The Impact of Fertilizer Subsidy on Malaysia Paddy/Rice Industry Using a System Dynamics Approach

Nurul Nadia Ramli, Mad Nasir Shamsudin, Zainalabidin Mohamed, and Alias Radam

***Abstract*—The Malaysian paddy and rice industry has always been given special treatment based on the strategic importance of rice as a staple food commodity. This study attempts to simulate the impacts of changes in government intervention policy, namely the fertilizer subsidy on the Malaysian paddy and rice industry using system dynamics model. Simulation result indicates that fertilizer subsidy does give a significant impact to the paddy and rice industry. Fertilizer subsidy increases the yield obtained and hence increase paddy production. The removal of fertilizer subsidy decreased the paddy production and consequently, decrease the self sufficiency level (SSL). With the removal of fertilizer subsidy the importation of rice seem inevitable due to the reduction in productions. Meantime the growth in population will further put a pressure to the government to increase importation and to find alternative policies to sustain production and to increase yield.**

***Index terms*—System dynamics, fertilizer subsidy, paddy/rice industry, policies, importation.**

I. Introduction

Rice has been a staple food of the Malaysian community and the paddy/rice industry is considered as a strategic industry and always gets special treatment from the government [1]. The industry is heavily regulated because of its social, political and economic importance. In 2009, apart from being the main source of food, it also provides the livelihood to 172,000 paddy farmers in the country. Land utilization for paddy production is currently at 674,928 hectares which is 76 percent in Peninsular Malaysia (515,657 ha) while Sarawak and Sabah accounted for 18 percent (118,919 ha) and 6 percent (40,352 ha) of the total hectareage respectively. The complexity of the paddy/rice industry makes planning and policy formulation is not an easy task. For example the instability in rice prices in world market which occur in early 1970, middle of 1980 and recently in 2008 give a big negative impact to the industry. Besides, paddy/rice industry is also the most highly protected industry in the country. There are three types of government interventions, these are: import restriction or quota, fertilizer subsidies and price supports.

With trade liberalization, the allowable policy instruments to continue supporting and subsidizing the industry will be limited. Thus, it will have some impact to the industry if the trade liberalization is fully implemented. The changes in the government policy such as the removal of fertilizer subsidy for paddy production due to trade liberalization may give negative impacts to the paddy/rice industry. This scenario may lead to the reduction in rice production, decreased in self sufficiency level (SSL) and increase in import. This study attempts to simulate the impacts of changes in government intervention policy, namely the fertilizer subsidy on the Malaysian paddy and rice industry using system dynamics model.

Studies have shown that inputs subsidies such as fertilizer help to maintain the productivity of the paddy farm. For example rice producers in India continued to benefit from high government subsidies on inputs: in particular fertilizers and irrigation, but also from procurement at minimum support prices. These subsidies lead to the increase in production [2]. Similarly supporting elements ranging from provision of agricultural inputs for rice production such as increasing fertilizer supply, provision of good quality seed, credit with low interest rate played significant role in providing basic support to increase productivity, improving rice quality and minimizing losses in Indonesia [3]. All these intervention contributed greatly to Indonesia's self-sufficiency in paddy and rice production. Similarly as in [4] indicate that among the factors affecting the increasing gap between production and consumption of rice include input subsidies, credit programs, guaranteed price, distribution of coupons, and the importing of rice using foreign exchange valued at a special cheap rate allocated for food. Reference [5] conducted a study on the Indonesia rice supply performance in trade liberalization era. The objective of the study was to analyze the impact of free trade and its consequences to the Indonesian rice economy. They used simultaneous regression analysis (two-stage least square method) to analyze the impact of free trade to the rice economy. They found that removal of import tariff and government involvement will significantly reduce producer surplus. Reference [6] conducted a study on maize trade liberalization versus fertilizer subsidies in Tanzania. They used computable general equilibrium model (CGE) in order to evaluate two policy measures meant to stimulate growth and crop production in Tanzania. The simulation results indicate that fertilizer subsidies promote cash production and a more land intensive production pattern while maize trade liberalization, on the other hand, stimulates food crops and land extensive production processes. In contrast, as in [7] indicated that the fertilizer subsidy is not a key determinant of the use of fertilizer in paddy cultivation. The regression results from this study indicated that changes in the prices of fertilizer and paddy do not have a significant effect on fertilizer usage, which points to the fact that the fertilizer subsidy is not a key determinant of the use of fertilizer in paddy cultivation. The study also found that there is a

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relatively higher correlation between fertilizer usage and paddy price than between fertilizer usage and fertilizer price. These findings suggest that the fertilizer subsidy could be withdrawn gradually over time.

