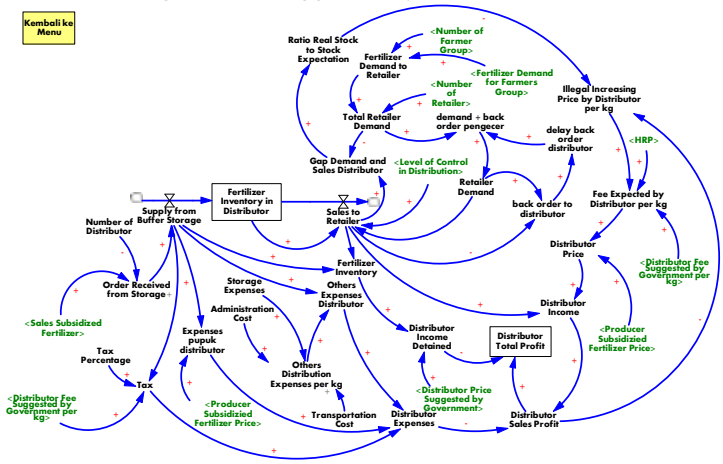


Figure 6 Distributor Sub-model

- **Retailer Sub-model** illustrates fertilizer distributing activities conducted by retailers to farmer groups or to farmers in its area. The retailer sub-model has almost the same logic to that of the distributor sub-model.

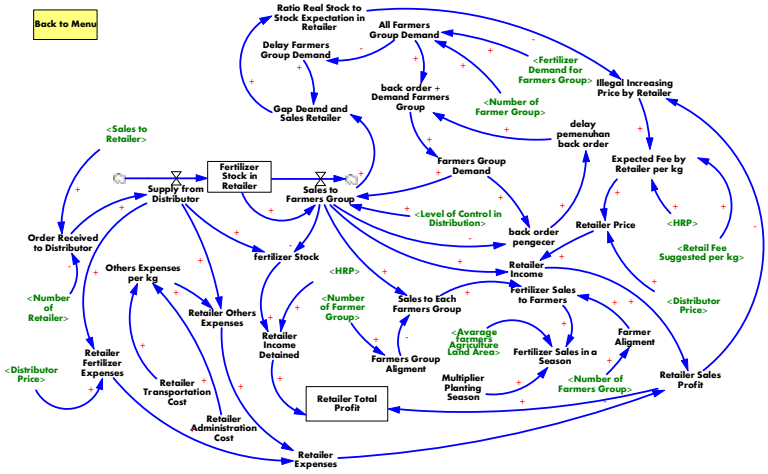


Figure 7 Retailer Sub-model

- **Farmer Sub-model** illustrates influence of distribution system of subsidized fertilizer constituting a primary production means of farmers to their income. This sub-model is classified into 3 categories in order to be able to easily see impacts of fertilizer distribution system upon farmers' incomes from respective commodities, namely: *paddy, corn*, and *soybean*.

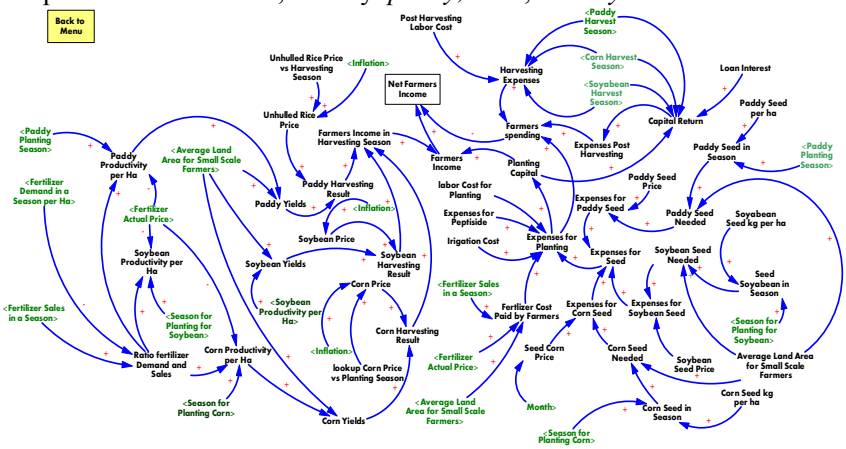
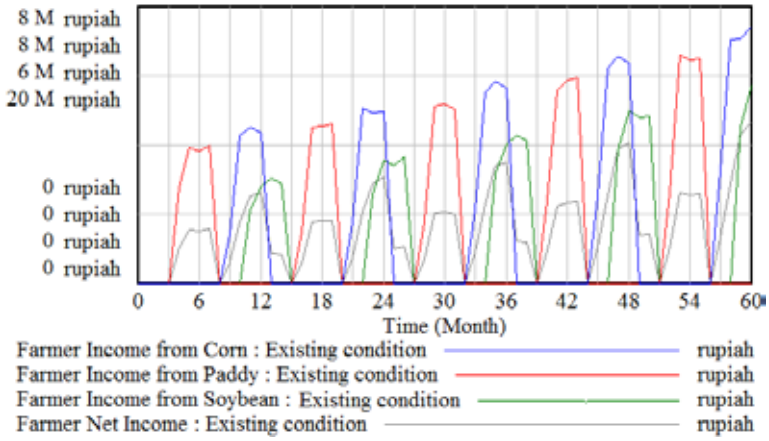