II. Methodology

SYSTEM DYNAMICS

System dynamics model is being utilized in the study. System dynamics is a methodology for analyzing complex systems and problems with the aid of computer simulation software. It is an approach for understanding the behavior of complex systems over time which includes all the relevant cause effect relationships, time delays and feedback loops. Reference [8] revealed, system dynamics as the application of the attitude of mind of a control engineer to the improvement of dynamics behaviors in a managed system.

Vensim software was used to run the analysis [9]. The stock and flow diagram for System Dynamics Model for the overall Malaysian paddy and rice industry is presented in Figure 1 (Appendix).

The Malaysian paddy and rice industry can be divided into two sub models which are technical component and economic component (Figure 2 and Figure 3). The technical component consists of yield as the main outcome. Factor that can affect the yield is the fertilizer used. The farmers' net income represents stock in this sub model while farmers' gross income acts as the inflow. There are three types of outflows in the technical sub model. These are; farmers' expenditure, total cost and farmers' expenditure for fertilizer. There are two types of farmers' expenditures. The first one refers to farmers' expenditure for other uses while the second one refers to farmers' expenditure for fertilizer. Farmers' expenditure on fertilizer can affect the quantity of extra fertilizer used, and this extra fertilizer will give positive impact to the yield and paddy production. The equation for the yield is equal to effect of fertilizer on yield multiplied by maximum yield. In this case, lookup function was used in order to see the impact of fertilizer used on yield. If total fertilizer used is equal to recommended rate of fertilizer, the yield obtained will be at maximum value.

On the other hand the economic component consists of rice production, consumption and import as the main outcomes. The economic component consists of 3 types of state variables (stock). These variables are total consumption, rice stock and population. The inflow for the rice stock comes from rice production while the outflows are rate of local supply and rate of rice stock release. The rate of rice production is derived from conversion of paddy production. Paddy production is derived from multiplication of yield and area planted. The rate of stock release depends on the desired import and actual import. If the actual import is less than desired import, the amount of rice stock release will be equal to the gap in import. The gap in import refers to the difference between desired import and actual import. If the actual import is equal to desired import, the amount of rice stock release will be zero.

The second outflow of rice stock is local supply. In this case, the minimum function was used. Local rice supply is derived from the multiplication of fraction of rice stock release and rice stock. However, in certain extreme conditions, the local supply equals to rice stock divided by time step. This equation implies that "it takes what you want' (fraction rice stock release * rice stock) out of the stock. But, if there is inadequate stock, it completely empties the stock (rice stock/time step). The fraction of rice stock release for local supply is assumed to be constant at 90 percent. This value is based on the data provided by Ministry of Agriculture (MOA).

Usually 10 percent of rice will be kept as the rice stock in order to ensure adequate supply of the rice during crisis. The amount of import depends on the desired import and import quota. Desired import refers to the amount of rice that needs to be imported in order to meet demand. However due to imposition of import quota only a certain amount of rice is allowed to be imported. Adjusted import variable is used to adjust the quantity of rice needed to be imported.

The adjusted import variable depends on the desired import and also import quota. If the desired import is less than import quota, the amount of adjusted import will be equal to desired import. In contrast, if desired import is greater than import quota the adjusted import will be equal to import quota. If total consumption is greater than rice production, the amount of desired import will be equal to the gap in supply and demand. Gap in supply and demand refers to the difference between rice production and total consumption. On the other hand, if total consumption is less than local rice production, the amount of desired import equals zero.

The secondary data used in this study comes from various sources such as MOA, Department of Agriculture, Lembaga Pertubuhan Peladang (LPP) and Department of Statistic (DOS). In this study, the scenario on the impacts of fertilizer subsidy is simulated. Two types of simulations were conducted to see how the behaviour of the system changes with the changes in government policy. The scenario 1 refers to the baseline scenario. The baseline scenario refers to the current scenario in Malaysia with no changes in government policy. On the other hand, scenario 2 refers to the simulation under removal of NPK fertilizer subsidy.

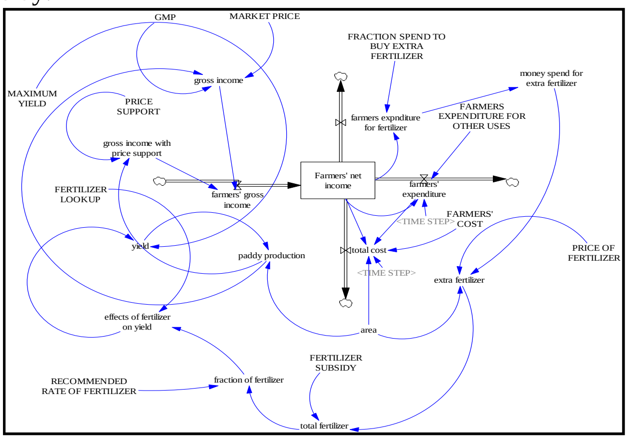

Fig.2. Technical component for system dynamics model for the Malaysian rice industry (First Sub Model)

III. Results

Baseline Scenario 1: Simulation under current scenario in Malaysia with no changes in government

policy.

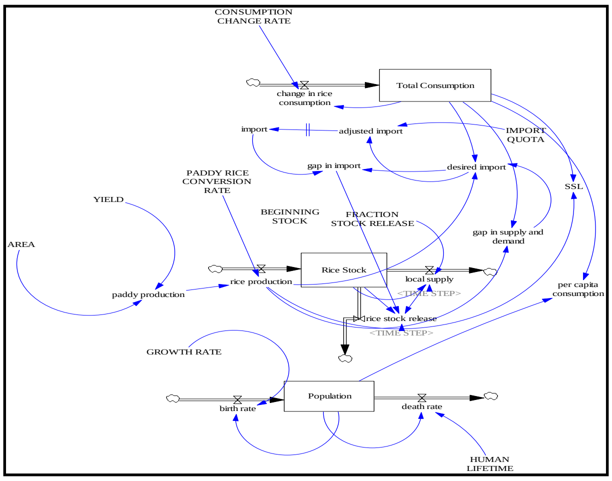

Fig.3. Economic component for system dynamics model for the Malaysian rice industry (Second Sub Model)

As indicated earlier the baseline scenario refers to the current scenario in Malaysia with no changes in government policy. The description of baseline scenario is as follows. Total fertilizer subsidy remains the same that is; urea, compound and NPK fertilizer, guaranteed minimum price (GMP) at RM750 per metric tonne and price support at RM248.10 per metric tonne. The import quota is constant at 700,000 metric tonne per year. The 700,000 metric tonne is the initial value of import quota that was set in 2010. This information was provided by MOA. The area planted is assumed to be constant at 611,166 hectares and paddy to rice conversion rate also constant at 65 per cent. The growth rate of population is assumed to be constant at 2.1 per cent per year and average lifetime of human constant at 74 years. Market price of paddy is constant at RM1100 per metric tonne. In this scenario it is assumed that farmers used all the subsidised fertilizer provided by the government efficiently.

Simulation results on yield, rice production, total consumption, import and self sufficiency level (SSL) for baseline scenario are presented in Figure 4, Figure 5, Table 1 .

Under baseline scenario, since there is no improvement in yield and no increment in fertilizer used, yield remains at 4.052 metric tonne per hectare per year as can be seen in Figure 4 and Table 1. At this level of yield, rice production is constant at 1.609 million metric tonne per year (Figure 5 and Table 1). On the other hand, total consumption shows an increasing trend due to population growth at 2 percent per year.