Figure 8 Farmer Sub-model

5. Model Simulation

This simulation is intended to see behavior of system model already been set up by means of inserting values on the constants and functional table pursuant to condition available at actual system. Time unit applied at simulation is *'month'*, under a consideration that the period commonly used in cultivating season for commodity is the month unit. Simulation results of several output variables are as follows:

- **Outputs of paddy, soybean, corn farmers**. Farmer income from each commodity is net earning at harvest season of each commodity. The highest earning is obtained from corn commodity, followed by paddy and the lowest is soybean. The said income during simulation time has a tendency to increase.



Farmer9 Farmer Income from each Comodities

- **Ratio of fertilizer demand and sale**. It is a comparison between total demand and total fertilizer available. If value is less than one, it indicates the farmers' demand for fertilizer is smaller than fertilizer sales; and so is the contrary. Result of simulation indicates that it frequently occurs that demand for fertilizer planned by farmers is bigger than amount of fertilizer available. This enables price increase above the HRP conducted by stakeholders involved in process of fertilizer distribution.

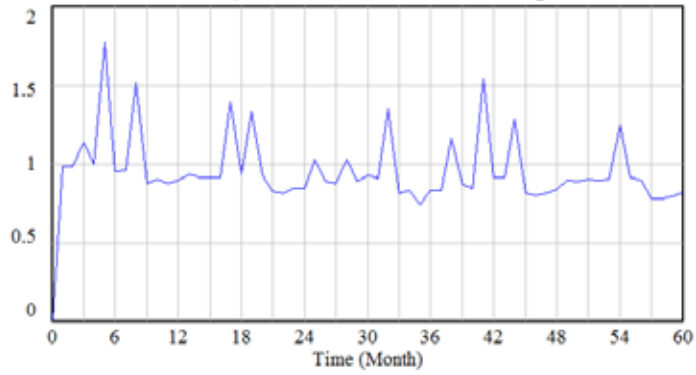


Figure 10 Ratio of Fertilizer Demand and Sale

Figure-10 shown that the ratio of demand and sales tend to be less than 1 along the time of simulation. In this regard, distributor's and retailer's *fee* per kilogram of fertilizer exceeds the amount determined by Government, namely Rp 80.00 and Rp 50.00 consecutively.

- **Total Price Increase above HRP**. Figure-11 indicates total price increase occurring at a process of entire chains of fertilizer distribution conducted by distributors and retailers. The price increase will occur, if actual price of fertilizer exceeds HRP determined by Government.

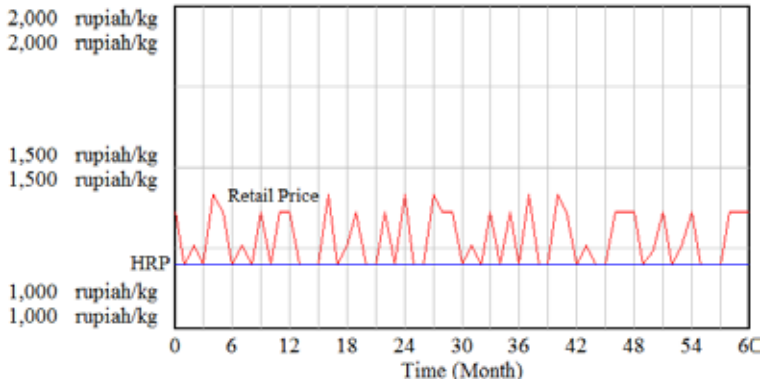


Figure 11 Fertilizer Price and HRP

6. Verification and Validation

Verification is a stage to confirm whether national fertilizing model has been logically proper. In order to confirm this matter, two forms of checking are carried out, namely ***'Model Check'*** to confirm that there is no error in formulation and ***'Unit Check'*** concerning with unit/dimension consistency applied in model. This stage can be taken easily, because *Vensim Modeling Software* has already been facilitated by those two forms of checking, so in case of error in modeling logic, it can be immediately identified.

Validation process is carried out in order to confirm whether the model has already represented reality of national fertilizing system, so it can be convinced it can fulfil the objective of this model making. Validation process is carried out through two approaches, namely ***'White Box'*** which inserts all variables and inter-related variables into national fertilizing model, based on inputs from experts. Meanwhile ***"Black Box'*** is carried out by comparing statistically the average price of agricultural commodities, incomes either of farmers, retailers and distributors of fertilizer, as well as price of subsidized fertilizer as result of simulation to actual data. Validation testing shown in this paper only concerns with *model behavioral test*, although 4 other validation tests have been conducted, namely: model structure, model parameter, limitation sufficiency and extreme condition test.

Model behavioral test is carried out by comparing simulation results to the past behavior of actual system being compared. If the data statistically tested are equal, then it is stated the model is capable to replicate the actual system. S*tatistic test* is conducted with the help of *Minitab Software* and *One-Sample T Method* is selected at 95% degree of confidence.
Table-1 reveals that value of simulation output upon average price of each commodity is **P-value > α = 0.05**, then it is declared that the average value of simulation result is not different from the actual price, and model can be declared as sufficiently representative to represent the system reality.

Table 1 Validation of The Simulation Output

Month	Comodities									
	Rice		Corn		Soyabean		Fertilizer			
	Price*	P-value	Price*	P-value	Price*	P-value	Price*	Pvalue	Sales**	P-value
1	2.315		2.824		4.341		1.124		5.433	
2	2.335		2.848		4.367		1.137		13.910	
3	2.358		2.872		4.406		1.148		13.430	
4	2.380		2.892		4.440		1.158		10.650	
5	2.398		2.913		4.480		1.169		6.901	
6	2.417	0.216	2.937	0.072	4.510	0.399	1.177	0.269	16.290	0.22
7	2.441		2.952		4.552		1.187		16.870	
8	2.458		2.975		4.577		1.202		4.546	
9	2.479		2.993		4.625		1.214		13.170	
10	2.494		3.021		4.661		1.230		5.051	
11	2.516		3.048		4.700		1.238		6.474	
12	2.538		3.070		4.742		1.250		7.059	

Note: *) Rupiah/kg,
**) Tonne

7. Policy Scenario Model

Based on model development already been verified and validated, such model can be utilized to design various scenarios of policy related to fertilizer subsidy. The setting of policy scenario on subsidized fertilizer is carried out by changing values of variables that can be controlled by Government through regulation, covering: HRP, amount of budget for fertilizer subsidy, and determination of price standard for agricultural commodities. Whereas variables used as parameter cover as follows: farmers' income from paddy, corn and soybean commodities, profits for retailers and distributors. The designs of policy scenario proposed among others are as follows:

1. **Budget Value of Government Subsidy** for price subsidy is changed based on subsidy budget for the year 2009 at the amount of Rp 17.5 trillion to become Rp11.3 trillion with total allocation for fertilizer demand increasing from 5,200,000 tons to 6,000,000 tons in the year 2010.
2. **Increasing Fertilizer HRP** from Rp 1,200.00 to Rp 1,800.00 without any policy determining the price increase of agricultural commodity.
3. **Increasing Fertilizer HRP to Rp 1,800.00** and increasing 10% of price standard for agricultural commodities, namely paddy, soybean and corn.
4. **Increasing Fertilizer HRP to Rp 2,400.00** and increasing 15% of price standard for agricultural commodities.