The third graph represents the trend for quantity of rice imported (see Figure 5). Simulation result suggests that quantity of rice import increase every year until 2015 to make sure Malaysian have enough rice to eat. After 2015 the quantity of rice imported will be equal to import quota as stipulated by the import policy. Thus if the import quota remain the same after 2015, then Malaysia don't have enough rice as the SSL is declining due to no increase in production and increase in demand for rice due to population growth.

Figure 5 and Table 1 show the effect of scenario 1 (baseline) on the rice production, consumption, import and SSL. This is because, rice production is fixed at 1.609 million metric tonne, meanwhile total consumption is increasing. Consequently SSL will decline. Initially the SSL was at 74.9 percent and decrease gradually to 56.6 per cent in 2025 (Table 1).

Scenario 2: Simulation under removal of NPK fertilizer. In this scenario the impacts of fertilizer subsidy is simulated. The descriptions of scenario are similar with the baseline scenario 1. The different is only in terms of fertilizer used. In this scenario, it is assumed that the government stop the NPK fertilizer subsidy in 2015, while other fertilizer subsidy such as urea and compound fertilizer remain the same. The simulation results for scenario 2 are presented in Figure 6, Figure 7, Table 2 and Table 3.

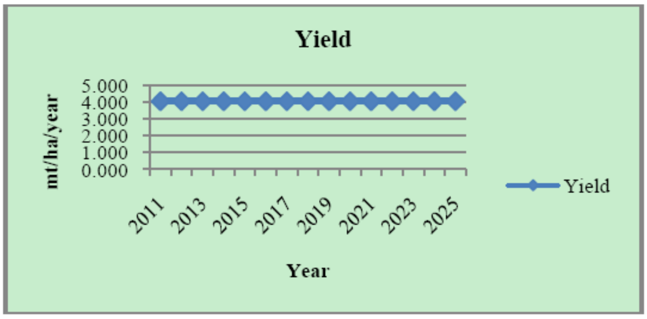

Fig. 4. Yield, scenario 1

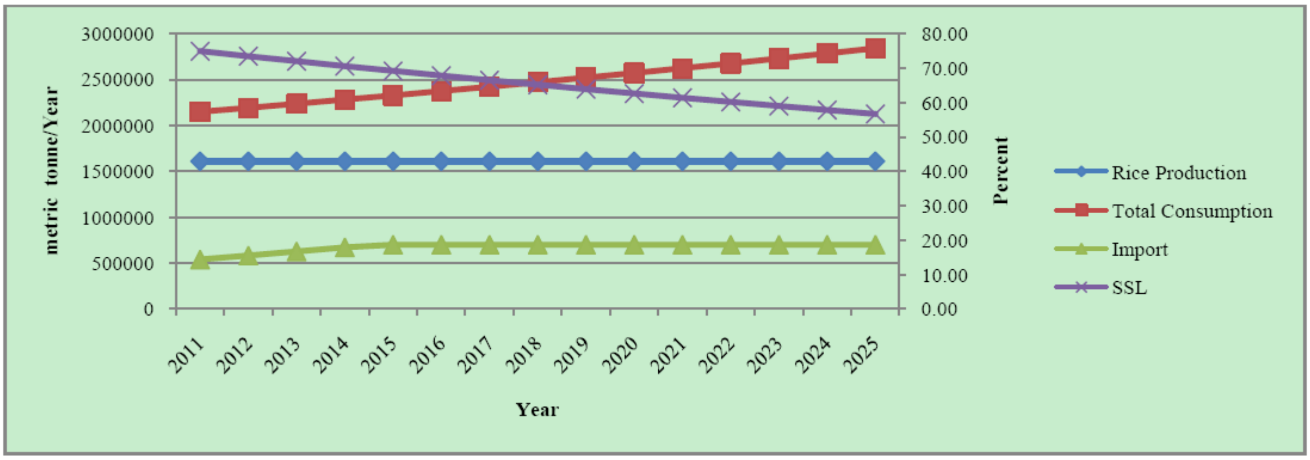

Fig.5. Rice production, total consumption, import and SSL, scenario 1

TABLE I: YIELD, RICE PRODUCTION, TOTAL CONSUMPTION, IMPORT AND SELF SUFFICIENCY LEVEL (SSL), SCENARIO 1

Year	Yield (metric tonne/ha/year)	Rice Production (metric tonne/year)	Total Consumption (metric tonne/year)	Import (metric tonne/year)	Self Sufficiency Level (SSL), (percent)
2011	4.052	1,609,808	2,148,812	539,004	74.92
2012	4.052	1,609,808	2,192,112	582,303	73.44
2013	4.052	1,609,808	2,236,284	626,475	71.99
2014	4.052	1,609,808	2,281,346	671,538	7056
2015	4.052	1,609,808	2,327,316	700,000	69.17
2016	4.052	1,609,808	2,374,213	700,000	67.80
2017	4.052	1,609,808	2,422,054	700,000	66.46
2018	4.052	1,609,808	2,470,860	700,000	65.15
2019	4.052	1,609,808	2,520,649	700,000	63.86
2020	4.052	1,609,808	2,571,441	700,000	62.60
2021	4.052	1,609,808	2,623,257	700,000	61.37
2022	4.052	1,609,808	2,676,116	700,000	60.15
2023	4.052	1,609,808	2,730,041	700,000	58.97
2024	4.052	1,609,808	2,785,053	700,000	57.80
2025	4.052	1,609,808	2,841,173	700,000	56.66

As indicated earlier the only changes in Scenario 2 is the absent of NPK fertilizer subsidy. In this scenario it is also assumed that the farmers do not use additional fertilizer in the production of paddy as the paddy farmers depend heavily on subsidized fertilizer. Simulation result indicates that there is a reduction in yield obtains in 2015 as a result of removal of NPK fertilizer subsidy by the government. The yield obtained decreased from 4.052 metric tonne per hectare to 3.081 metric tonne per hectare as shown in Figure 6 and Table 2. This implies that NPK fertilizer does give a significant impact to the yield. This finding is consistent with the previous study conducted as in [10]. Their finding indicated that the improvement in yield performance resulting from the increase in the NPK fertilizer used. In the other words, the yield declines as the fertilizer used decreases. Therefore, in this simulation, when there is no initiative taken by farmers to buy NPK fertilizer on their own, the yield obtain will remain at 3.081 metric tonne per hectare per year.

The interrelationship between quantity of rice production, total consumption, import and SSL for Scenario 2 is presented in Figure 7. Simulation result suggests that in 2015 rice production decline from 1.6 1 million metric tonne to 1.22 million metric tonne due to removal of NPK fertilizer subsidy in 2015. Removal of NPK fertilizer caused a declining in yield obtained. Consequently it caused a decline in rice production. Simulation result also indicates that from 2011 until 2015 total import increase every year due to increase in total consumption and reduction in yield. Simulation result from Scenario 2 suggests that in 2016, due to decline in rice production, SSL declines drastically from 69.17 per cent to 51.55 per cent. The percentage decline in SSL is about 25 per cent. Thereafter, SSL continues to decline to up to 43.08 per cent in 2025.

IV. CONCLUSION

It can be concluded that the overall policy implication indicated that paddy production in Malaysia cannot be sustain without fertilizer subsidy and the farmers are not willing to buy their own fertilizer. However, due to trade liberalization the allowable of continue supporting the paddy and rice industry will be limited.

Thus if the government decide to slowly or drastically remove the fertilizer subsidy attention should be given to encourage farmers to buy their own fertilizer in order to increase the yield in order to meet the increasing demand of rice. Alternative policy mechanisms should be introduced to increase the yield. The saving from allocation from fertilizer subsidy program can be channeled to construction of new irrigation scheme for rain fed areas.

The extension services should be enhanced to educate and motivate farmers to invest in buying additional fertilizer. The investments by the government in the R&D, extension and technology transfer must continue and be strengthen. These efforts would considerably improve the agricultural productivity in order to ensure adequate supply of rice for Malaysian population.