8. Analysis on Simulation Results against Policy Scenario

Simulation result of **Scenario-1** and **Scenario-2** indicate decrease of farmers' income at average of 9.5% and 8.1%. It is because policy to increase HRP is not accompanied by other policies in order to cover up the loss due to application of policies using Scenario-1 and Scenario-2. Whereas **Scenario-3** in form of HRP increase to Rp1,800.00 and followed by 10% increase of price standard of paddy commodity is able to increase farmers' income at the sum of 5.8%. In **Scenario-4**, fertilizer HRP increase to Rp2,400.00 accompanied by 15% price increase of paddy commodity, the farmers' income increases 10%. Although the increase of fertilizer HRP is sufficiently high, determination of paddy standard price is far above reduction of subsidy burden given to farmers.

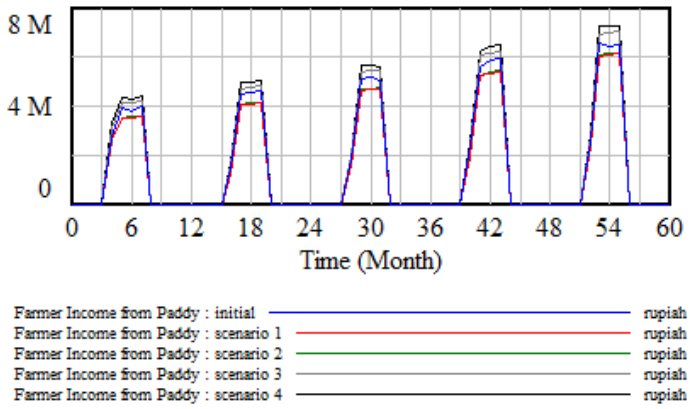


Figure 12 Scenario Income from Paddy

For corn commodity, **Scenario-1** and **Scenario-2** have impact to decrease 9% and 8.14% of income of corn farmers. Meanwhile **Scenario-3**, namely increasing fertilizer HRP to Rp1,800.00 and increasing price of corn commodity of 10% can increase farmers' income at average amount of 6.2%. In **Scenario-4**, increase of fertilizer HRP to Rp 2,400.00 increases farmers' Income at average of 9.3% compared to the previous one.

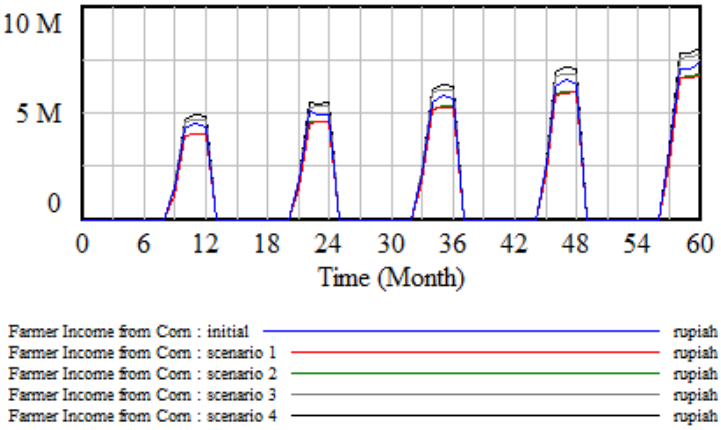


Figure 13 Scenario Income from Corn

In Scenario-1 and Scenario-2, increase of fertilizer HRP has impact to the decrease of income of **soybean farmers** at the sum of 12% and 10.5%. In **Scenario-3**, increase of fertilizer HRP to Rp1,800.00 and 10% price increase of soybean commodity is able to increase farmers' income at the sum of 6.2%. It is quite different that in **Scenario-4**, the increase of fertilizer HRP to Rp 2,400.00 per kilogram and increasing 15% of standard price of soybean commodity, the farmers' income increases 9.53% and becomes the biggest compared to other scenarios.