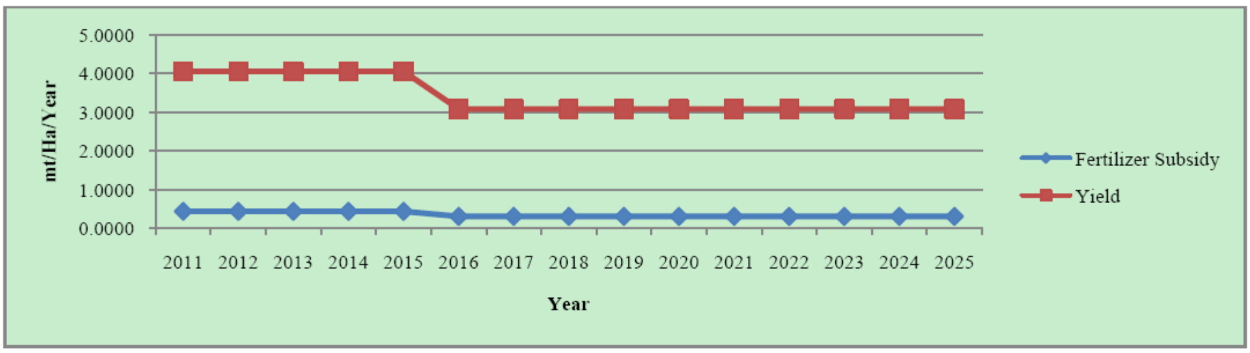

Fig. 6. The effects of fertilizer subsidy on yield, scenario 2

TABLE II: THE EFFECTS OF FERTILIZER SUBSIDY ON YIELD, SCENARIO 2

Year	Fertilizer Subsidy (mt/ha/year)	Yield (mt/ha/year)
2011	0.4336	4.052
2012	0.4336	4.052
2013	0.4336	4.052
2014	0.4336	4.052
2015	0.4336	4.052
2016	0.3036	3.081
2017	0.3036	3.081
2018	0.3036	3.081
2019	0.3036	3.081
2020	0.3036	3.081
2021	0.3036	3.081
2022	0.3036	3.081
2023	0.3036	3.081
2024	0.3036	3.081
2025	0.3036	3.081

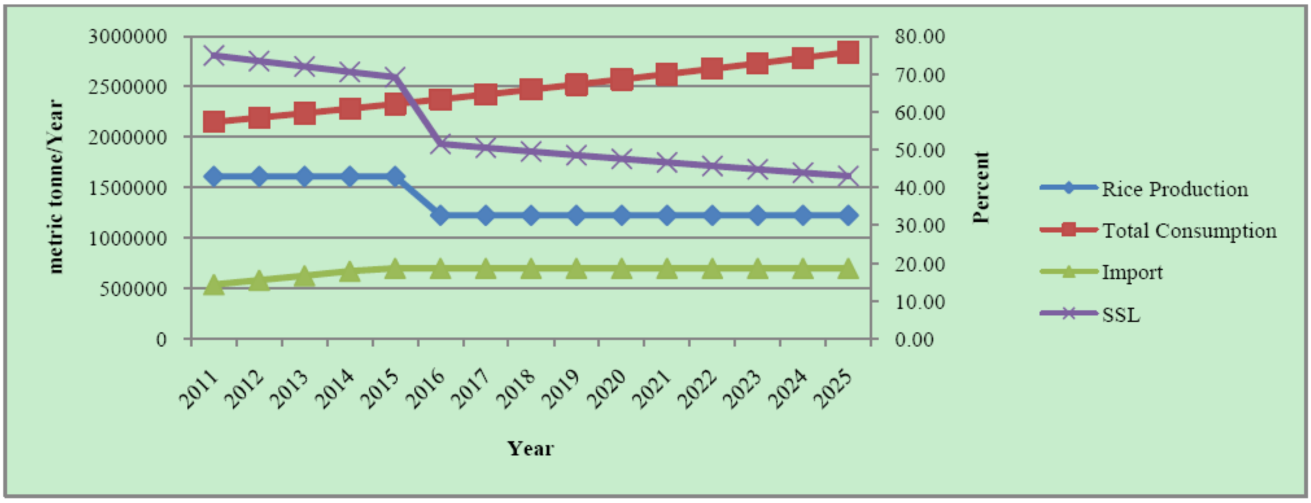

Fig. 7. Relationship between rice production, total consumption, import and Self Sufficiency Level (SSL), scenario 2