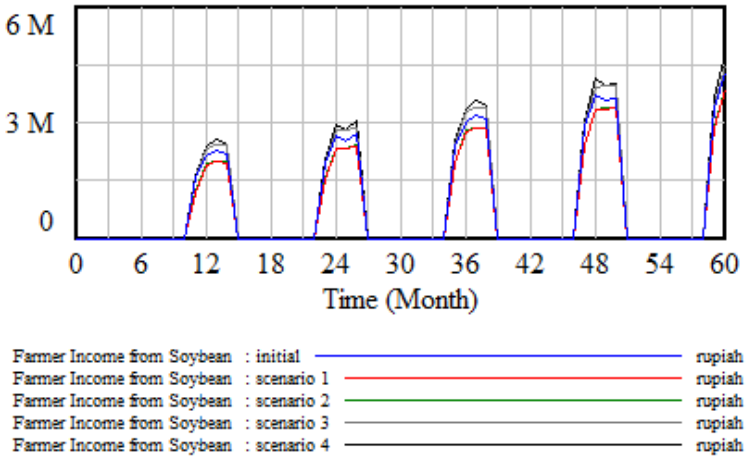


Figure 14 Scenario Income from Soybean

Simulation results to policy scenarios of subsidized fertilizer has impacts not only to farmers but also to distributor and to retailers as parts of system of fertilizer supply chain. Simulation result on existing condition indicates that the average profit obtained by distributor is Rp12,534,000.00 for each supply quota owned by a distributor. The higher the fertilizer HRP is, the bigger profit will be obtained by a distributor, namely: 93.5%, 70.4%, 70.4% and 140.80% for each scenario. This is quite logical, considering that *margin (fee)* of marketing is calculated based on HRP.

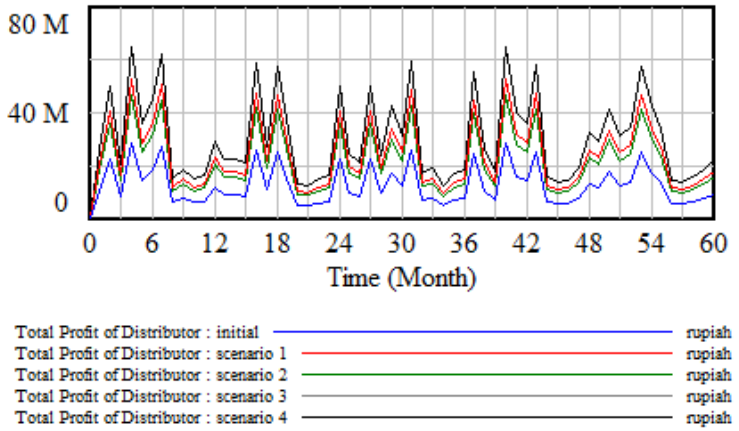


Figure 15 Scenario Distributor Profit

Similar to that of distributor, profit of retailers also increases from the average profit of Rp 1,029,000.00. In Scenario-1 to Scenario-4, there have been an increase in retailers' profits, respectively at the sum of 72%, 54%, 54%, and the biggest one at this Scenario-4 is 107%.

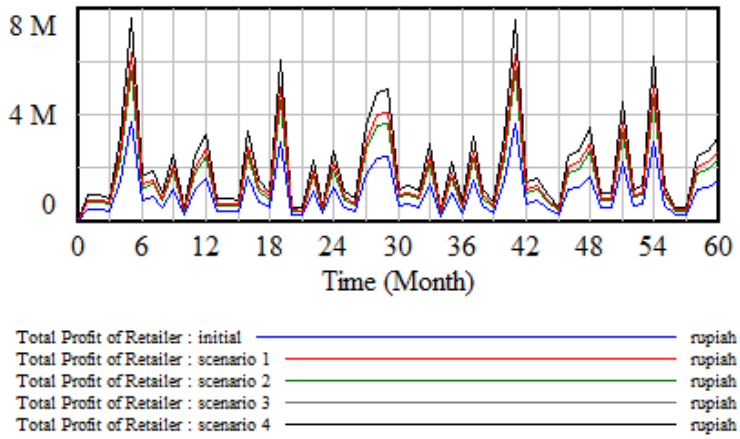


Figure16 Scenario Retailer Profit

9. Conclusion

Based on simulation result analysis on models of fertilizer distribution and some policy alternative scenarios, a conclusion can be taken as follows: Variables influencing farmers' income are the control level on fertilizer distribution, highest retailed price, actual fertilizer price and agricultural productivity. Decrease of subsidy will increase HRP at farmer level and will decrease the farmers' income. To anticipate such decrease of the farmers' income, Government shall increase standard price of commodity of agricultural products as stated at the fourth policy scenario, namely increasing fertilizer HRP at the farmer level from Rp 1,200.00 to Rp2,400.00 per kilogram, accompanied by determination of 15% increase in price standard of commodity of agricultural products. However, such policy scenarios still need to be improved by Government concerning with *fees* obtained by distributor and retailers in order to be more balanced with efforts to prevent distributors and retailers from doing pilling-up to engineer non-availability of fertilizer.

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