TABLE III: Quantity of Rice Production, Total Consumption, Import and Ssl, Scenario 2

Year	Rice Production (metric tonne/year)	Total Consumption (metric tonne/year)	Import (metric tonne/year)	Self Sufficiency Level (SSL), (percent)
2011	1,609,808	2,148,812	539,001	74.91
2012	1,609,808	2,192,112	582,301	73.43
2013	1,609,808	2,236,284	626,473	71.98
2014	1,609,808	2,281,346	671,535	70.56
2015	1,609,808	2,327,316	700,000	69.17
2016	1,223,930	2,374,213	700,000	51.55
2017	1,223,930	2,422,054	700,000	50.53
2018	1,223,930	2,470,860	700,000	49.53
2019	1,223,930	2,520,649	700,000	48.56
2020	1,223,930	2,571,441	700,000	47.60
2021	1,223,930	2,623,257	700,000	46.66
2022	1,223,930	2,676,116	700,000	45.74
2023	1,223,930	2,730,041	700,000	44.83
2024	1,223,930	2,785,053	700,000	43.95
2025	1,223,930	2,841,173	700,000	43.08

APPENDIX

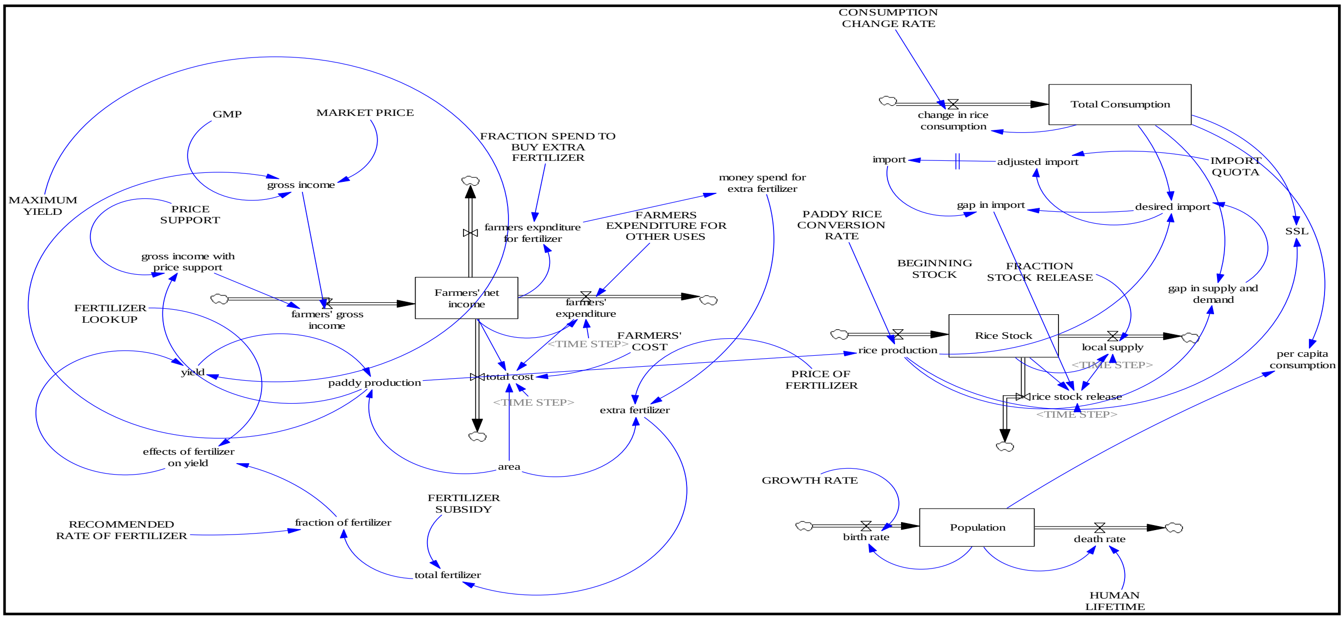

Fig.1. System dynamics model for the Malaysian rice industry

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